



Plot 11, First Street

For

Downing Living
(Manchester) Limited
Partnership Incorporated

Wind Microclimate Report

1690207rep2v2

08 December 2021

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Issue History

	Previous Issue			Current Issue
Comment				
Issue			1	2
Date			08 December 2021	07 December 2021
Prepared by			H. Hashim	H. Hashim
Signature				
Checked by			A. Turpitt	A. Turpitt
Signature				
Report Number			1690207rep2v1	1690207rep2v2

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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 Plot 11, First Street development in Manchester, UK.

The study has employed computational modelling (CFD) to predict the strength of winds. Then using the industry standard Lawson criteria, it has established the suitability of wind conditions and the impact on the surrounding area, following the introduction of the proposed development. The development has already received planning permission and the wind microclimate assessment for previously conducted via wind tunnel testing, the current study aims to benchmark a CFD assessment against the approved scheme and associated wind microclimate results, and then provide an assessment of the 'worst-case' phasing scenario to determine likely effects in an interim phase of construction.

The study therefore compares two configurations of the proposed scheme, the 'as tested' or consented scheme, and with Block D without other proposed blocks in place, which is deemed to be the worst likely phasing scenario in terms of wind.

The aim of the current report is to assure comfort in discharging planning conditions 3 as follows:

Before development commences final details of any wind mitigation measures required to mitigate any impacts from the phasing of the development as agreed within the timetable for implementation in condition 5 below, including in relation to the development of Plots 9 and 10 within the First Street SRF shall be submitted to and approved by the City Council as local planning authority. All works approved in discharge of this condition shall be fully completed before the development hereby approved is first occupied.

Conclusions

The following conclusions have been drawn:

- With the introduction of the proposed development with consented landscaping scheme, wind conditions within and immediately surrounding the site meet the safety criteria, this includes conditions in and around the undeveloped Plot 9 and Plot 10 sites.
- With respect to comfort, wind conditions throughout the site and surrounds would generally be considered suitable for proposed pedestrian usage. Some localised areas particularly the proposed outdoor seating areas around Blocks A & D would be considered too windy for prolonged sitting usage but would be suitable for general recreation activities for at least during summer. This fact should not preclude the offer to the residents of the space for any amenity use, should they desire, for the large proportion of time (more than 85%) that conditions are suitable for long periods of sitting.

- During key stages of construction, for example with Blocks A, B and D complete or with just Block D complete, conditions would also be considered suitable for pedestrian passing by the site in terms of both comfort and safety. Some exceedances are likely to occur on site, but these are expected to be tolerable for construction workers assuming that safety precautions for working in high winds would be adhered to.
- Within cumulative surrounds, including within the context of likely Plot 9 and Plot 10 massing, wind conditions within the site and immediate surrounds are suitable for pedestrians in terms of both safety and comfort.

Recommendation

With regards to Conditions 3 of the planning approval, providing wind mitigation including any proposed landscaping and architectural elements such as screens for each Block is in place before the public are allowed access, conditions within any construction or cumulative scenario are suitable in terms of comfort and safety with respect to wind. It is therefore recommended that Condition 3 can be discharged. This is on the basis that the landscaping scheme contained within this report provides suitable mitigation for wind.

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 Downing Living (Manchester) Limited Partnership Incorporated, to assess the wind microclimate for the proposed Plot 11, First Street development in Manchester, UK.

2 The Project

2.1 Site Location and Surrounding Area

The Plot 11, First Street development is bounded by Hulme Street to the north, Wilmott Street to the east, Chester Street to the south and Medlock Street to the west. The site sits within the First Street development framework with the Great Jackson Street area is immediately adjacent and further beyond lies the Oxford Road corridor and the Cultural Core.

Further afield the terrain is typical of suburban residential areas. To the north lies Manchester City Centre, with mid-rise to high-rise office and residential developments and buildings typical of a UK city centre.

2.2 The Proposed Development

The proposed development will comprise four residential towers, linked with a common landscape, stepping in height from 10 storeys to 45 storeys including the ground floor level.

2.3 Soft Landscaping

The wind microclimate has been assessed for the proposed development with the consented landscaping proposals and surrounding landscaping, as shown in Figure 2.1.

2.4 Condition 3

The aim of the current study is to provide confidence in discharging condition 3 of the planning approval as follows:

Before development commences final details of any wind mitigation measures required to mitigate any impacts from the phasing of the development as agreed within the timetable for implementation in condition 5 below, including in relation to the development of Plots 9 and 10 within the First Street SRF shall be submitted to and approved by the City Council as local planning authority. All works approved in discharge of this condition shall be fully completed before the development hereby approved is first occupied.

The study will further draw on ArcAero's experience of wind microclimate in the area, including studies previously carried out for Plot 9 and on the nearby Premier Inn site.

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

A digital model of the site and surrounds was used for the study. The surrounding area was modelled up to a distance of 360 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 Consented Development with Landscaping and Mitigation as Previously Tested within Existing Surrounds

The results for the proposed development within existing surrounds with landscaping and mitigation as tested are presented graphically within Figure 4.1 and Figure 4.2 for worst-seasonal and summer comfort respectively.

The results show a reliable match with the scheme as approved via wind tunnel testing.

4.1.1 Safety

Upon the introduction of the proposed development, all areas within the site and immediate surrounds satisfy the safety criteria for wind.

4.1.2 Comfort

4.1.2.1 Thoroughfares

Wind conditions at thoroughfares within the site are generally suitable for leisurely strolling and thus for comfortable pedestrian access to and passage through the site. A single exception to this is the thoroughfare to the east of Block D (location 78). Here conditions are marginally windy during winter, suitable for ~94% of the time in winter and would therefore still be considered tolerable for proposed use.

4.1.2.2 Entrances

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

4.1.2.3 Recreational Spaces

Wind conditions at recreational spaces would be considered suitable for short-term standing and sitting from spring to autumn and thus for comfortable general recreational activities.

4.1.2.4 Outdoor Seating

Wind conditions at the outdoor seating areas are generally suitable for long period of sitting during summer and thus for proposed usage. Exceptions to this are to the following areas:

- to the southwestern side of ground level Block A (locations 68 and 95), where conditions are marginally windy during summer, suitable for only ~94% of the time rather than the required 95% of the time in summer. Here, conditions are suitable for general leisure and short periods of sitting throughout the year but still tolerable for outdoor sitting.
- to the western side of podium level Block A (location 65), where conditions are generally suitable for strolling throughout the year.
- to the southeastern corner of Block D (location 90), where conditions are only suitable for standing in summer. Here, conditions are suitable for general leisure and short periods of sitting throughout the year.

Elsewhere, the proposed seating areas throughout the site are suitable for long periods of outdoor sitting in summer.

4.1.2.5 Surrounding Area

Upon the introduction of the proposed development, wind conditions to the surrounding area are suitable for at least strolling and thus for comfortable pedestrian access to and passage through the site and car park spaces. Conditions are also comfortable for pedestrian ingress / egress at entrances. Recreational space within the Unite Students - Parkway Gate courtyard is also comfortable for recreational uses.

4.2 Block D within Existing Surrounds

Sections 4.1 of this report validates the previous microclimate assessment that wind conditions around the site are generally suitable for their proposed uses.

Planning condition 3 of consent 125573/FO/2019 request further details, to demonstrate the impact any phased delivery of the development has on microclimate conditions:

Before development commences final details of any wind mitigation measures required to mitigate any impacts from the phasing of the development as agreed within the timetable for implementation in condition 5 below, including in relation to the development of Plots 9 and 10 within the First Street SRF shall be submitted to and approved by the City Council as local planning authority. All works approved in discharge of this condition shall be fully completed before the development hereby approved is first occupied.

Being the tallest building within the site, the worst case phasing scenario is expected to be associated with the delivery of Block D in isolation, hence a study has been made on this phasing scenario. It is more likely that Blocks A & B will completed first, followed shortly by Block D – this assessment therefore represents a conservative approach to the wind microclimate during phased construction.

The results for Block D within existing surrounds are presented graphically within Figure 4.3 and Figure 4.4 for worst-seasonal and summer comfort respectively.

4.2.1 Safety

The wind conditions within the Block D site and throughout the rest of the development and immediate surrounds generally satisfy the safety criteria for wind. A single exception to this is the construction site to the northwest corner of Block B (location 118), where conditions do not satisfy the safety criteria for wind.

While the area is not accessible to pedestrians, it would be recommended that this area is closed off to on-site workers due to the magnitude of the safety exceedance here or that warnings are implemented on windy days. Alternatively, if possible, the revised landscaping to the northern area of Block C would be introduced upon the completion of Block D.

4.2.2 Comfort

Within the Block D, the wind conditions are generally the same as with the completed configurations. Exceptions occur at the following areas:

- thoroughfare to the east of Block D (location 78). Conditions here are suitable for pedestrian strolling all year. Upon development completion, the wind conditions here are marginally windy during winter, however conditions would still be considered tolerable for proposed use.
- outdoor seating area to the south of Block D (location 87). Here, conditions are marginally windy during summer, suitable for ~94% of the time in summer for prolonged seating and would therefore still be considered tolerable for proposed use.

Elsewhere, the wind conditions within the rest of the construction site (Blocks A, B and C) are generally suitable for pedestrian strolling, with a localised area towards the construction site to the northwest corner of Block B (location 118) that is only suitable for pedestrian strolling during winter. While conditions at these areas would be considered too windy for comfortable leisure strolling, the on-site workers are anticipated to be able to tolerate the windier conditions during the construction phase.

As construction progresses, the wind conditions within the site would gradually adjust to those for the completed development.

The wind conditions to the surrounding area are suitable for at least strolling and thus for comfortable pedestrian access to and passage through the site and car park spaces. Conditions are also comfortable for pedestrian ingress / egress at entrances. Recreational space within the Unite Students - Parkway Gate courtyard is also comfortable for recreational uses.

Therefore, wind conditions within the immediate surrounds are expected to be no worse during any stage of construction of Plot 11, than when the development is complete.

4.3 Completed Development with Plot 9 and 10 in place

Whilst the completed development with both Plot 9 and Plot 10 in place has not been assessed, studies have been conducted with proposals for Plot 9 in place.

The results for the completed development within existing surrounds are presented graphically within Figure 4.5 and Figure 4.6 for worst-seasonal and summer comfort respectively.

4.3.1 Safety

All areas within the immediate surrounds generally pass the safety criteria for wind. One exception to this exists along River Street (location 71) which is understood to be present within the existing site and is not an impact of either Plot 9 or Plot 11.

4.3.1 Comfort

Conditions within the immediate surrounds are generally suitable for existing and proposed pedestrian activities. Exceptions to this occur only at the norther corner of Plot 9, which are known to be an impact of Plot 9. It is understood that this area has been successfully mitigated and as such, all areas within the surrounds are comfortable for proposed pedestrian uses with both Plot 9 and a completed Plot 11 in place. This conclusion is in line with "Appendix 12.1 – Wind Microclimate" submitted with the Plot 11 application.

4.3.2 Likely Conditions with Plot 10 in place

Whilst not quantitatively assessed, current studies show that with Plot 11 and Plot 9 in place, conditions within and around the site of Plot 10 are not adversely impacted and are expected to be safe and comfortable for pedestrians. Furthermore, the impacts on wind microclimate of the developments are reasonably local and are mitigated using mitigation on site.

Being downwind with respect to prevailing wind directions in Manchester, it is further expected that Plot 10 will not have an adverse impact on wind conditions within and around the Plot 9 and Plot 10 sites. It is likely that some local effects of Plot 10 will require mitigation on site, but these are likely to be determined through wind microclimate assessments conducted during the design development of that site, and would not be considered an adverse cumulative impact of Plot 9 and Plot 11.

5 Conclusions

The following conclusions have been drawn:

- With the introduction of the proposed development with consented landscaping scheme, wind conditions within and immediately surrounding the site meet the safety criteria, this includes conditions in and around the undeveloped Plot 9 and Plot 10 sites.
- With respect to comfort, wind conditions throughout the site and surrounds would generally be considered suitable for proposed pedestrian usage. Some localised areas particularly the proposed outdoor seating areas around Blocks A & D would be considered too windy for prolonged sitting usage but would be suitable for general recreation activities for at least during summer. This fact should not preclude the offer to the residents of the space for any amenity use, should they desire, for the large proportion of time (more than 85%) that conditions are suitable for long periods of sitting.
- During key stages of construction, for example with Blocks A, B and D complete or with just Block D complete, conditions would also be considered suitable for pedestrian passing by the site in terms of both comfort and safety. Some exceedances are likely to occur on site, but these are expected to be tolerable for construction workers assuming that safety precautions for working in high winds would be adhered to.
- Within cumulative surrounds, including within the context of likely Plot 9 and Plot 10 massing, wind conditions within the site and immediate surrounds are suitable for pedestrians in terms of both safety and comfort.

6 Recommendation

With regards to Conditions 3 of the planning approval, providing wind mitigation including any proposed landscaping and architectural elements such as screens for each Block is in place before the public are allowed access, conditions within any construction or cumulative scenario are suitable in terms of comfort and safety with respect to wind. It is therefore recommended that Condition 3 can be discharged. This is on the basis that the landscaping scheme contained within this report provides suitable mitigation for wind.

7 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.

8 Figures

Figure 2.1 – Consented landscaping scheme



Figure 4.1 – Pedestrian wind conditions, proposed development with landscaping and mitigation as tested within existing surrounds, worst case season

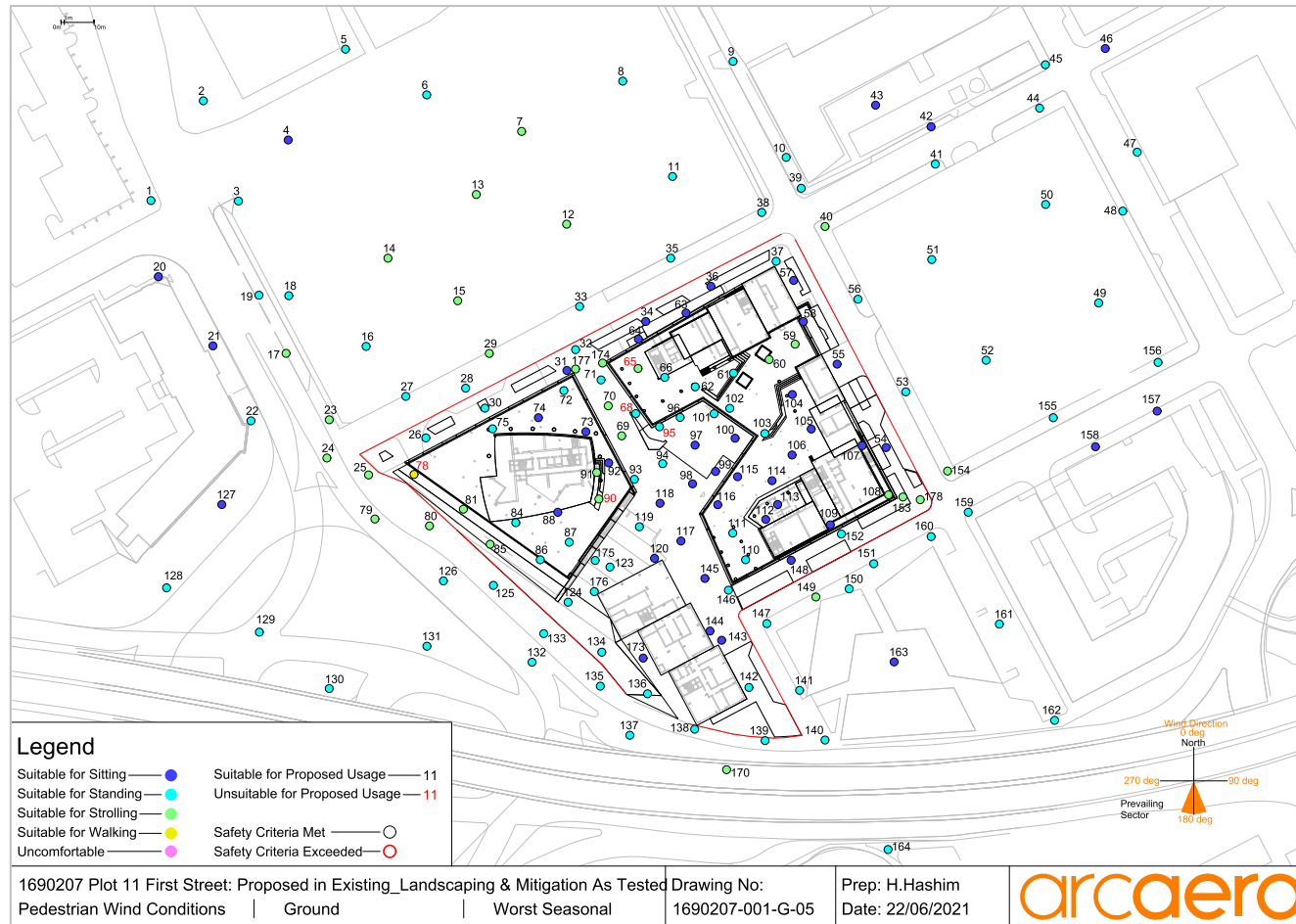


Figure 4.2 – Pedestrian wind conditions, proposed development with landscaping and mitigation as tested within existing surrounds, summer season

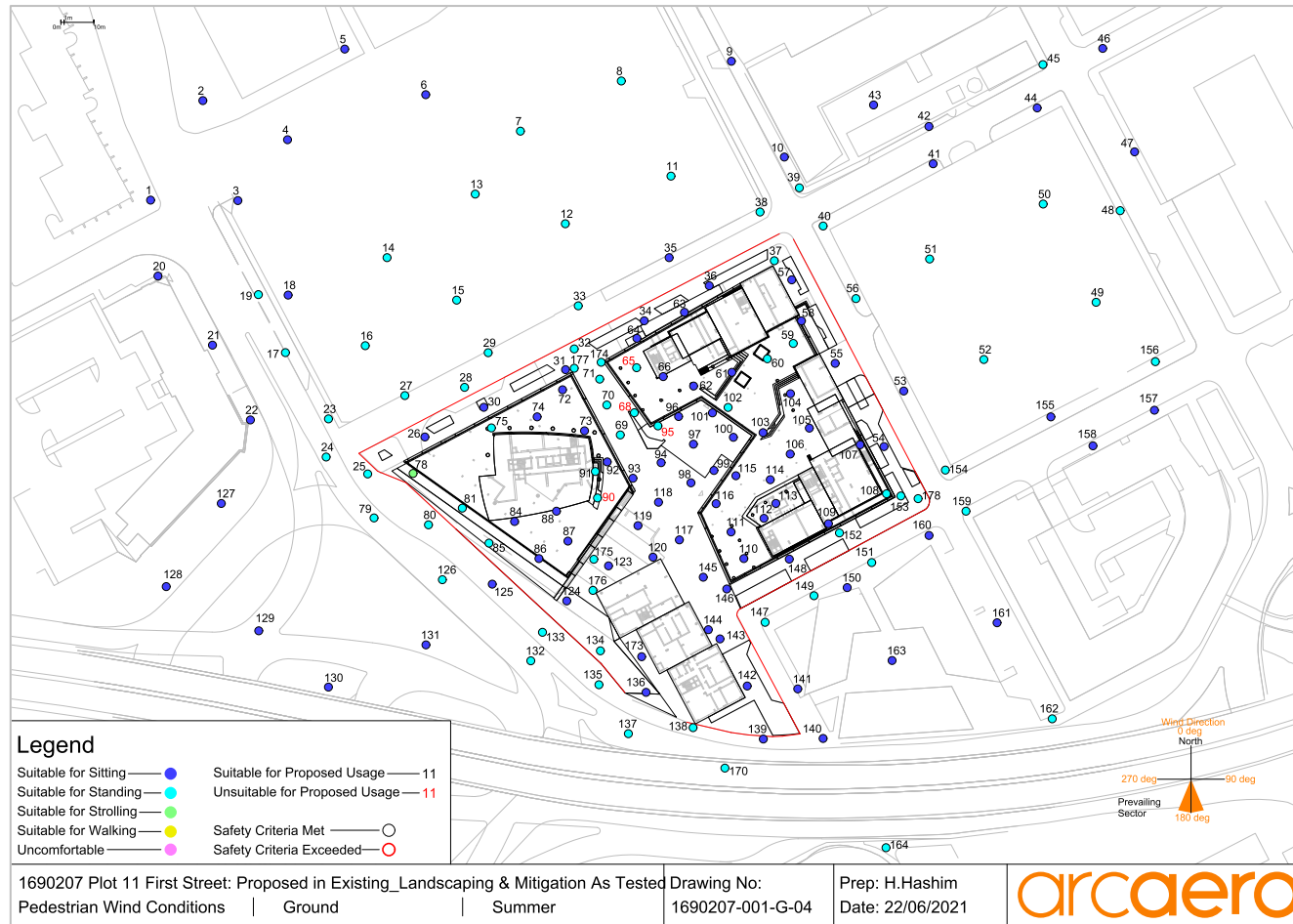


Figure 4.3 – Pedestrian wind conditions, Block D within existing surrounds, worst case season

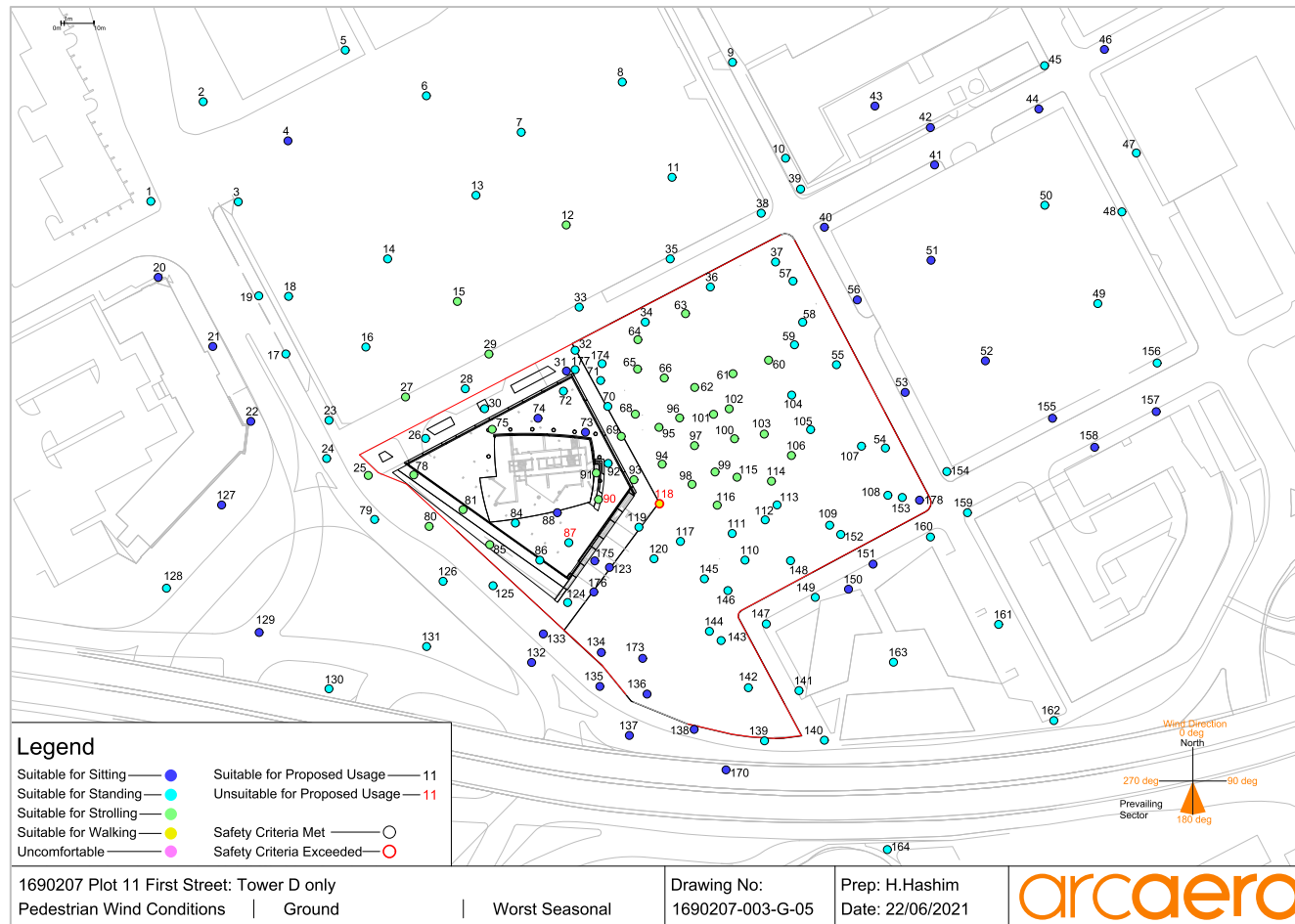


Figure 4.4 – Pedestrian wind conditions, Block D within existing surrounds, summer season

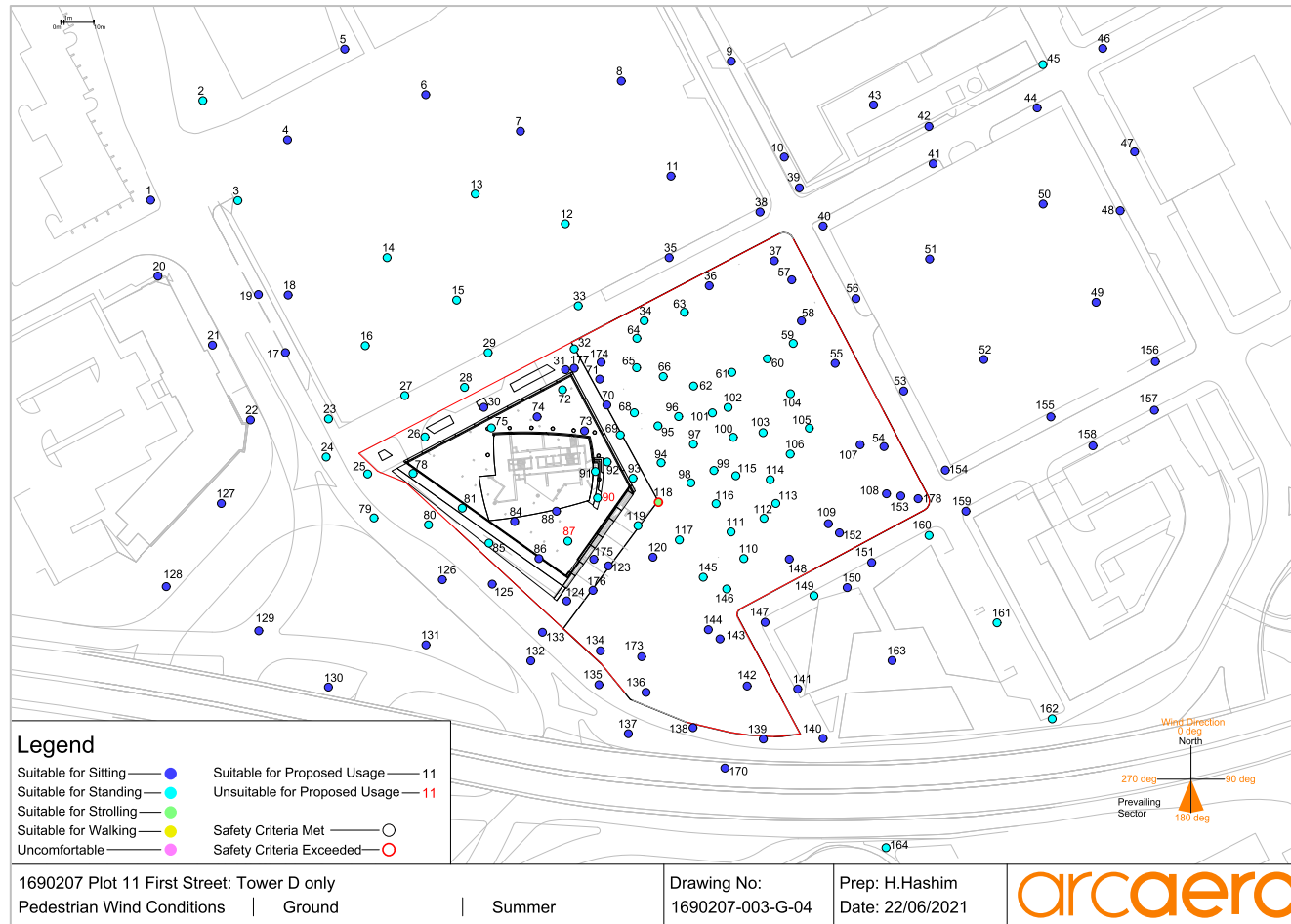


Figure 4.5 – Pedestrian wind conditions, Completed Development in the context of Cumulative Surrounds including Plot 9, worst case season

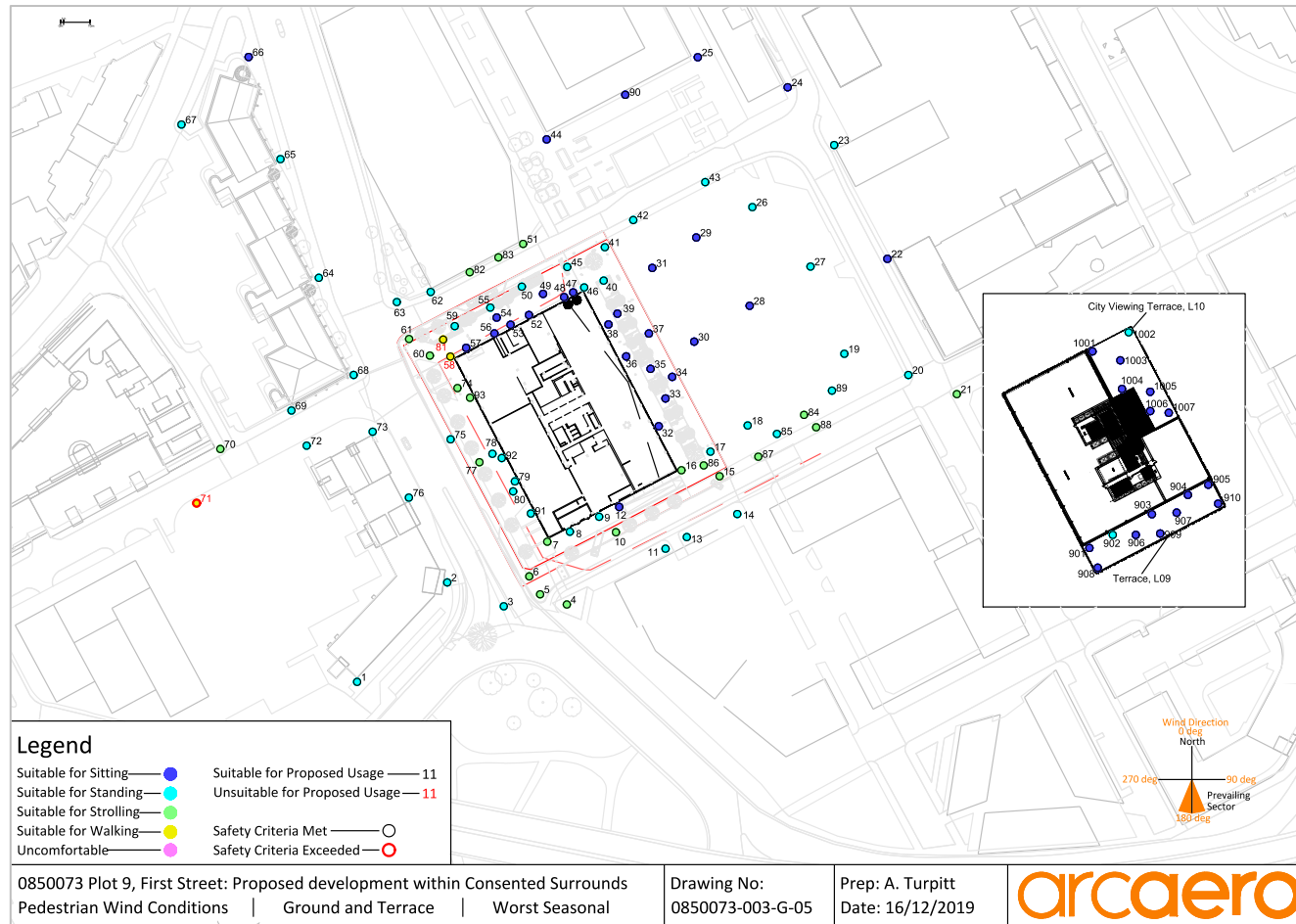
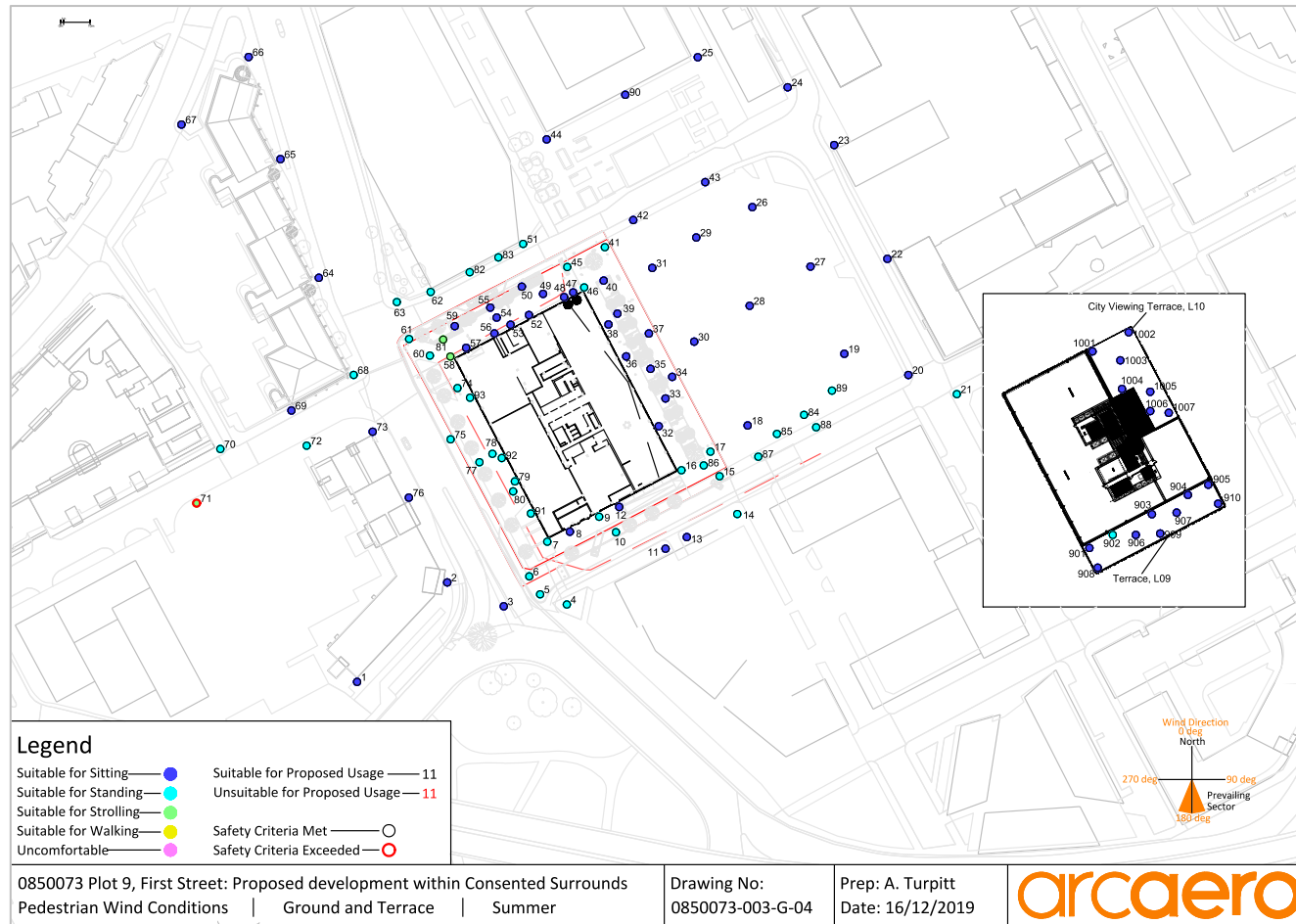


Figure 4.6 – Pedestrian wind conditions, Completed Development in the context of Cumulative Surrounds including Plot 9, summer season



Appendix A Wind Climate Analysis

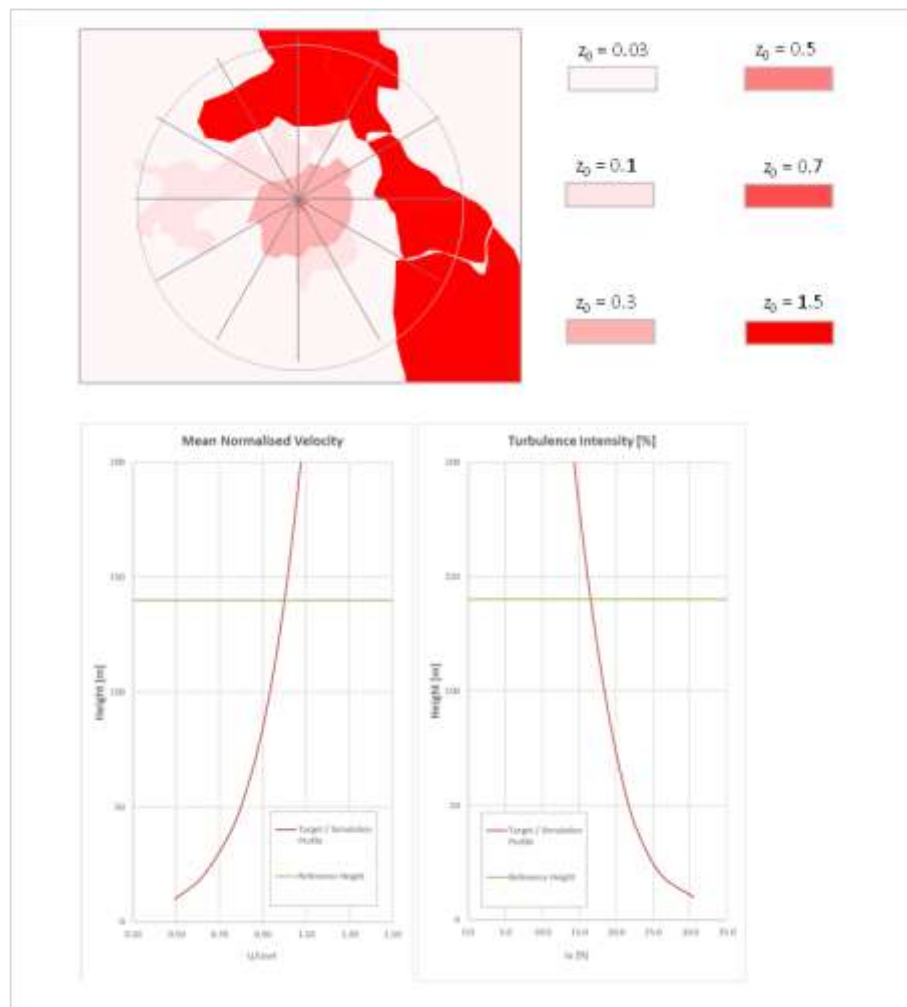
A.1 Surrounding Terrain Assessment

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

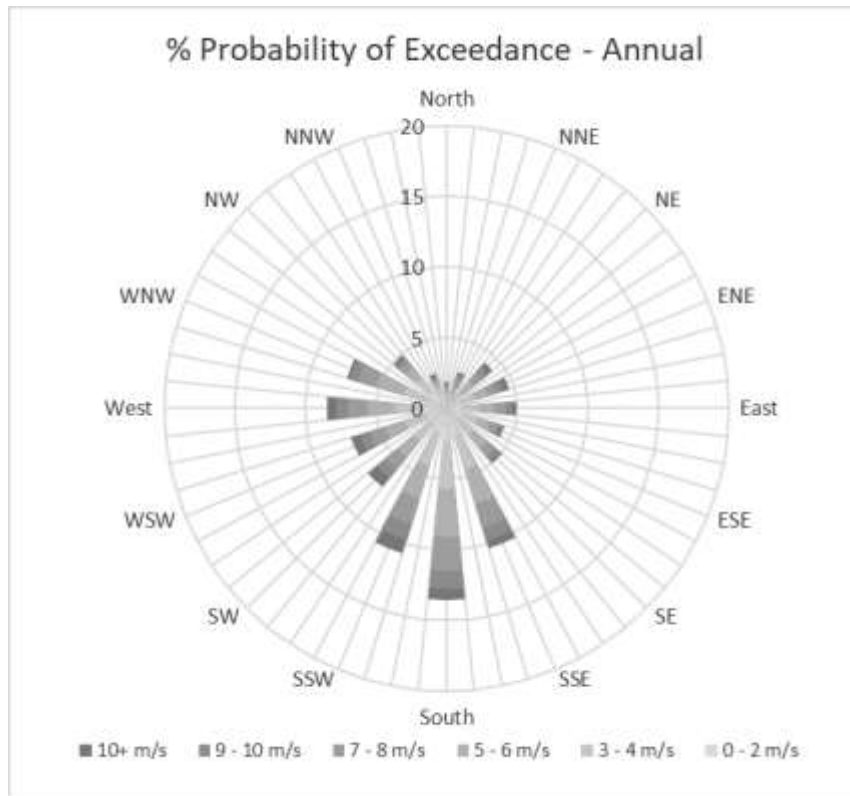


Figure A.3 – Cumulative wind speed probability distribution at site, spring

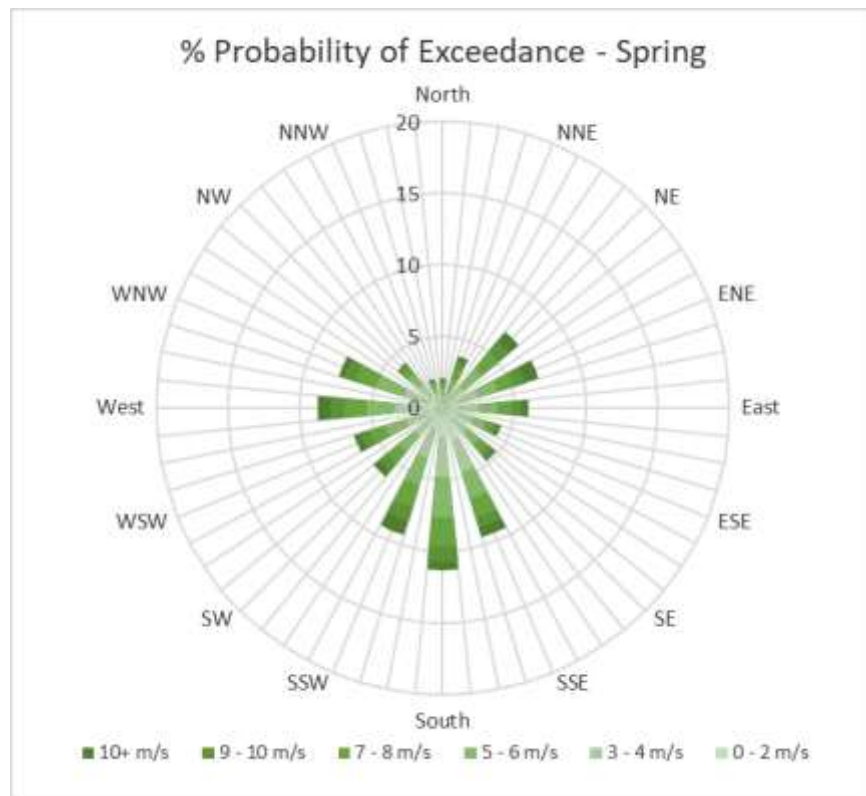


Figure A.4 – Cumulative wind speed probability distribution at site, summer

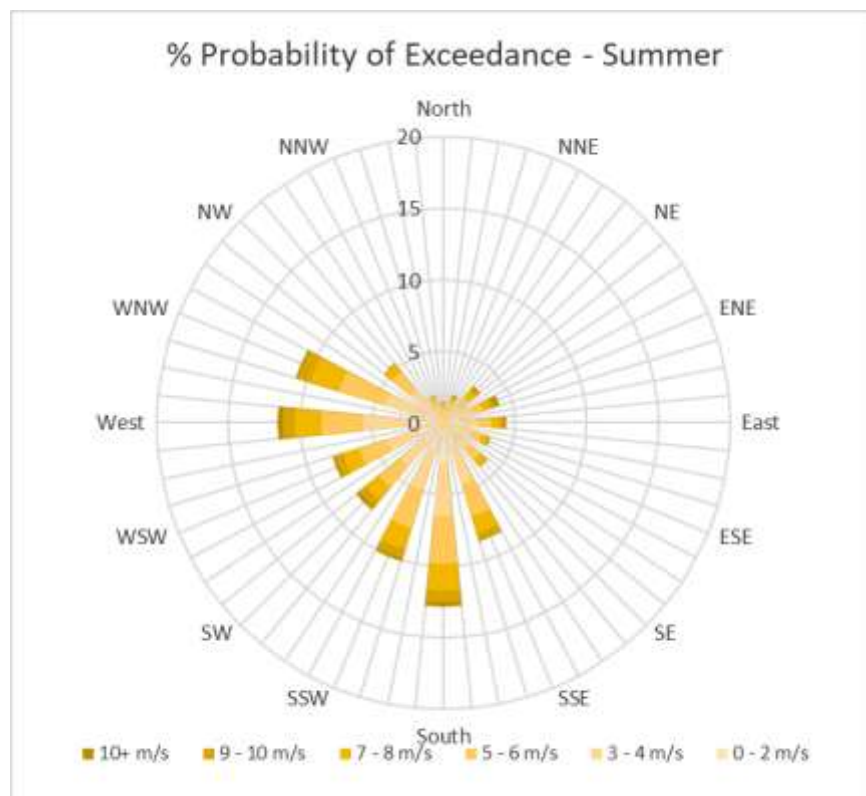


Figure A.5 – Cumulative wind speed probability distribution at site, autumn

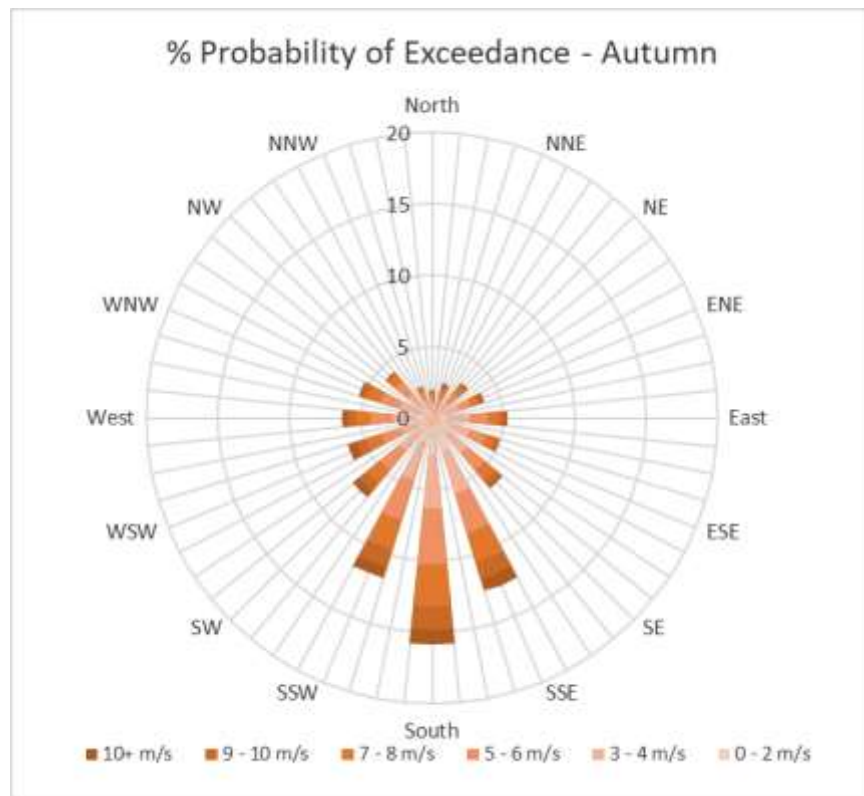
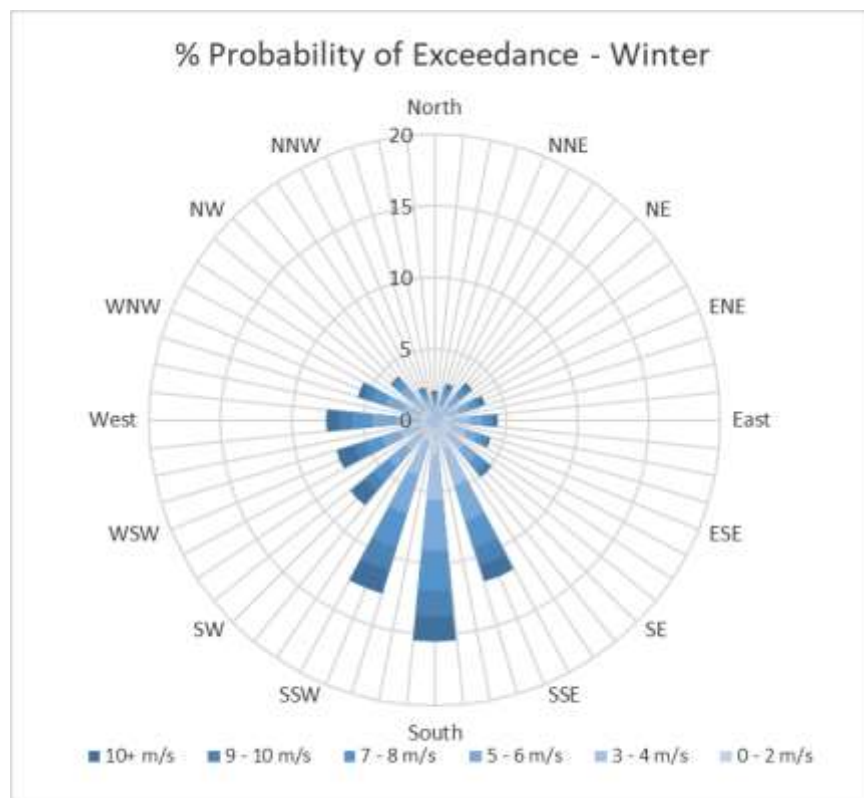


Figure A.6 – Cumulative wind speed probability distribution at site, winter



Appendix B CFD Modelling

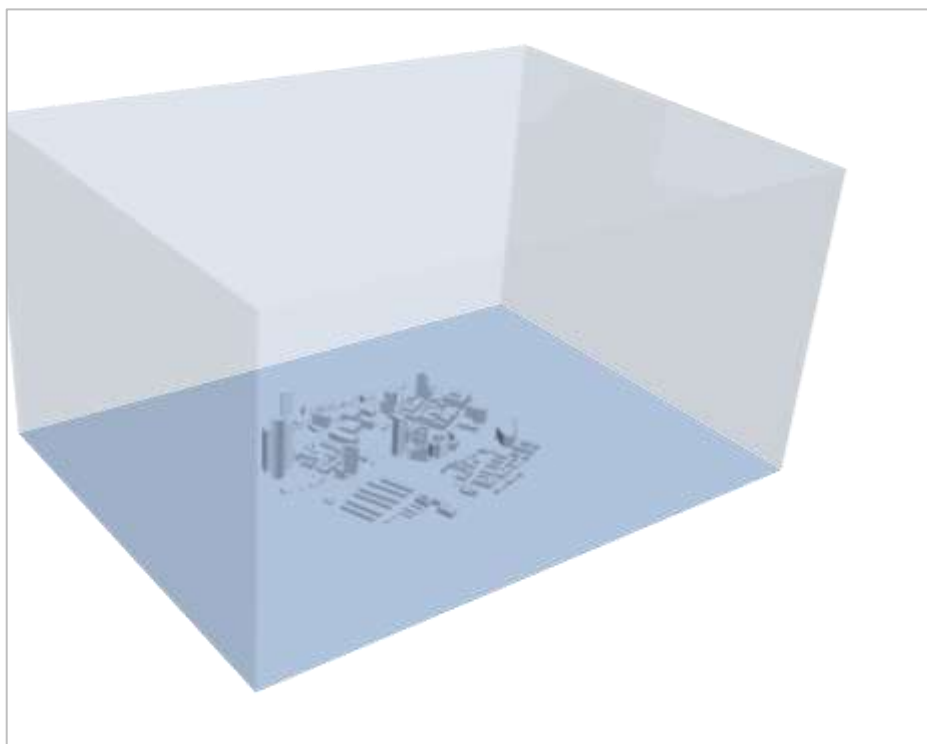
B.1 Spatial discretization

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 360 m radius represented explicitly. The full computational domain extends to 1400m in the along-wind direction, 1900m in the across-wind direction, and 1000m 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 $k-\epsilon$ 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 360 m 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: Proposed development within existing surrounds
- Figure C.2: Block D within existing surrounds
- Figures C.3 to C.5: Close-ups of the proposed development

Figure C.1– Proposed development within existing surrounds viewed from south



Figure C.2 – Block D within existing surrounds viewed from south



Figure C.3 – Proposed development with consented landscaping, close-up from south



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



Figure C.5 – Block D with revised landscaping, close-up from south

