



Lee Green

For

Galliard Homes Limited

Wind Microclimate Report

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Architectural Aerodynamics Ltd.

Kemp House

160 City Road

London

United Kingdom

EC1V 2NX

Submitted by:

Robin Stanfield

robin@architecturalaero.com

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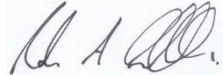
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Executive Summary

Background

A study has been carried out by Architectural Aerodynamics Ltd. (ArcAero) to assess the wind microclimate for the proposed Lee Green development in London, 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:

- Following the introduction of the proposed development, wind conditions are predicted to meet the criteria for pedestrian safety and to be suitable, in terms of comfort, for existing and proposed uses.

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 Galliard Homes Limited, to assess the wind microclimate for the proposed Lee Green development in London, UK.

2 The Project

2.1 Site Location and Surrounding Area

The Lee Green development is bounded by Eltham Road to the north, Leyland Road to the east, Carston Close to the south and Burnt Ash Road to the west. The immediate surrounding area, perhaps with the exception of four medium-rise flat blocks to the east and south, is predominantly comprised of low-rise residential housing and commercial (typical high street) buildings. Further afield the area comprises residential housing and open spaces.

2.2 The Proposed Development

The proposed development will comprise the demolition of the existing Leegate Shopping Centre buildings and redevelopment of the site to provide a residential led mixed use development consisting of up to 630 residential units, together with retail units, office, assembly and leisure, and community space. The proposed buildings will range in height from 2 storeys to 15 storeys in the north.

2.3 Soft Landscaping

The wind microclimate has been assessed for the proposed development with soft landscaping proposals. These are presented within Figures 2.1 to 2.3.

2.4 Cumulative Schemes

A number of cumulative schemes have been identified by the wider project team in carrying out the full environmental impact assessment. Several major developments have been identified, but none fall within the study area for the wind assessment. As a result, cumulative effects will not be present, and the current assessment considers the proposed development within an existing surrounding context only.

3 Assessment Methodology

3.1 Overview

CFD modelling has employed a steady-state RANS 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.

Full details on this approach are provided in Appendix A of this report - salient highlights of this approach are:

- the Shear Stress Transport k- ω turbulence model has been employed.
- Architectural features of 0.5 metres or more have been captured within the geometry modelled.
- Cell sizes of as small as 0.2 metres were utilised to capture flow behaviour in critical locations.
- The region of interest closest to the ground (1.5 metres) incorporated 5 layers of cells.

Modelling has derived mean and gust equivalent mean wind speeds, in accordance with best industry practice. In doing so 16 wind directions were assessed, in 22.5° increments.

The industry standard criteria for wind microclimate assessments, the LDDC variant of the Lawson criteria ⁽¹⁾, has been employed for the study.

3.2 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 450 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. Details of the model, including the configurations tested, are presented within Appendix B of this report.

3.3 Wind Climate Analysis

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 London Heathrow Airport.

Full details of the wind climate relevant to the site, the wind properties approaching the site and the modelling of those wind properties in the CFD models are provided in Appendix C of this report. All analysis of wind data and the atmospheric boundary layer has employed the methods of ESDU item 01008 ⁽²⁾, in accordance with best industry practice.

3.4 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.

3.4.1 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.

3.4.2 Comfort

The LDDC 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 – LDDC 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 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.

Wind conditions within the site and surrounding area, prior to the introduction of the proposed development, meet the criteria for pedestrian safety, and are suitable (in terms of comfort) for current uses, which are predominantly thoroughfare and ingress/ egress to and from local shops and residences.

4.2 Proposed Development within Existing Surrounds

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

Following the introduction of the proposed development the safety criteria are met throughout the site and surrounding area.

4.2.2 Comfort

4.2.2.1 Thoroughfares

Following the introduction of the proposed development wind conditions on thoroughfares are suitable for strolling or better, and thus suitable for use.

4.2.2.2 Entrances

Entrances are suitable for short-term standing or better in the worst of all seasons – these conditions are suitable for comfortable entrance uses.

4.2.2.3 Recreational Spaces

Wind conditions within the restaurant seating area immediately south of Block A are predicted to be suitable for long-term sitting during summer. The recreational space immediately further south is also suitable, with a mixture of short-term and long-term sitting during summer, predominantly the latter. In addition, the wind conditions to the recreational space to the south of Block B are also expected to be suitable for long-term sitting in summer and thus for intended uses.

At podium level, conditions on Blocks B and C are suitable for long-term sitting in summer, while conditions on Block A are suitable for a mixture of short-term and long-term sitting.

In short, conditions in recreational areas are all suitable for planned uses.

4.2.2.4 Balconies

Wind conditions are acceptable on balconies throughout the development. All balconies around the development are suitable for short-term standing / sitting, and thus for general recreational

uses. Additionally, 90% of the balconies are suitable for more sedentary use, meeting the criteria for long-term sitting during summer.

4.2.2.5 Surrounding Area

Wind conditions within surrounding area, following to the introduction of the proposed development remain suitable for thoroughfare and ingress/ egress to and from local shops and residences.

4.3 Proposed Development within Future Surrounds

As noted in section 2.4, no major developments fall within the study area for the wind assessment. As a result, cumulative effects will not be present.

5 Conclusions

The following conclusions have been drawn:

- Following the introduction of the proposed development, wind conditions are predicted to meet the criteria for pedestrian safety and to be suitable, in terms of comfort, for existing and proposed uses.

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 2.1 – Soft landscaping proposals, 1 of 3

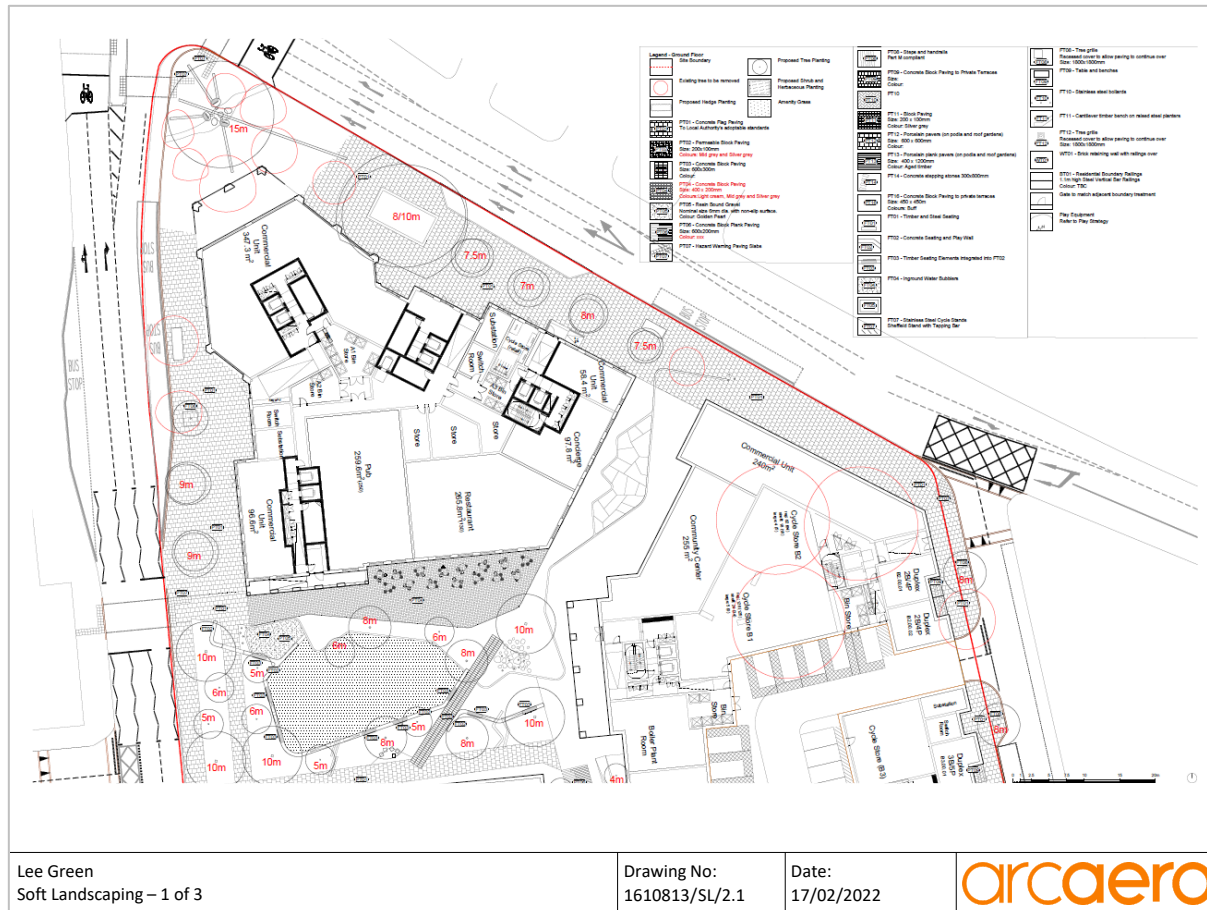


Figure 2.2 – Soft landscaping proposals, 2 of 3

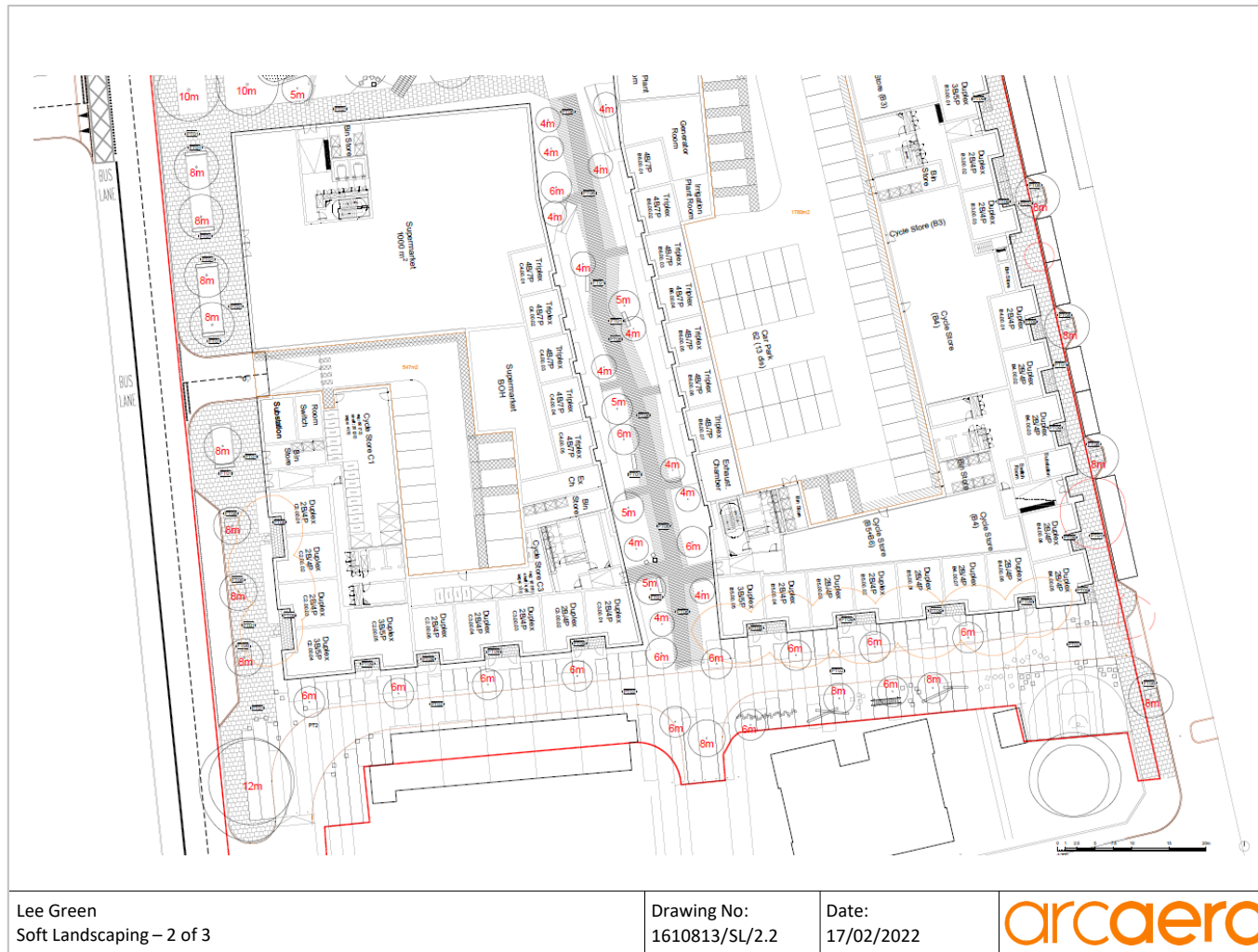


Figure 2.3 – Soft landscaping proposals, 3 of 3



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

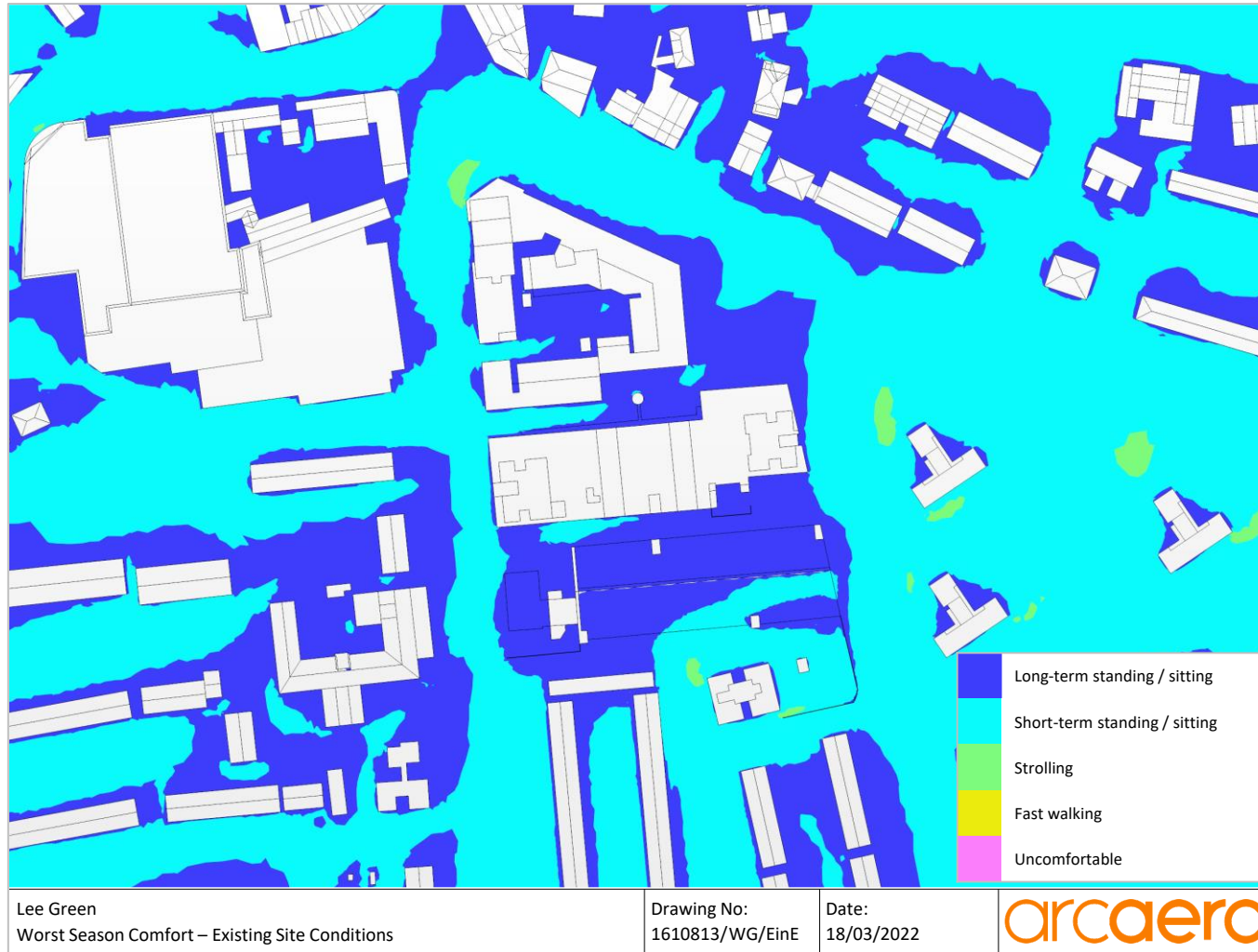


Figure 4.3 – Pedestrian wind conditions, existing site within existing surrounds, summer



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 – podium

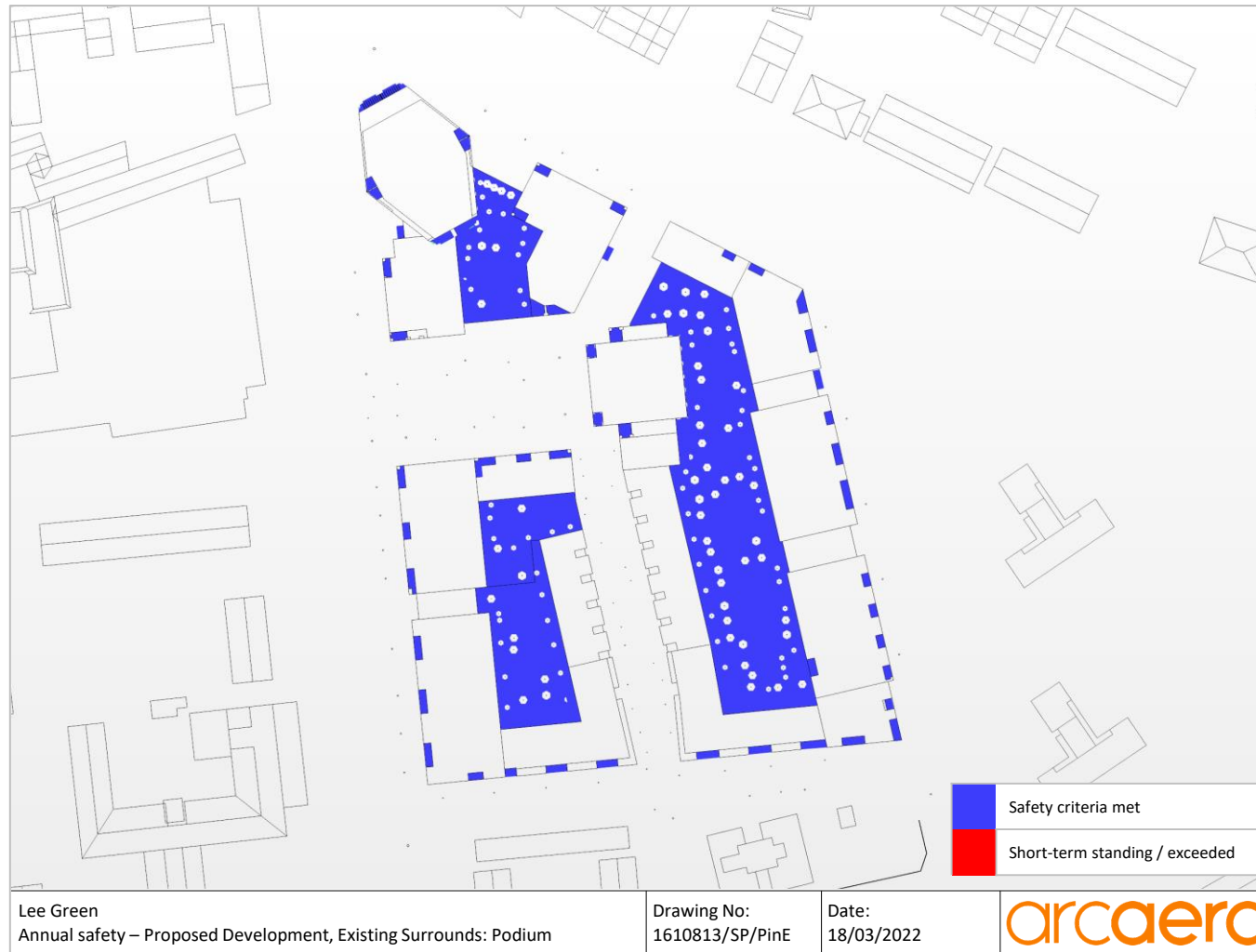


Figure 4.6 – Pedestrian wind conditions, proposed development within existing surrounds, worst case season – ground level



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



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

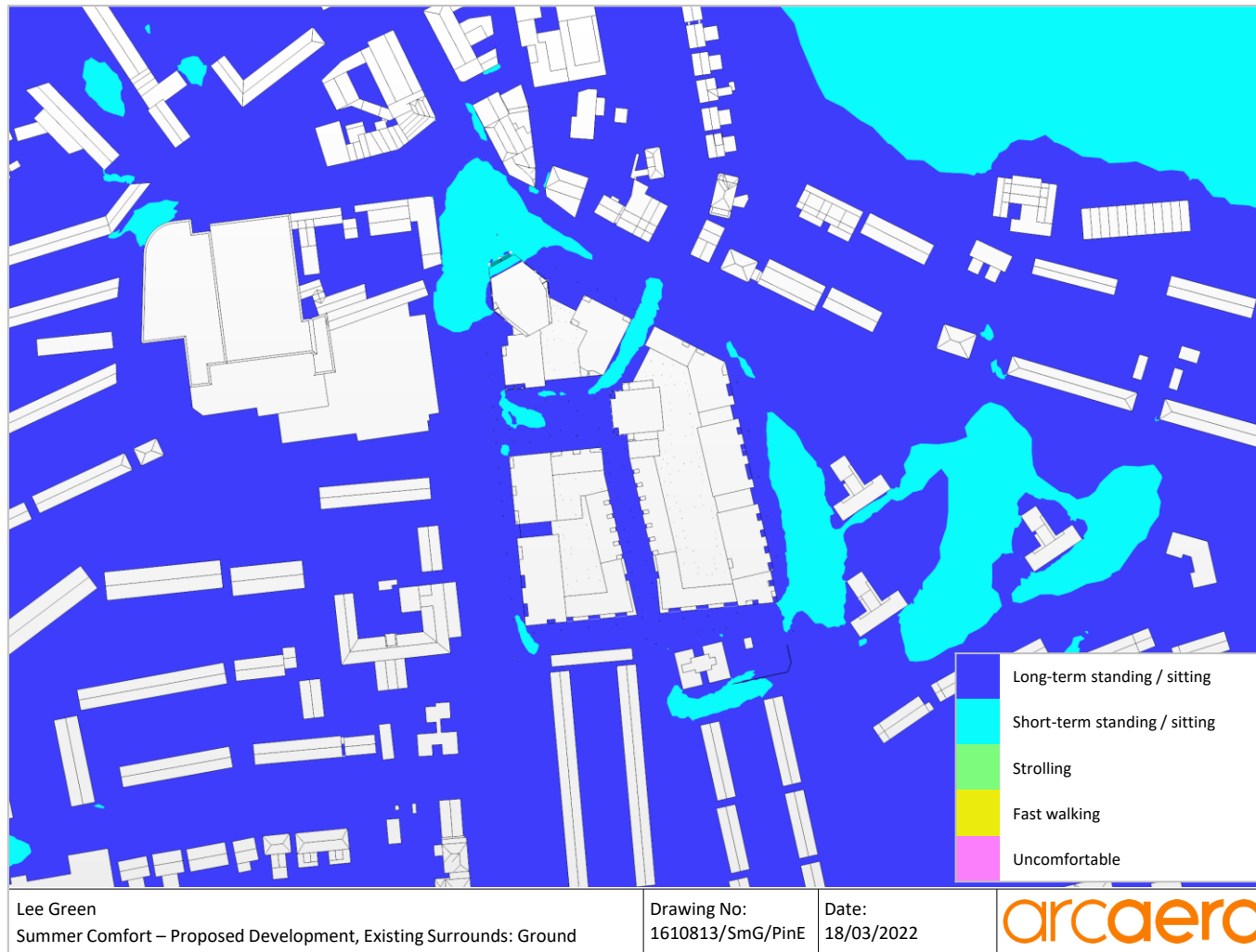


Figure 4.9 – Pedestrian wind conditions, proposed development within existing surrounds, summer – podium



Appendix A CFD Modelling

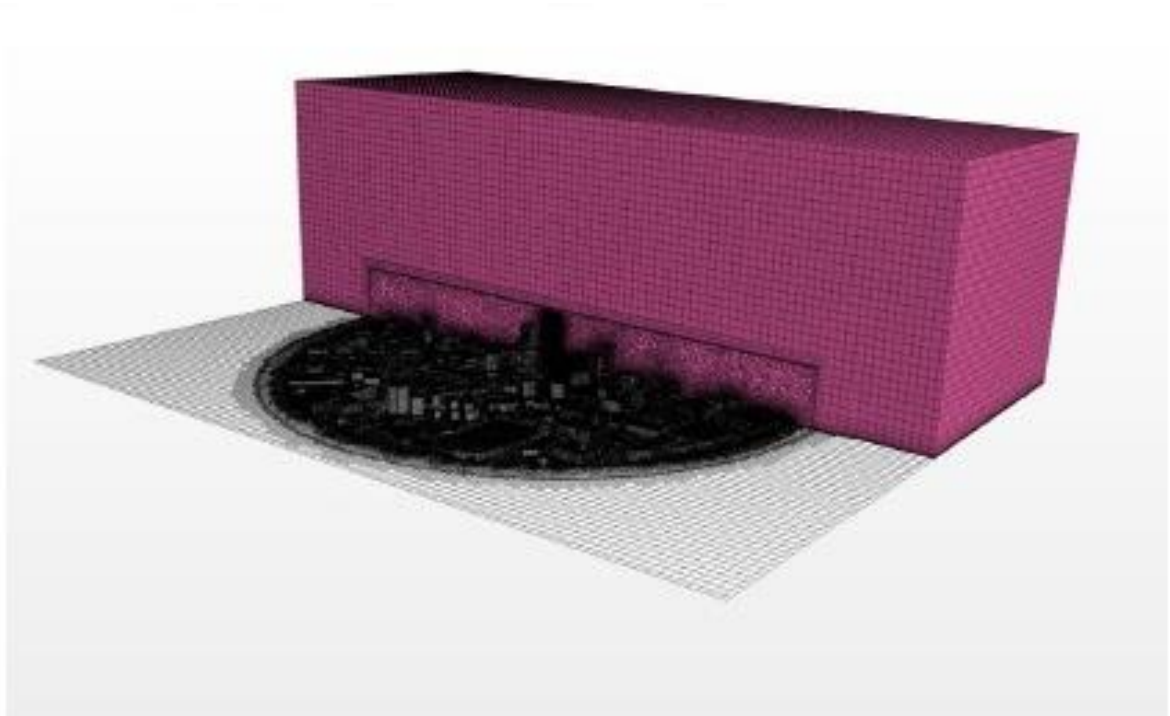
A.1 Spatial discretization

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 1500m 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 A.1 – Computational Domain



A.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-ε behaviour in the free-stream regions of the solutions. Further details for the selected turbulence model are provided in the work of Menter⁽⁴⁾.

A.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.

A.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 B 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.

B.1 Model Images

Images of the computational model are presented as follows:

- Figure B.1 and Figure B.2: Existing site and surrounds
- Figure B.3 and Figure B.4: Proposed development within existing surrounds
- Figure B.5 to Figure B.8: Close-ups of the proposed development

Figure B.1 - Existing site and surrounds, viewed from southeast

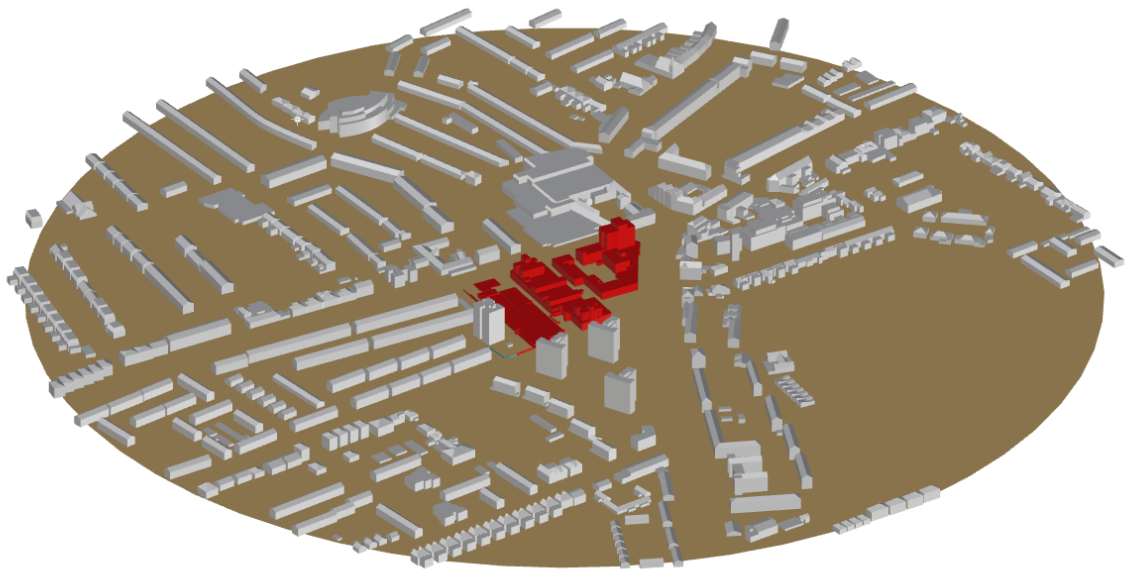


Figure B.2 - Existing site and surrounds, viewed from southwest

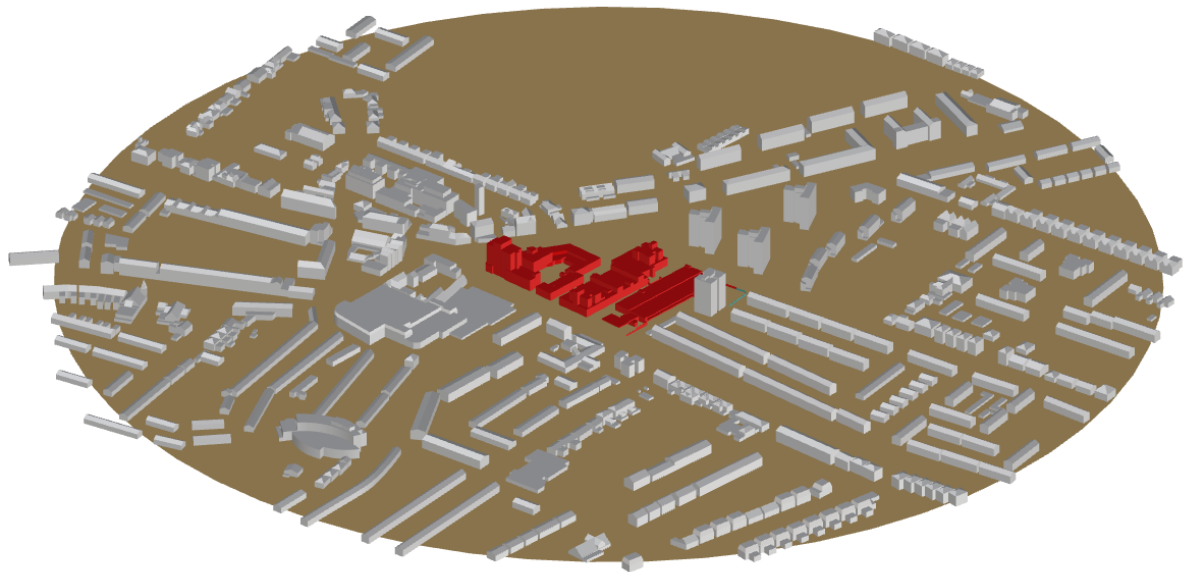


Figure B.3– Proposed development within existing surrounds, viewed from southeast

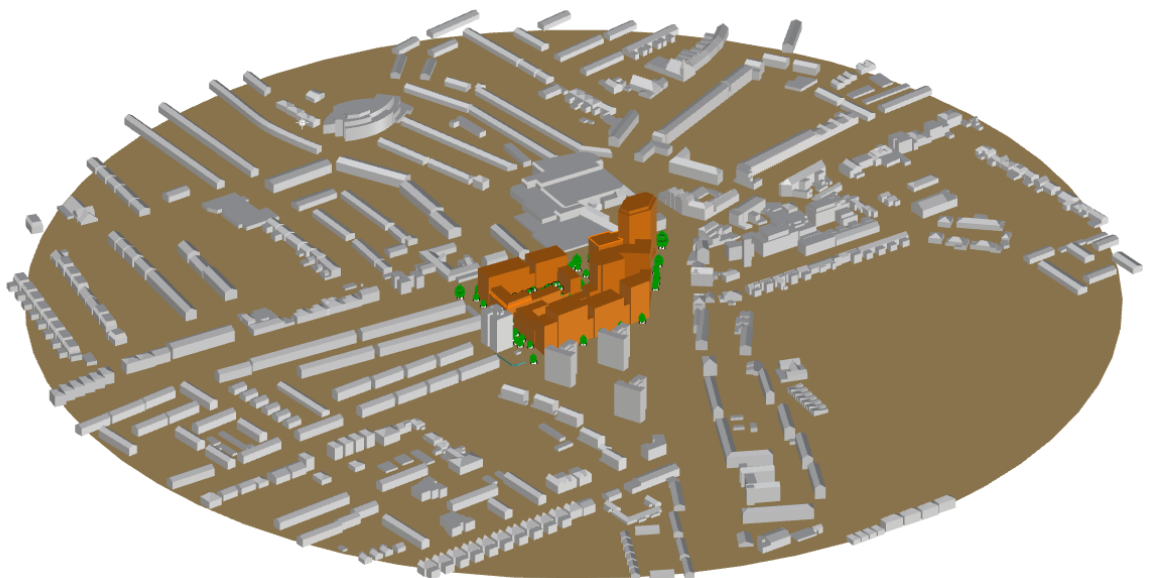


Figure B.4 – Proposed development within existing surrounds, viewed from southwest

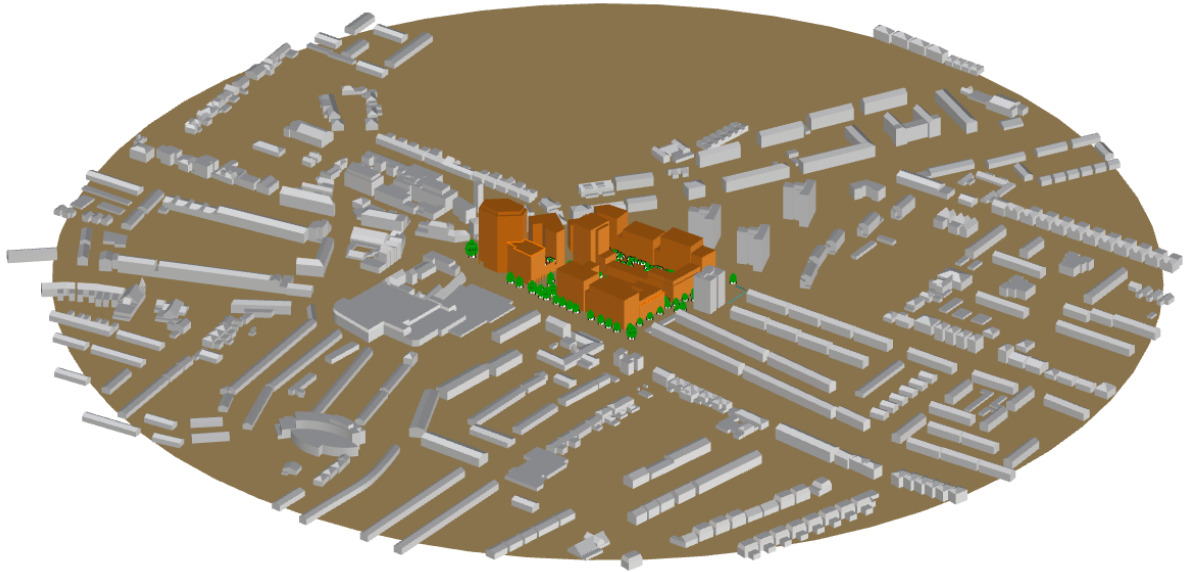


Figure B.5 – Proposed development, close-up from southwest

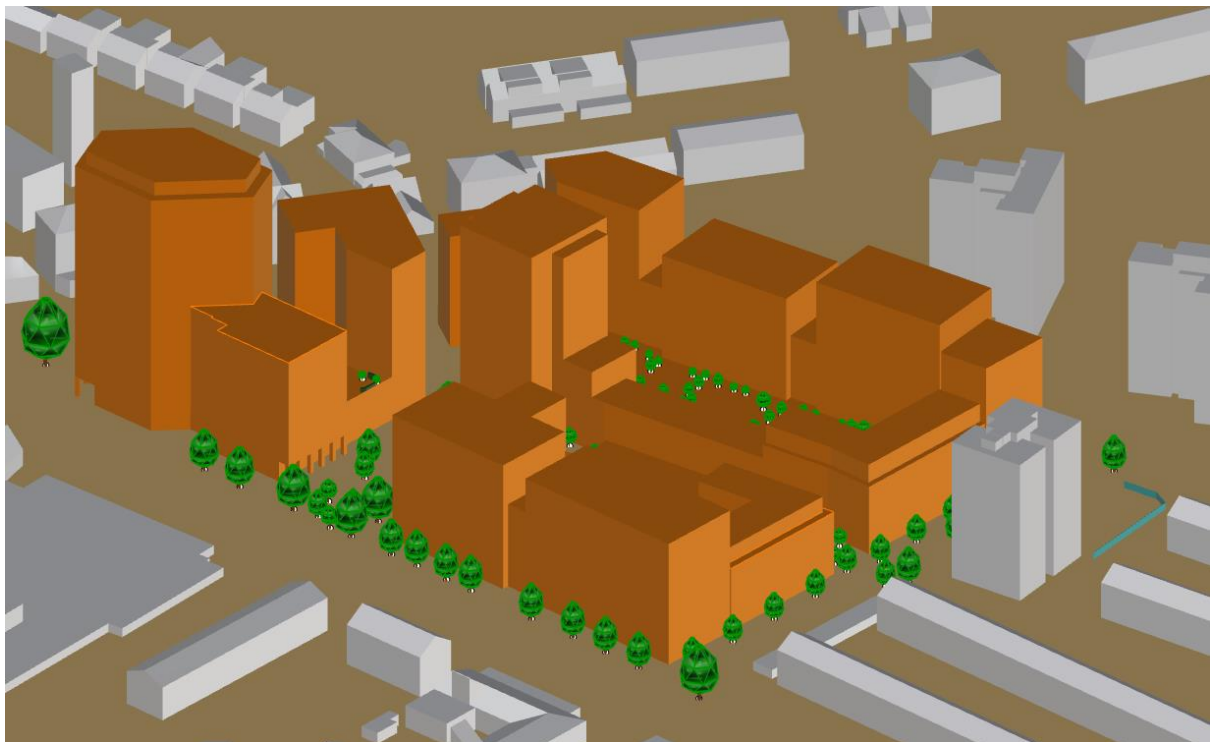


Figure B.6 – Proposed development, close-up from southeast

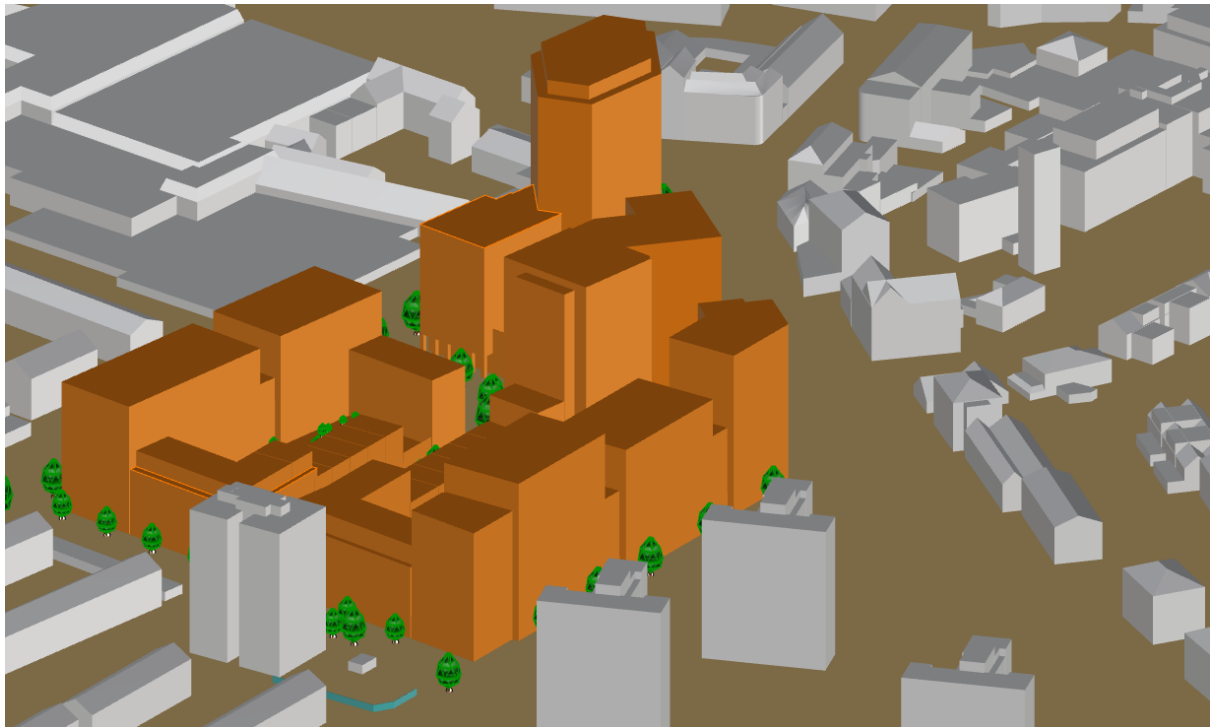


Figure B.7 – Proposed development, close-up from northeast

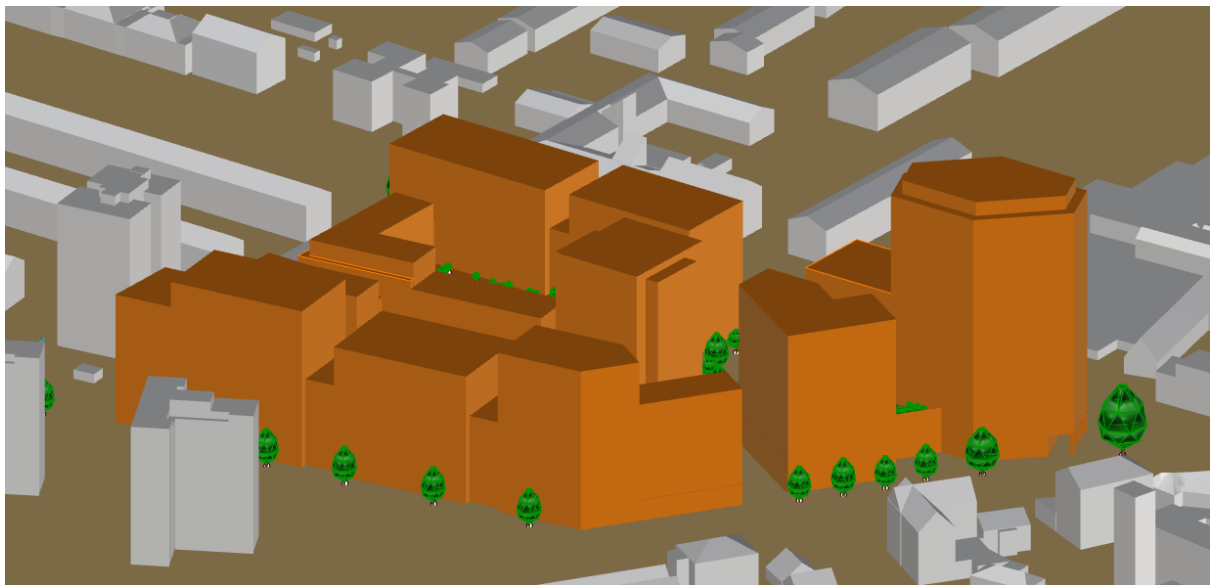
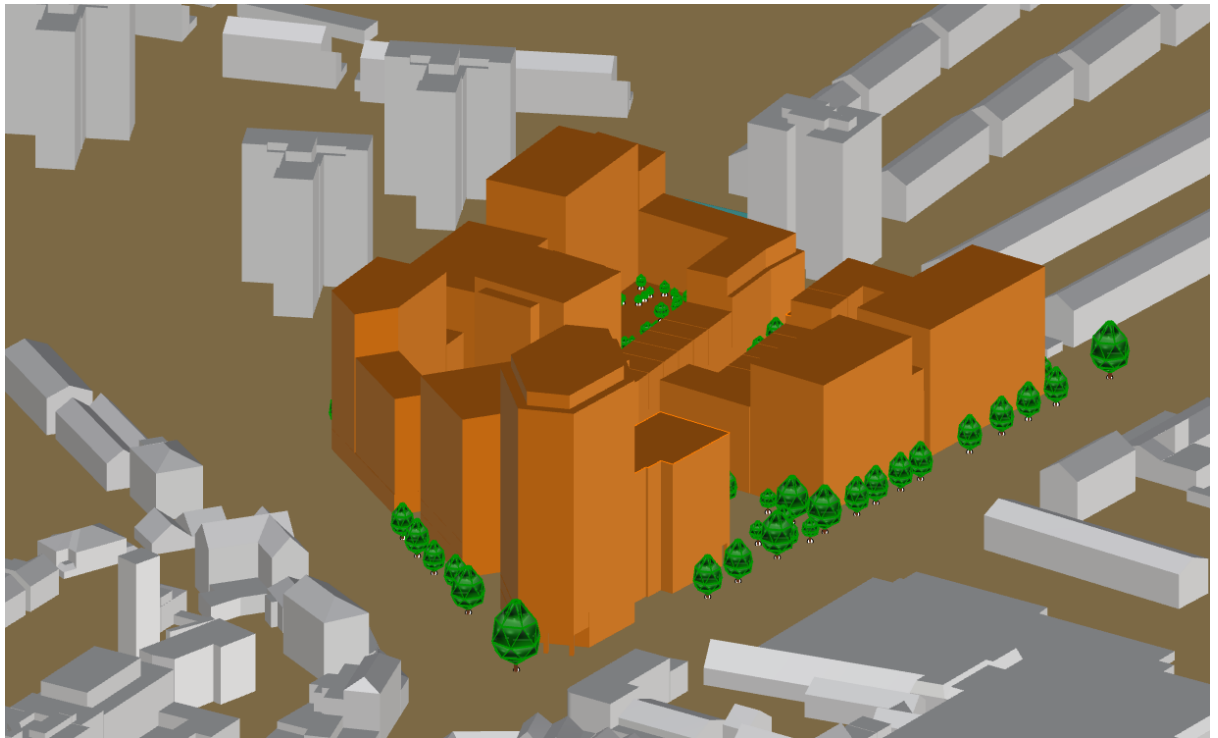


Figure B.8 – Proposed development, close-up from northwest



Appendix C Wind Climate Analysis

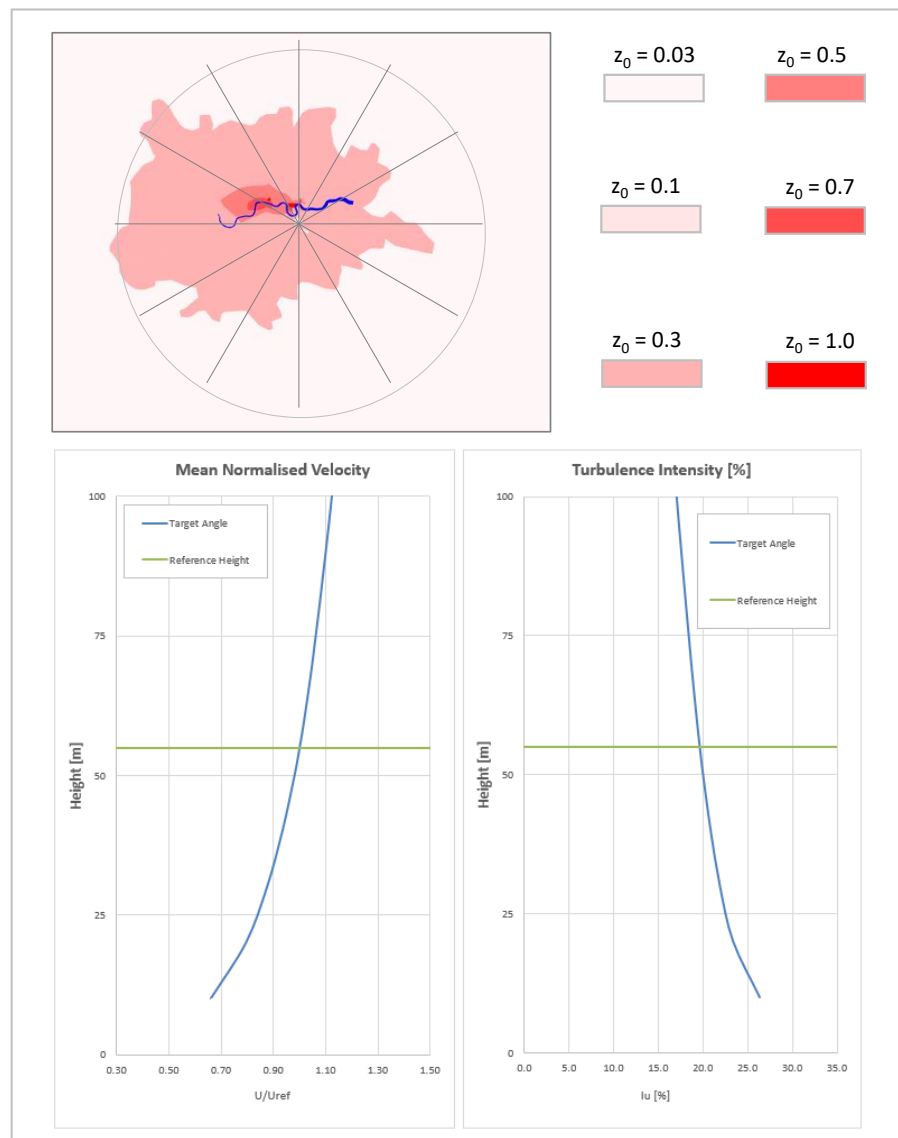
C.1 Surrounding Terrain Assessment

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.

C.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 C.1.

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



C.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 London Heathrow Airport. The cumulative wind speed probability distributions, transposed to building height at site are provided in Figure C.2 to Figure C.6.

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

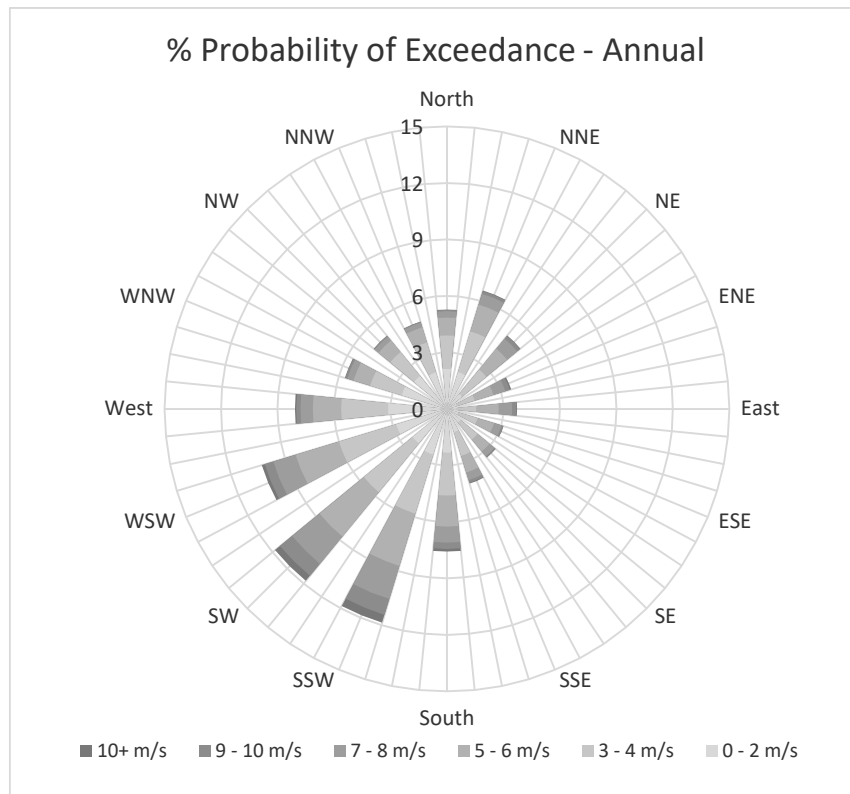


Figure C.3 – Cumulative wind speed probability distribution at site, spring

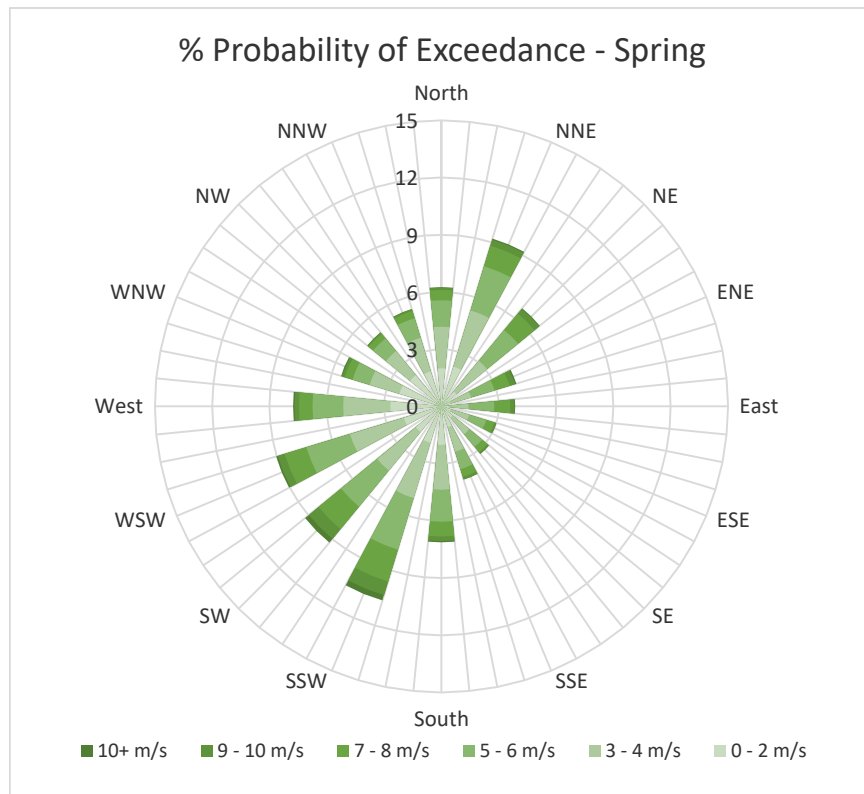


Figure C.4 – Cumulative wind speed probability distribution at site, summer

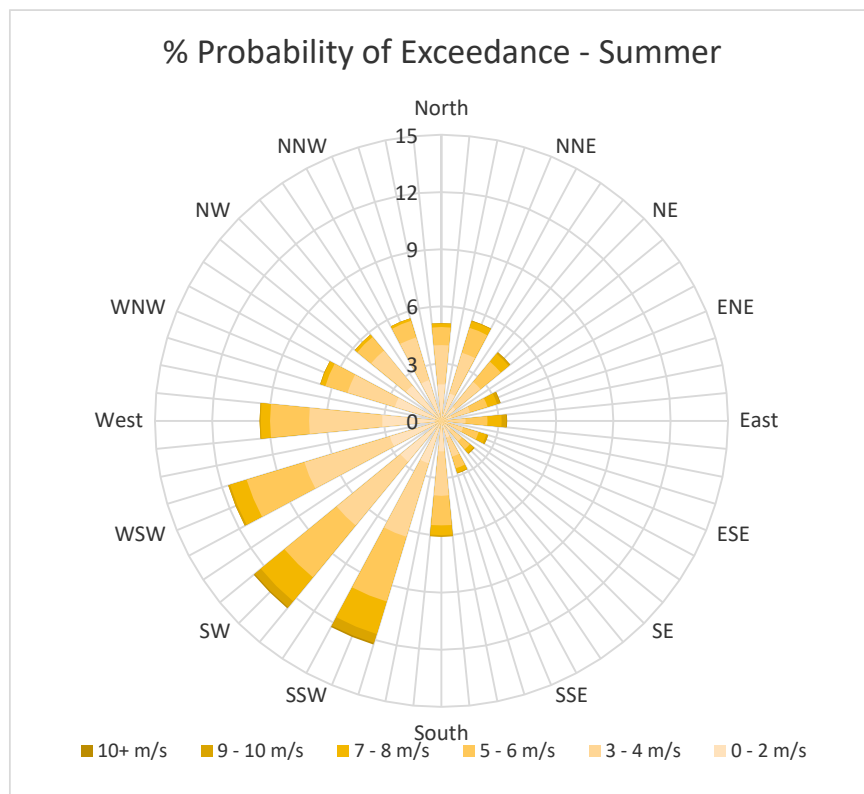


Figure C.5 – Cumulative wind speed probability distribution at site, autumn

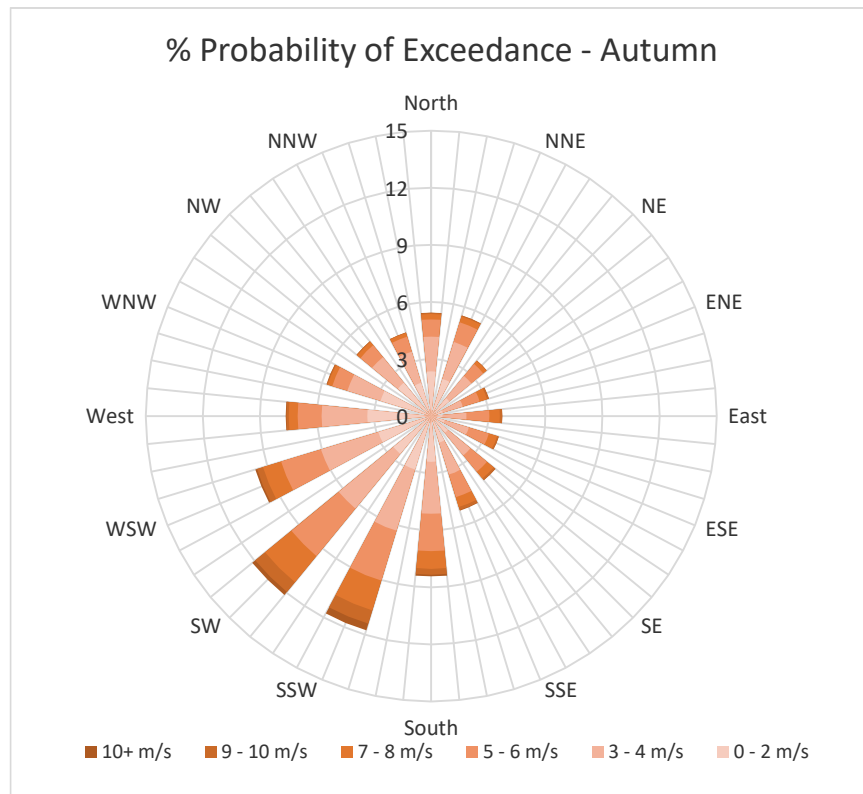


Figure C.6 – Cumulative wind speed probability distribution at site, winter

