



Rochdale Road

For

Portwood Developments
Ltd

Wind Microclimate Report

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Executive Summary

Background

A study has been carried out by Architectural Aerodynamics Ltd. (ArcAero) to assess the wind microclimate for the proposed Rochdale Road development in Manchester, UK.

The study has employed computational modelling (CFD) to predict the strength of wind speeds that will occur following the introduction of the proposed development.

This suitability of wind conditions is determined using the widely accepted industry standard Lawson criteria to determine the suitability of wind conditions on site and the impact of the proposed development on the surrounding area.

Conclusions

The following conclusions have been drawn:

- Wind conditions within and around the existing site satisfy the safety criteria with respect to wind and are suitable for all pedestrian activities.
- Upon introduction of the proposed development the wind microclimate is generally suitable for all existing and proposed pedestrian activities.
- Wind conditions at each balcony are suitable for at least general recreational activities as well as long periods of sitting for large proportions of time in the summer, and would thus be considered suitable for use.

1 Introduction

A microclimate is defined as the distinctive climate of a small-scale area. The weather variables in a microclimate, such as wind, may be different to the conditions prevailing over the area as a whole. Wind microclimate assessments consider the wind conditions that would result upon the introduction of a new development into an existing space.

Such assessments predict the proportion of time an area will experience wind speeds in excess of threshold values associated with safe and comfortable use by pedestrians and occupants once the development is introduced. It can therefore be shown within the various parts of a new proposal and neighbouring properties whether wind conditions are suitable or unsuitable, and whether design adjustment or mitigation measures are required. It is for this purpose that wind microclimate assessments are undertaken.

This report summarises the results of a CFD study, commissioned by Portwood Developments Ltd, to assess the wind microclimate for the proposed Rochdale Road development in Manchester, UK.

2 The Project

2.1 Site Location and Surrounding Area

The Rochdale Road development is bounded by Rochdale Road to the south, Gould Street to the west, Clive Street to the east and a parking area to the north. At present, the immediate surrounding areas are characterised by low-rise industrial to mid-rise commercial and residential developments.

Manchester City Centre lies approximately 100m to the west. Further afield to the east, south and north, the area is dominated by low rise commercial and residential buildings.

2.2 The Proposed Development

The proposed development will comprise two duplex townhouses and two residential blocks connected with a one storey podium. The residential blocks will form an L-shape, with heights ranging from ~35m to ~45m tall from the ground level.

2.3 Soft Landscaping

The wind microclimate has been assessed for the proposed development with the current soft landscaping proposals based on the following drawings received on 20th July 2021:

- 2624-PLA-XX-XX-DR-L-0002.pdf
- 2624-PLA-XX-XX-DR-L-2000.pdf

2.4 Cumulative Schemes

A number of cumulative schemes have been considered in the assessment. These schemes are presented in tabular format in Table 2-1.

Table 2-1 – Cumulative Schemes

Development Name	Planning Reference
The Gasworks, New Town	128248/FO/2020
25 Rochdale Road	116777/FO/2017
Victoria Riverside	126944/FO/2020
2&3 Angel Square	109865/FO/2015
Northview	114860/FO/2016
Swan House	121380/FO/2018

3 Assessment Methodology

3.1 The Assessment of Wind Microclimate

The assessment of wind microclimate in the urban environment is not covered by internationally recognised wind codes – which tend to focus on wind loading issues. As such, a typical wind microclimate study will involve one or more of an experience-based desk study, a computational fluid dynamics (CFD) assessment and boundary layer wind tunnel studies.

For such studies, and for use in conjunction with the industry standard Lawson criteria (for full details, see section 3.5) (1) wind speeds are derived via two principal metrics, these being the mean, or average wind speed, and the Gust Equivalent Mean (GEM), which typically equates to a 3-second short-duration gust normalised by the factor 1.85 (1).

3.2 Wind Climate Analysis

Details of the wind climate relevant to the site are provided in Appendix A of this report.

3.3 Computational Fluid Dynamics Studies

The current assessment adopts a steady-state ‘RANS’ CFD approach. This method employs turbulence models to approximate the magnitude of velocity fluctuations about the average wind speeds predicted, in order to derive an estimation of the effect of gusts. Further details on this, as well as technical details of the CFD methodology are provided in Appendix B of this report.

3.4 Computational Model

Assessment models for the proposed development have been constructed on the basis of the following drawings received from Jon Matthews Architects on 15th and 21st July 2021:

- 136-JMA-MP-XX-P-A-001000.dwg
- 136-JMA-MP-XX-P-A-001005.dwg
- 136-JMA-ZZ-XX-M3-A-0002-Architectural.dwg
- 002020_Rochdale Road,Manchester_HD_MASTER.dwg

There have been some minor design changes to the development, based on the drawings received on the 1st September 2021 “136-JMA-ZZ-XX-M3-A-0002-Architectural_hbruceY6HFB - 3D View - {3D - hbruceY6HFB}.dwg”. These include:

- Reduction in height on the rooftop levels of both blocks, by ~0.7m
- Roof orientation at Level 13 of Block 2
- Increase in height by ~4m to the western terrace of the duplex coach houses
- Projecting / exposed balconies at the elevated levels

The changes have been assessed qualitatively and with the exceptions of the wind conditions to the balconies, conditions are expected to remain suitable for proposed use as described in Section 4.2.2.

A digital model of the site and surrounds was used for the study. The surrounding area was modelled up to a distance of 450 m and all features which are likely to impact the wind flow to and through the site have been replicated. Details of the model, including the configurations tested, are presented within Appendix C of this report.

3.5 The LDDC Lawson Criteria

The industry standard criteria for such assessments are commonly referred to as the Lawson criteria. Architectural Aerodynamics use the London Docklands Development Corporation (LDDC) variant of the Lawson Criteria (1).

The LDDC variant of the Lawson criteria applies a single percentage probability of exceedance of a range of wind speeds related to different pedestrian uses.

3.5.1 Safety

A wind speed of 15 metres-per-second occurring once per year is rated as unsafe, with the potential to de-stabilise the less able members of the public including the elderly, cyclists and children.

3.5.2 Comfort

The LLDC variant of the Lawson criteria (1) dictates that wind conditions are suitable for a given activity when the threshold is exceeded no more than 5% of the time in seasons relevant to the activities that will take place in a given area. The value of 5% has been established as giving a reasonable allowance for extreme and relatively infrequent winds that are tolerable within each category. These threshold wind speed values are presented in Table 3-1.

Table 3-1 – LLDC Wind Comfort Thresholds

Threshold Wind Speed [m/s]	Comfort Rating / Activity	
4	C4	Long-term sitting
6	C3	Standing / short-term sitting
8	C2	Strolling
10	C1	Walking
> 10	C0	Uncomfortable

4 Results

4.1 Existing Site Conditions

The existing site comprises low-rise warehouses and parking site and as such the wind conditions are correspondingly benign.

The results for the existing site conditions are presented graphically within Figure 4.1 for safety, and Figure 4.2 and Figure 4.3 for worst-seasonal and summer conditions respectively.

4.1.1 Safety

At the site and in the immediate surrounds, wind conditions satisfy the safety criteria for all users.

4.1.2 Comfort

Wind conditions within and around the site are suitable for at least standing throughout the year and thus for comfortable pedestrian access to and passage through the site as well as car park areas. Conditions are also comfortable for pedestrian ingress / egress at entrances.

4.2 Proposed Development within Existing Surrounds

While the proposed development protrudes slightly above the immediate surrounds, it is not considered a significant structure with respect to wind and it is well oriented to reduce downdraughts of prevailing winds. In addition, the presence of the proposed landscaping scheme results in favourable wind conditions throughout the site.

The results for the proposed development within existing surrounds are presented graphically within Figure 4.4 and Figure 4.5 for safety, Figure 4.6 and Figure 4.7 for worst-seasonal and Figure 4.8 and Figure 4.9 for summer comfort respectively.

4.2.1 Safety

Upon the introduction of the proposed development, the wind conditions throughout the site and the surrounds satisfy the safety criteria for all users.

4.2.2 Comfort

4.2.2.1 Thoroughfares

Wind conditions at thoroughfares within the site are suitable for at least strolling and thus for comfortable pedestrian access to and passage through the site.

4.2.2.2 Entrances

Wind conditions at entrances to the proposed development would be considered suitable for at least standing and thus for comfortable pedestrian ingress / egress.

4.2.2.3 Recreational Spaces

Wind conditions at the Garden Courtyard are suitable for long-term sitting in summer and at least short-term sitting throughout the rest of the year and thus for proposed recreational uses. The wind conditions to the resident's amenity space to the west of Block 1 and the Pocket Square to the north of Block 1 are suitable for short-term sitting or better from spring to autumn and thus for general recreational activities.

Wind conditions at the terraces for Level 10 of Block 1, Level 12 of Block 2 and the townhouses are suitable for short-term sitting or better throughout the year and thus for general leisure uses such as viewing and relaxation activities.

4.2.2.4 *Balconies*

Each balcony is expected to enjoy conditions suitable for short periods of sitting or long periods of sitting depending on the exact location within the balcony and the shelter provided to the wind direction at that time. Where conditions don't quite meet the criteria for long-term sitting, conditions are still expected to be suitable for outdoor sitting for large proportions of the time in summer and thus for proposed recreational and sitting use.

4.2.2.5 *Outdoor Seating*

Wind conditions to the outdoor seating areas along the northern and southern façades of Block 1 are suitable for long-periods of sitting in summer and short-periods of sitting for the remainder of the year and thus for outdoor sitting.

4.2.2.6 *Surrounding Area*

In the surrounding area, conditions are generally suitable for short-term standing or better and thus comfortable for thoroughfares and also for car park areas. Wind conditions are also suitable for short-term standing or better at the surrounding entrances and hence suitable for pedestrian ingress / egress.

4.3 Proposed Development within Future Surrounds

Majority of the consented developments lie to the north of the proposed development and as such they do not coincide with the southern prevailing winds to result in any significant impact on wind conditions in and around the proposed development.

Following the introduction of future developments, wind conditions within the site and surrounds do not materially differ from those within the existing surrounds scenario.

The results for the proposed development within future surrounds are presented graphically within Figure 4.10 and Figure 4.11 for safety, and Figure 4.12 and Figure 4.13 for worst-seasonal and Figure 4.14 and Figure 4.15 for summer comfort respectively.

5 Conclusions

The following conclusions have been drawn:

- Wind conditions within and around the existing site satisfy the safety criteria with respect to wind and are suitable for all pedestrian activities.
- Upon introduction of the proposed development the wind microclimate is generally suitable for all existing and proposed pedestrian activities.
- Wind conditions at each balcony are suitable for at least general recreational activities as well as long periods of sitting for large proportions of time in the summer, and would thus be considered suitable for use.

6 References

1. **Lawson, T.V.** *The determination of the wind environment of a building complex before construction*. Bristol : University of Bristol, Department of Aeronautical Engineering, 1990.
2. **ESDU (Engineering Science Data Unit).** *Item 01008. Computer Program for wind speeds and turbulence properties: flat or hilly sites in terrain with roughness*. 2001.
3. **F, Menter.** *Zonal Two Equation $k-\omega$ Turbulence Models for Aerodynamic Flows*. 1993. AIAA Paper 93-2906.
4. **F, Menter.** *Turbulence Modelling for Engineering Flows*. s.l. : ANSYS Inc., 2011.
5. **Richards, P.J. and Hoxey, R.P.** *Appropriate boundary conditions for computational wind engineering models using the $k-\epsilon$ turbulence model*. s.l. : Journal of Wind Engineering and Industrial Aerodynamics, 1993. vol. 46 & 47, pg. 145 - 153.
6. **Blocken, B. and Carmeliet, J.** *Pedestrian wind environment around buildings: Literature review and practical examples*. s.l. : Journal of Thermal Envelope and Building Science, 2004.

7 Figures

Figure 4.1 – Pedestrian wind conditions, existing site within existing surrounds, annual safety



Figure 4.2 - Pedestrian wind conditions, existing site within existing surrounds, worst case season



Figure 4.3 – Pedestrian wind conditions, existing site within existing surrounds, summer season



Figure 4.4 – Pedestrian wind conditions, proposed development within existing surrounds, annual safety – ground level



Figure 4.5 – Pedestrian wind conditions, proposed development within existing surrounds, annual safety – terrace level

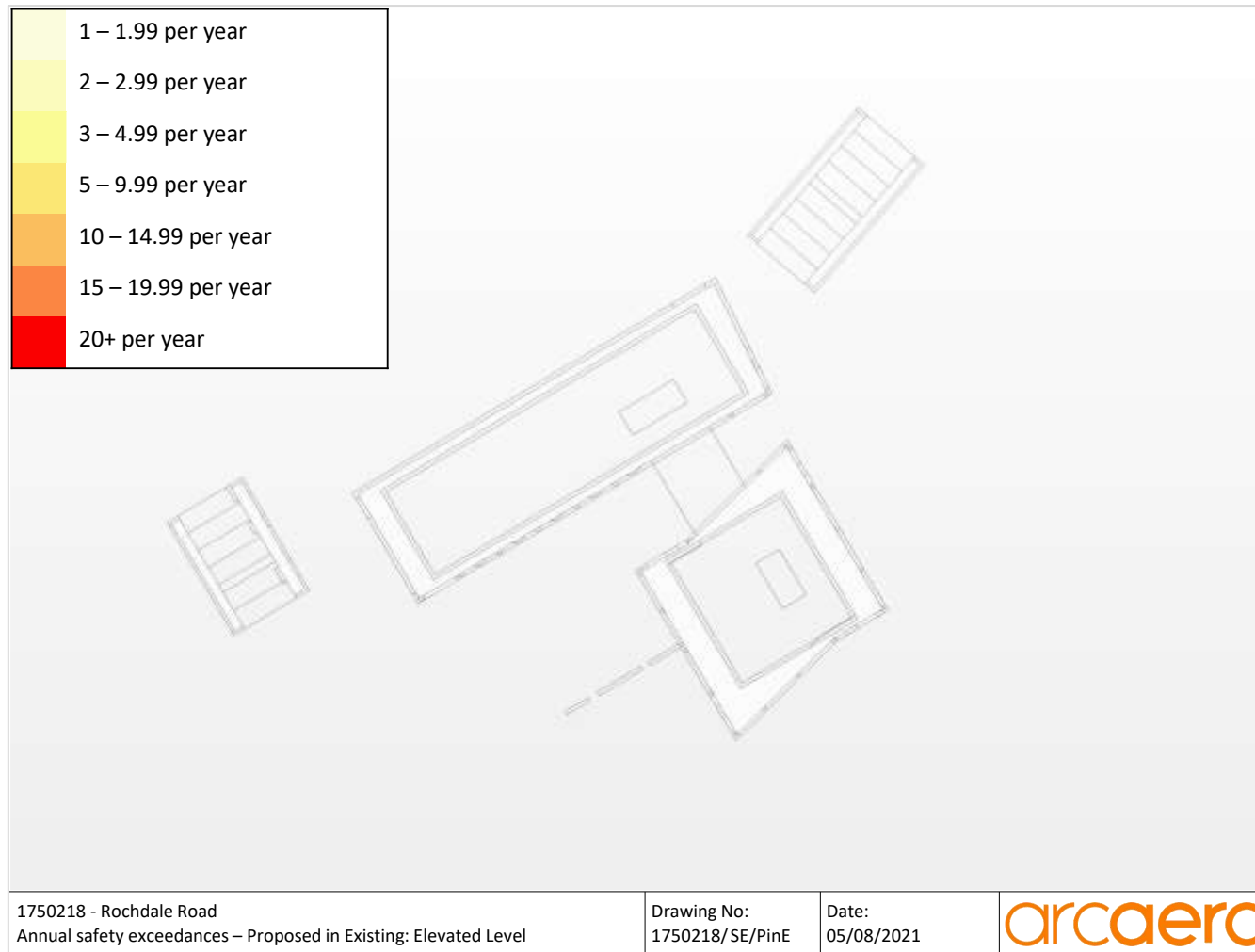


Figure 4.6 – Pedestrian wind conditions, proposed development within existing surrounds, worst case season – ground level



Figure 4.7 – Pedestrian wind conditions, proposed development within existing surrounds, worst case season – terrace level



Figure 4.8 – Pedestrian wind conditions, proposed development within existing surrounds, summer season – ground level



Figure 4.9 – Pedestrian wind conditions, proposed development within existing surrounds, summer season – terrace level

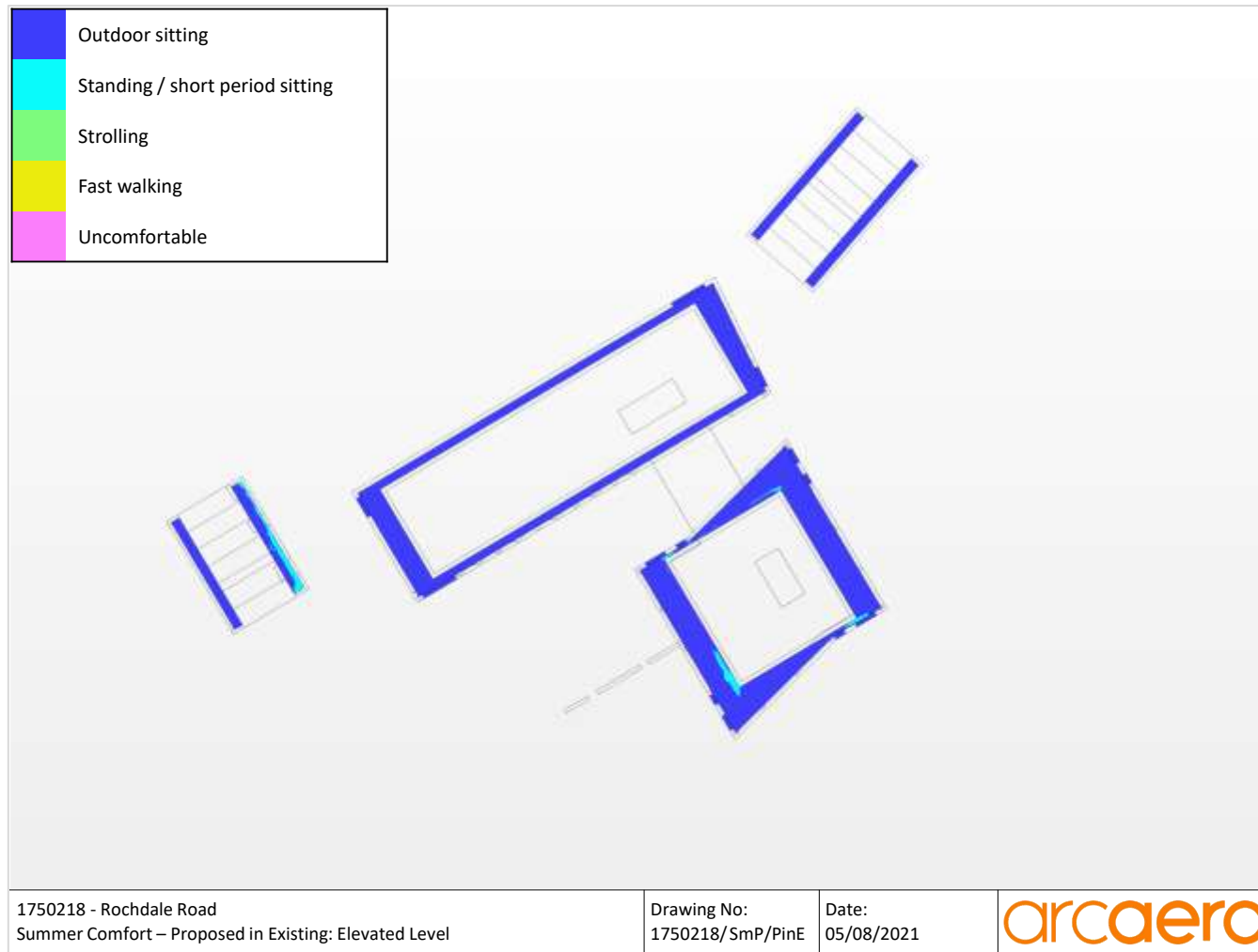


Figure 4.10 – Pedestrian wind conditions, proposed development within future surrounds, annual safety – ground level



Figure 4.11 – Pedestrian wind conditions, proposed development within future surrounds, annual safety – terrace level

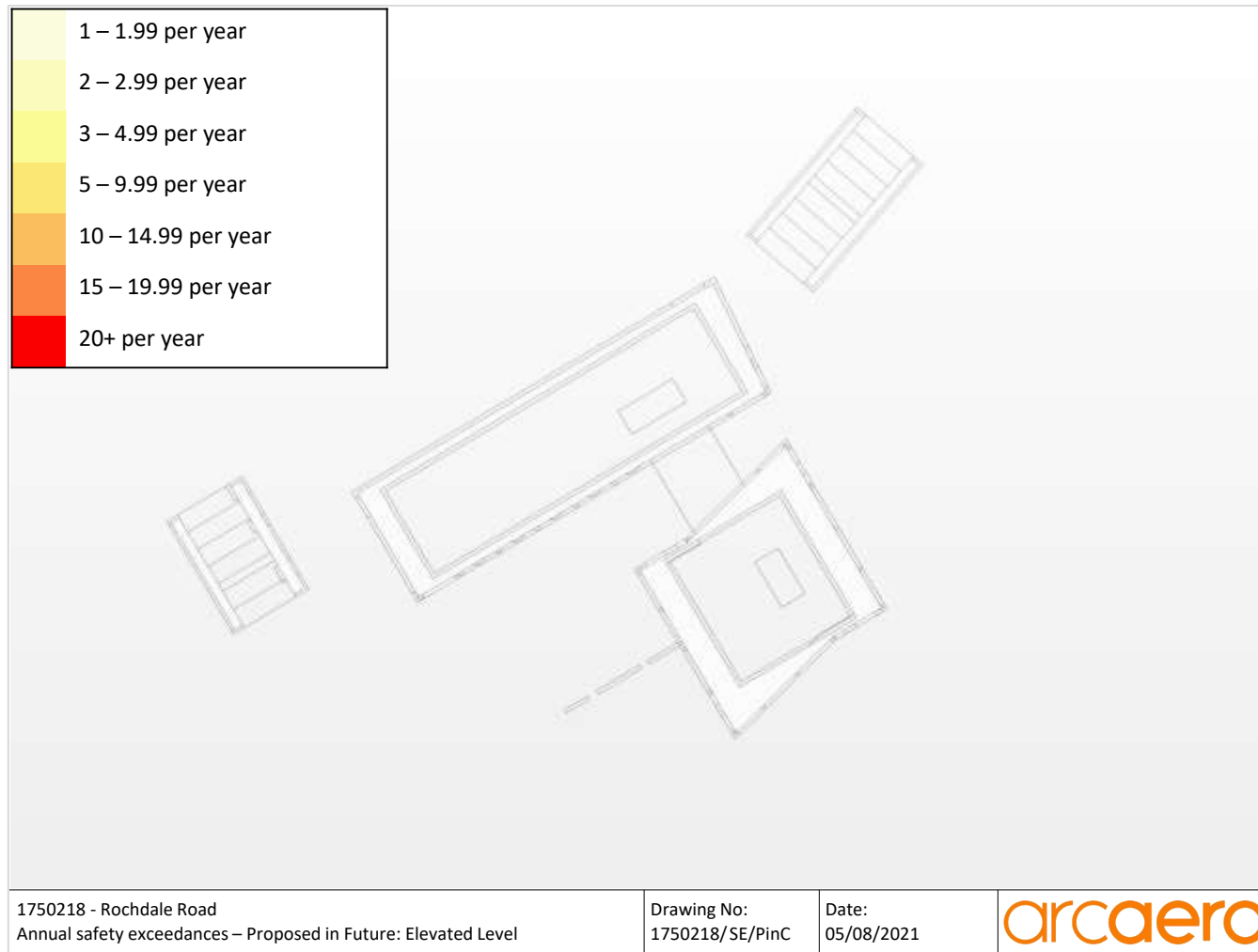


Figure 4.12 – Pedestrian wind conditions, proposed development within future surrounds, worst case season – ground level



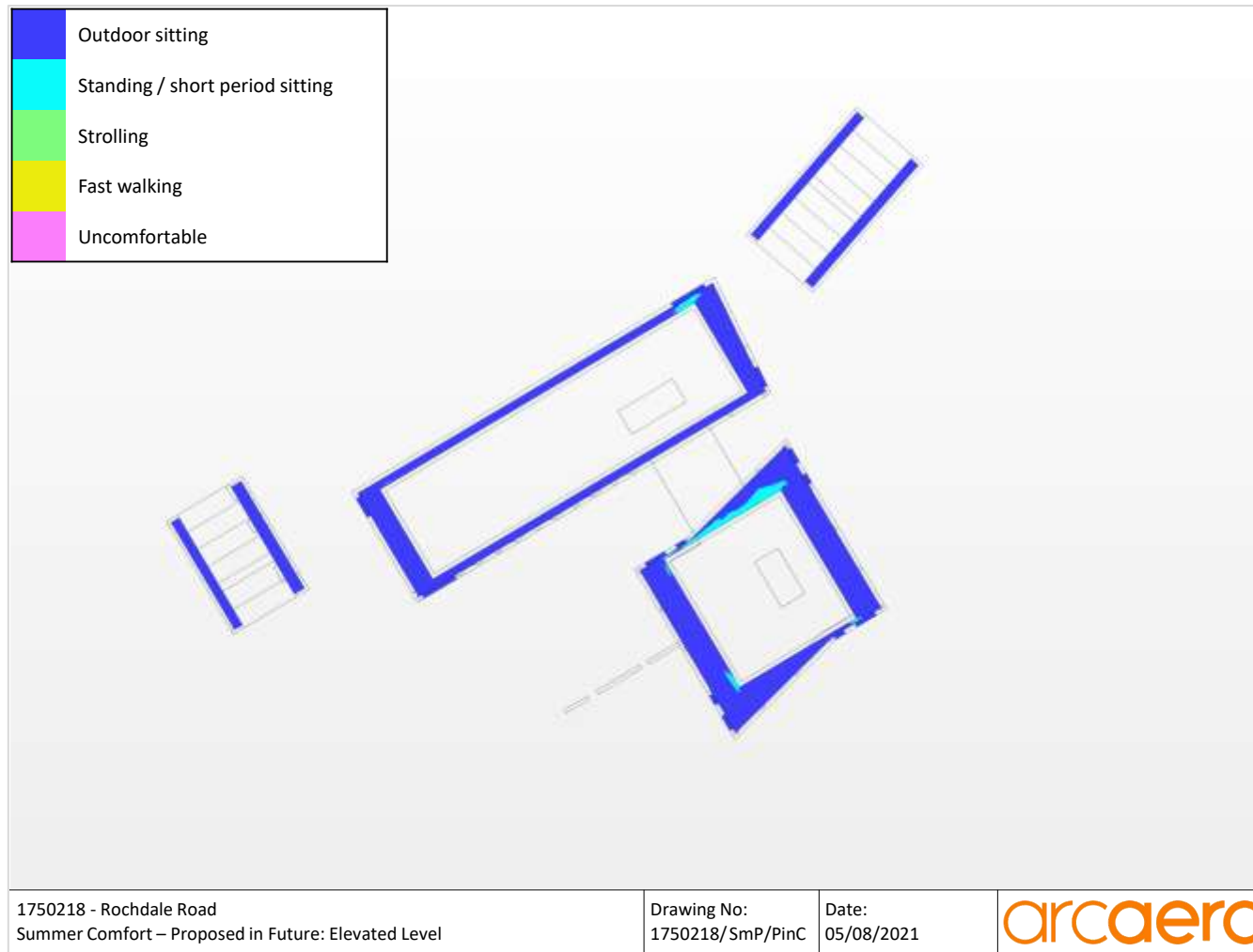
Figure 4.13 – Pedestrian wind conditions, proposed development within future surrounds, worst case season – terrace level



Figure 4.14 – Pedestrian wind conditions, proposed development within future surrounds, summer season – ground level



Figure 4.15 – Pedestrian wind conditions, proposed development within future surrounds, summer season – terrace level



Appendix A Wind Climate Analysis

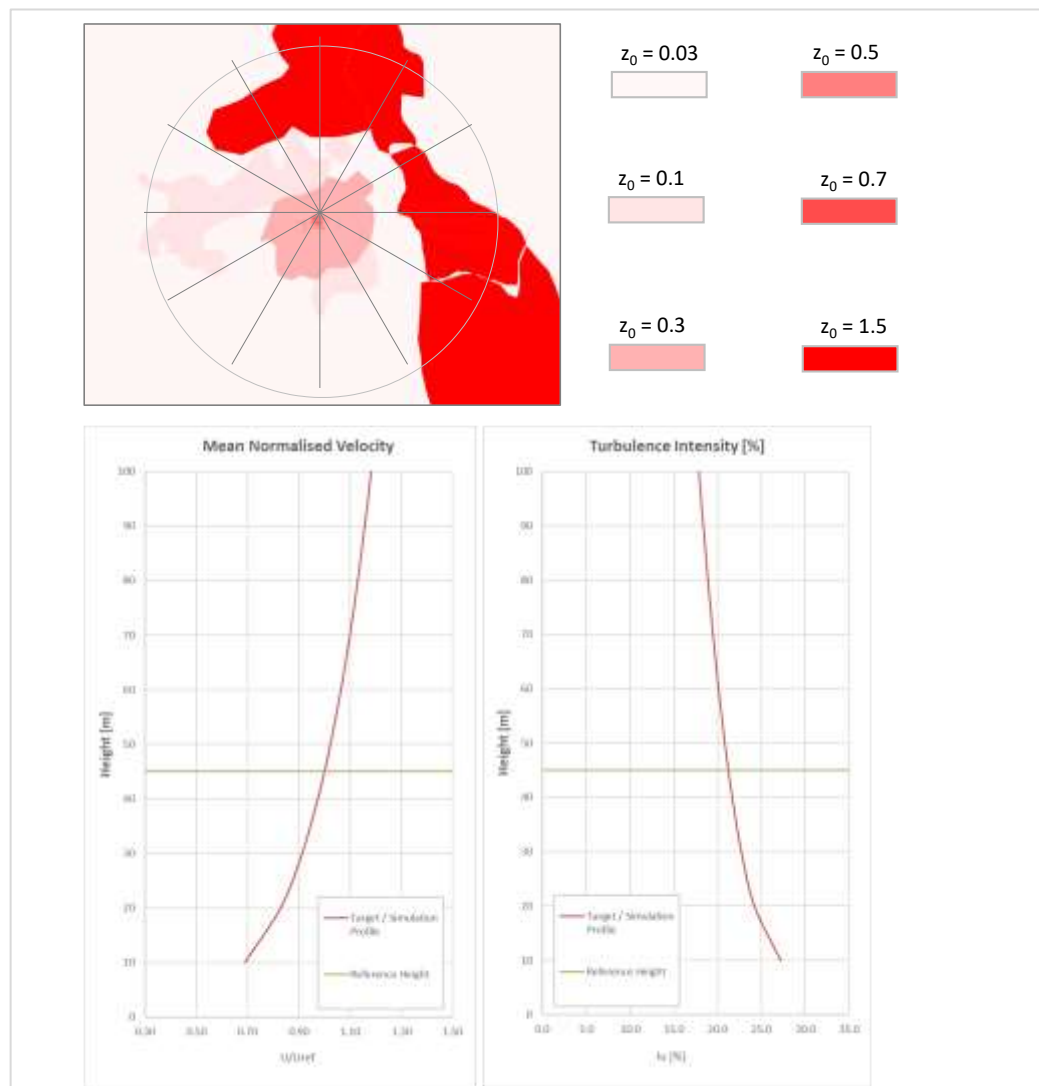
A.1 Surrounding Terrain Assessment

A detailed analysis, based on the widely accepted Deaves and Harris model of the atmospheric boundary layer, as defined in ESDU Item 01008 (2), has been carried out to determine the wind properties at the site. From this analysis, a representative profile was defined as a target profile for the CFD simulations.

A.2 Wind Properties at the Site

Upon conducting the ESDU analysis, each angle was replicated within the CFD model. As each angle exhibited very similar wind profiles, a generic wind profile used in the study is presented within Figure A.1.

Figure A.1 – Mean wind speed and turbulence intensity profiles



A.3 Wind Frequency Data

Wind microclimate studies require that meteorological data is transposed from a nearby weather station with sufficient wind data to produce accurate wind frequency statistics. The current study uses data from Manchester Airport. The cumulative wind speed probability distributions, transposed to building height at site are provided in Figure A.2 to Figure A.6.

Figure A.2 – Cumulative wind speed probability distribution at site, annual

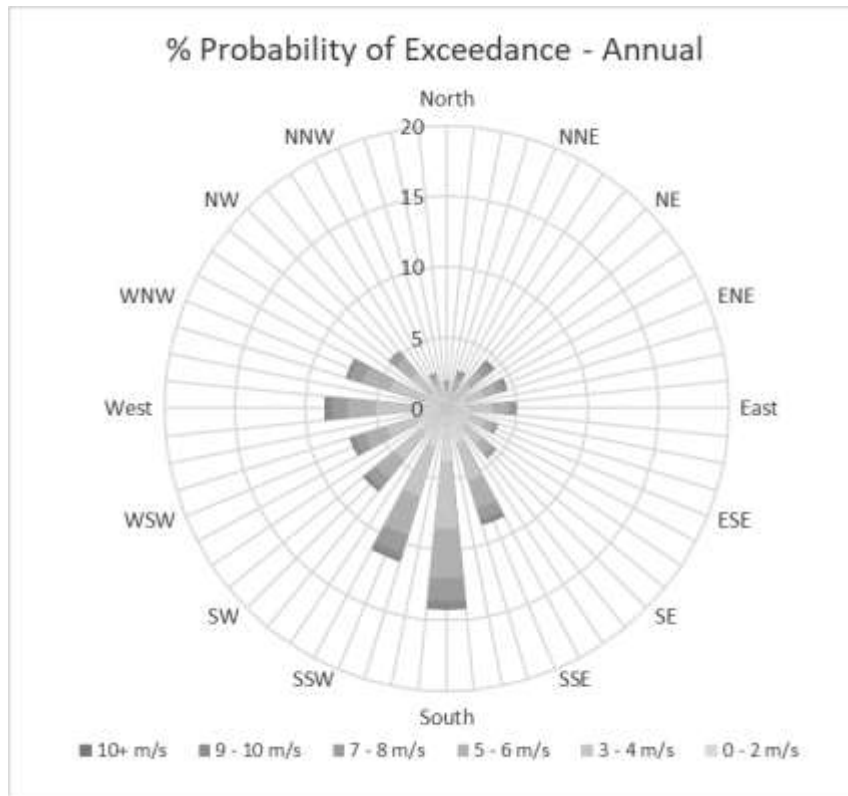


Figure A.3 – Cumulative wind speed probability distribution at site, spring

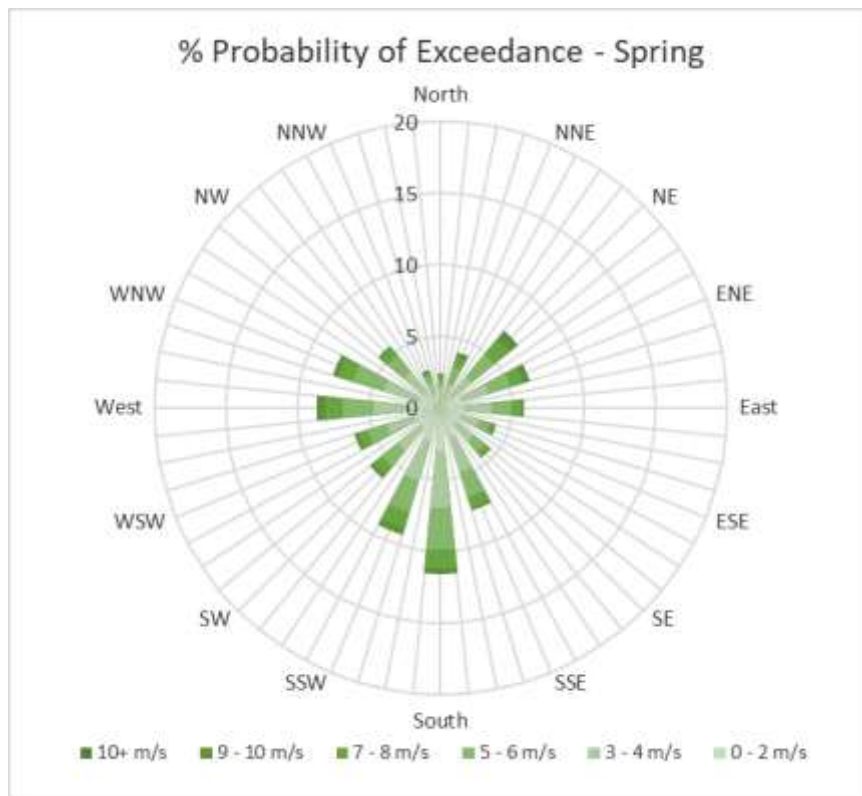


Figure A.4 – Cumulative wind speed probability distribution at site, summer

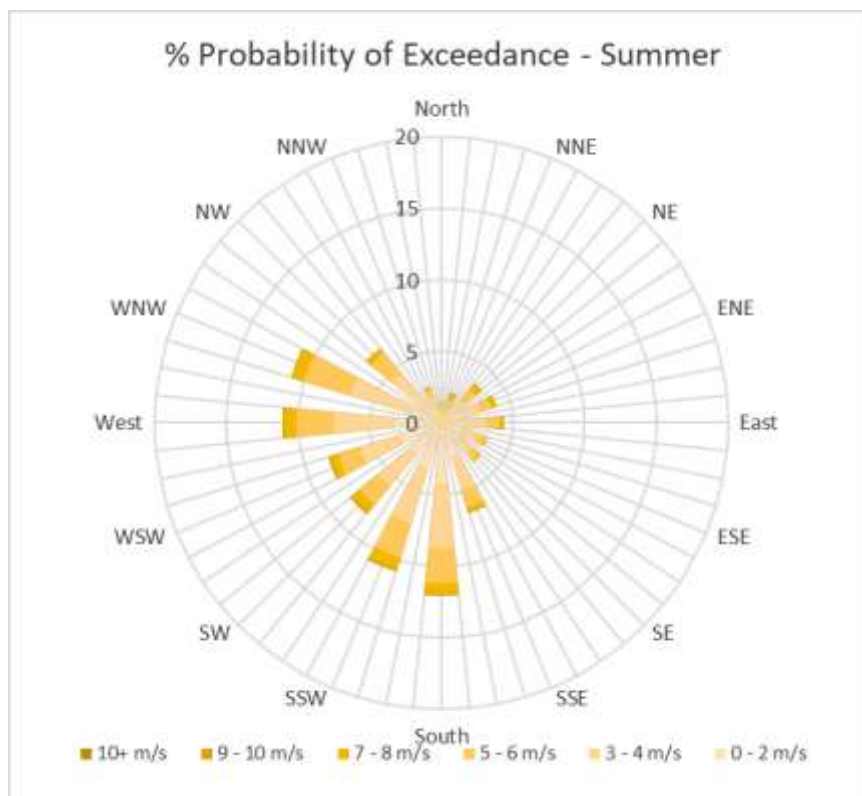


Figure A.5 – Cumulative wind speed probability distribution at site, autumn

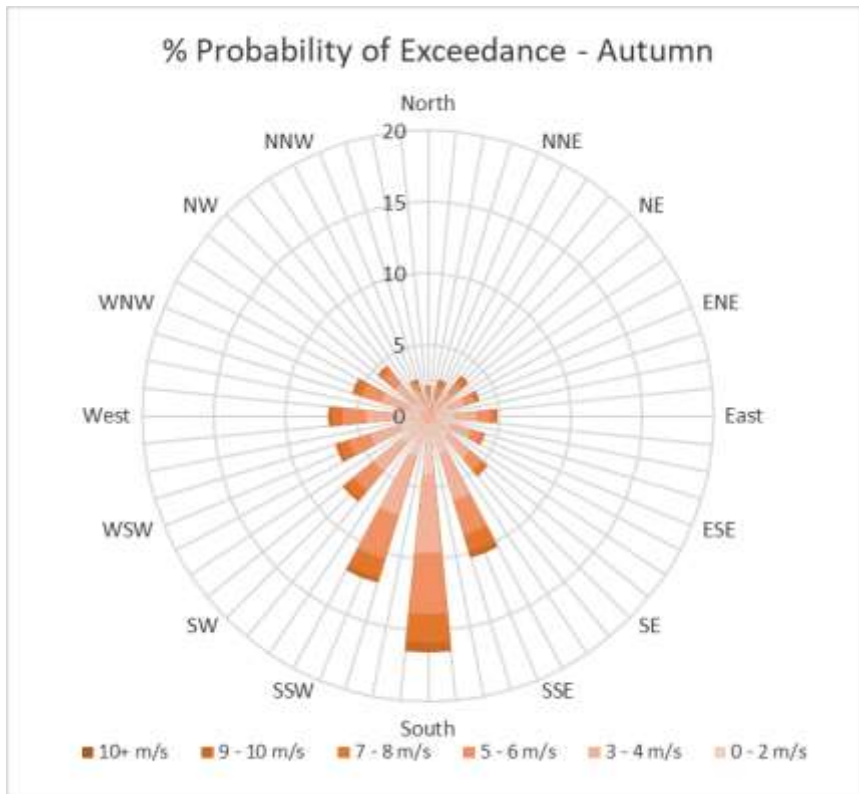
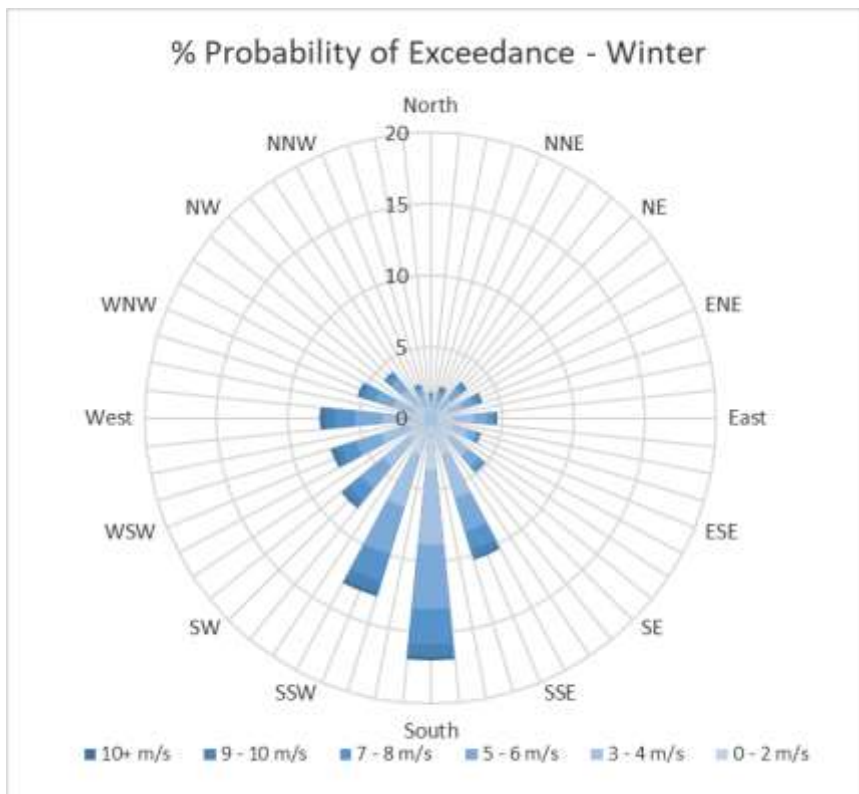


Figure A.6 – Cumulative wind speed probability distribution at site, winter



Appendix B CFD Modelling

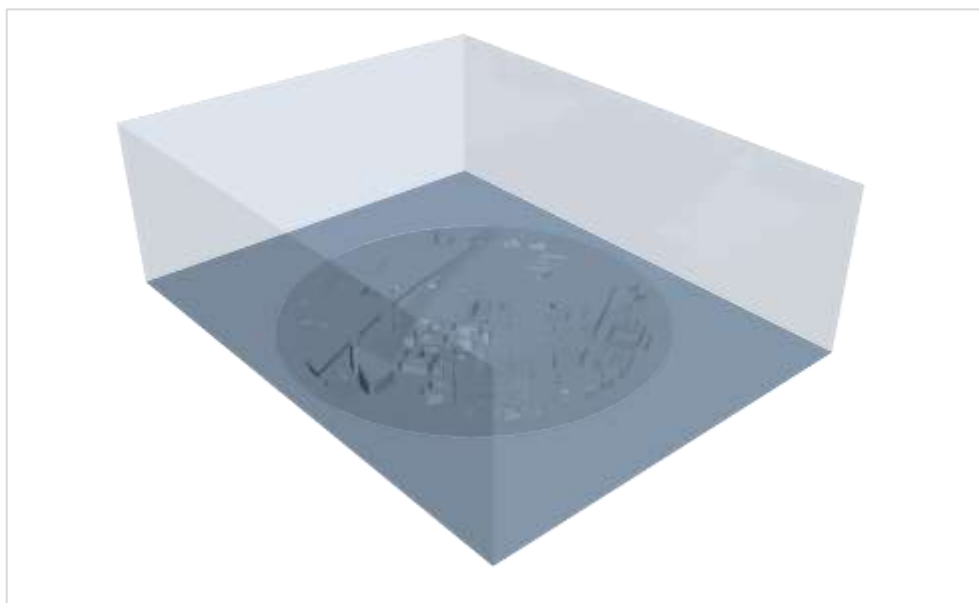
B.1 Spatial discretization

The computational domain was discretised using polyhedral cells for the core mesh, and low aspect-ratio prism cells adjacent to walls and the ground. Computational meshes were constructed for each of the three different study configurations.

The computational domain includes the proposed development site, with surrounding buildings and topographical features within a 450m radius represented explicitly. The full computational domain extends to 1400m in the along-wind direction, 1100m in the across-wind direction, and 450m vertically.

The proposed development and immediate vicinity were meshed down to a cell size of 0.2m in order to capture the detailed geometric features and resulting flow artefacts. The pedestrian ground level surfaces were meshed with a prism layer mesh of 5 layers, which, in the vicinity of the building rise up to a total height of 1.5m above the ground.

Figure B.1 – Computational Domain



B.2 Solution Method

The modelling of an incompressible fluid flow was completed with combinations of semi-implicit method for pressure-linked equations (SIMPLE) algorithms. The resulting flow turbulent features were modelled with introduction of the Shear Stress Transport (SST) $k-\omega$ turbulence model. This model was suggested by Menter (3) and is based on a two-equation eddy-viscosity approach, where the SST model formulation combines the use of a $k-\omega$ in the inner parts of the boundary layer, but also switches to a $k-\epsilon$ behaviour in the free-stream regions of the solutions. Further details for the selected turbulence model are provided in the work of Menter (4).

B.3 Initial and Boundary Conditions

The atmospheric boundary layer flow was simulated by implementing a logarithmic velocity profile model presented by Richards and Hoxey (5), with the following main assumptions:

- The vertical velocity component at the domain boundary is negligible
- The pressure gradient and shear stress are constant

The model implies the following equation for the mean inlet velocity at the CFD domain:

$$U(z) = \frac{U^*}{\kappa} \cdot \ln\left(\frac{z + z_0}{z_0}\right)$$

where:

- κ - is the von Karman's constant
- z - is the distance from the ground surface in vertical direction
- z_0 - is the ground surface roughness length in meters

The friction velocity U^* is calculated by the following equations:

$$U^* = \kappa \cdot \frac{U_{ref}}{\ln\left(\frac{z_{ref} + z_0}{z_0}\right)}$$

where:

- z_{ref} - is the reference height in metres
- U_{ref} - is the reference velocity in m/s measured at z_{ref}

The turbulent velocity fluctuations at the domain inlet are induced by the constant shear stress with height, maintained by the turbulent kinetic energy k equation below:

$$k(z) = \frac{(U^*)^2}{\sqrt{C_\mu}}$$

where:

- $C_\mu = 0.03$ - is a k - ϵ turbulence model constant

All surface boundary conditions were modelled as smooth walls with a no-slip condition. A no-slip wall boundary condition with a varying roughness length height based on the terrain analysis for the site was applied on the ground surface outside the explicit surrounds area of the domain.

B.4 Gust Equivalent Mean Calculation

The gusts in the wind flow is a major component that may lead to additional danger and discomfort to that caused by the mean wind flow. Thus, the gust wind speed is accounted by a calculation of the equivalent mean wind speed, considering the standard deviation of the mean wind speed, in particular the turbulent kinetic energy, k :

$$\sigma = \sqrt{(k * 2/3)}$$

The GEM is then calculated as:

$$U_{GEM} = \frac{U_{Mean} + 3.5\sigma}{k_g}$$

Where gust factor, $k_g = 1.85$

The final speedup used in the Lawson criteria is the worst case from U_{GEM} and U_{Mean} .

Appendix C Computational Model

A digital model of the site and surrounds was used for the study. The surrounding area was modelled up to a distance of 450m and all features which are likely to impact the wind flow to and through the site have been replicated. The model was reviewed and approved by the design team prior to the study.

C.1 Model Images

Images of the computational model are presented as follows:

- Figure C.1: Existing site
- Figure C.2: Proposed development within existing surrounds
- Figure C.3: Proposed development within future surrounds
- Figure C.4: Close-up of the proposed development

Figure C.1 - Existing site

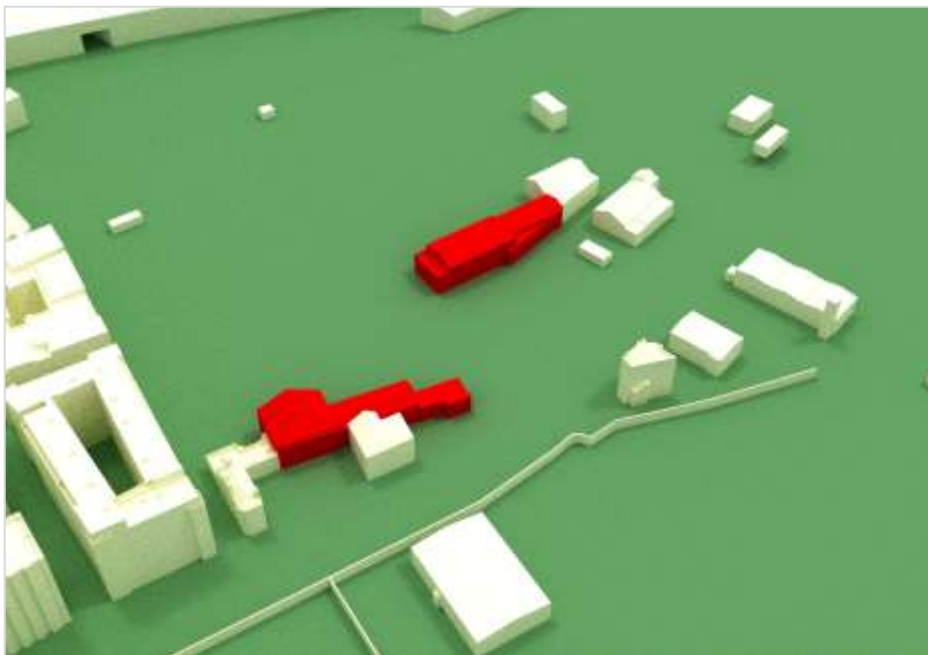


Figure C.2– Proposed development within existing surrounds, viewed from south



Figure C.3 – Proposed development within future surrounds, viewed from south



Figure C.4 – Proposed development, close-up from south

