WIND MICROCLIMATE REPORT

for

THE PROPOSED DEVELOPMENT

at

THE ARBOURY
BELGARD ROAD
DUBLIN 24

for

LANDMARQUE BELGARD DEVELOPMENT COMPANY LIMITED

La Vallee House
Upper Dargle Road
Bray, Co. Wicklow
A98 W2H9
Ireland

p: 00 353 (0)1 204 0005
e: info@metec.ie
w: www.metec.ie

mechanical ▪ electrical ▪ energy

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EXECUTIVE SUMMARY

METEC Consulting Engineers have been instructed by our client, Landmarque Belgard Development Company Limited, to carry out a pedestrian level wind microclimate assessment for the proposed development at ABB Site, Belgard Road. The pedestrian level wind microclimate assessment conclusions are summarised as:

The proposed development at Belgard Road constitutes a significant increase in the overall massing at the site. It is relatively exposed to the prevailing south-westerly winds and is thus at risk of downdraft/downwash causing wind acceleration at pedestrian level.

Regarding pedestrian comfort:

- Pedestrian comfort was achieved in all locations within and adjacent to the development with the following exceptions:
    - In summer, most of the podium was rated as suitable for sitting or standing, but a small area of the podium was rated as suitable for strolling. A general target rating of standing is recommended for the podium. A rating of sitting should be targeted in the vicinity of areas with seating.
    - In winter, some areas of the podium were rated as suitable for strolling or walking, above the recommended target of suitable for standing.

Regarding to pedestrian distress/safety:

- Pedestrian safety was achieved at ground level within the proposed site and adjacent public spaces with the following exceptions:
    - At the southwest corner of the adjacent development on the opposite side of Belgard Square North Road.
    - A small area at the northeast corner of the development, along Belgard Square North Road, which is a borderline failure.

Mitigation:

Mitigation is recommended in the form of solid and porous screens, and evergreen soft landscaping in the areas shown in Figure 16, which have been incorporated by the Landscape Architect and Architect. With introduction of the recommended mitigation, it is expected all pedestrian spaces outlined above will be safe and comfortable for their intended purpose.

1.0 INTRODUCTION

METEC Consulting Engineers have been instructed by our client, Landmarque Belgard Development Company Limited, to carry out a pedestrian level wind microclimate assessment for the proposed development at ABB Site, Belgard Road.

The methodology used in the study is presented in Section 2 Study Methodology with further details in Appendix C CFD Modelling Methodology. Section 3 Results of the Assessment gives results of Pedestrian Comfort and Pedestrian Distress. A summary of the assessment and findings are presented in Section 4 Summary.

The site of c.0.898 ha is located at the former ABB Site, Belgard Road, Tallaght, Dublin 24, D24 KD78. The site is bound by Belgard Road (R113) to the east, Belgard Square North to the North and Belgard Square East to the west and Clarity House to the south.

The proposed development will consist of:

1. Demolition of all existing structures on site (with a combined gross floor area of c. 3625 sqm)
2. The construction of a mixed-use residential development set out in 3 No. blocks including a podium over a basement, ranging in height from 2 to 13 storeys (with core access above to roof terrace), comprising:
    a. 334 no. residential units of which 118 No. will be Build to Rent (BTR) residential units, with associated amenities and facilities across the development,
    b. 4 No. retail/café/restaurant units and 3 no. commercial spaces associated with the 3 no. live-work units (723 sqm combined),
    c. Childcare facility (144 sq.m.),
    d. 670 No. bicycle parking spaces including 186 visitor spaces; 117 car parking spaces (including 6 disabled spaces) are provided at ground floor and basement level.
    e. The overall development has a Gross Floor Area of 29,784 sq.m.
    f. Two (2) podium residential courtyards and three (3) public accessible pocket parks, two (2) to the North & one (1) to the South.
    g. Linear Park (as a provision of the Tallaght Town Centre LAP) providing safe public pedestrian and cycling access between Belgard Rd and Belgard Square East
3. Of the total 334 residential units proposed, unit types comprise:

Block A (Build-to-Rent)

- 91 no. 1 bed units
- 1 no. 2 bed 3 person units
- 26 no. 2 bed 4 person units
- 88 no. 2-bed 4 person units including 5 no. duplex units
- 1 no. 2-bed 4 person live-work unit
- 11 no. 3-bed units

Blocks B & C

- 2 no. live-work studio units
- 102 no. 1-bed units
- 12 no. 2-bed 3 person units

4. All associated works, plant, services, utilities, PV panels and site hoarding during construction.

2.0 STUDY METHODOLOGY

2.1 LAWSON PEDESTRIAN COMFORT AND DISTRESS CRITERIA

This study uses the Lawson Pedestrian Comfort and Pedestrian Distress [1] criteria to assess the wind microclimate at pedestrian level for the proposed development at Belgard Road.

The pedestrian comfort criteria given in Table 1 quantify a person's comfort or discomfort due to the wind based on their activity. The criteria give an hourly average wind speed threshold that must not be exceeded for more than 5% of the assessment period. In this study, assessments covering the summer, winter, autumn, and spring periods, plus a whole year were undertaken. The report provides results of the summer assessment and the winter (worst-case seasonal) assessment.

Comfort Rating	Threshold Speed	Exceedance Time
Uncomfortable	10 m/s	> 5 %
Business walking	10 m/s	<= 5%
Strolling	8 m/s	<= 5%
Standing	6 m/s	<= 5%
Long-term sitting	4 m/s	<= 5%

Table 1: Lawson Pedestrian Comfort Criteria

Table 2 gives the recommended target pedestrian comfort designation for a variety of public area usage patterns.

Usage	Description	Target
Outdoor seating	For long periods of sitting such as for an outdoor café / bar	'Long-term sitting' in summer
Entrances, waiting areas, shop fronts	For pedestrian ingress / egress at a building entrance / window shopping, or short periods of sitting or standing such as at a bus stop, taxi rank, meeting point, etc.	'Standing' in all seasons
Recreational spaces	For outdoor leisure uses such as a park, children's play area, etc.	'Strolling' from spring through autumn
Leisure Thoroughfare	For access to and passage through the development and surrounding area	'Strolling' in all seasons
Pedestrian Transit (A-B)	For access to and passage through the development and surrounding area	'Business walking' in all seasons

Table 2: Recommended Target Comfort Rating for Different Public Space Usage

The pedestrian distress criterion given in Table 3 quantifies a person's distress and/or safety due to the wind. Application of the pedestrian distress/safety analysis seeks to identify areas where a pedestrian may find walking difficult or could even stumble or fall. The criterion gives a wind speed threshold that must not be exceeded and is based on an exceedance probability of 0.022% [1].

Distress/Safety Rating	Threshold Speed
Unsuitable	15 m/s

Table 3: Lawson Pedestrian Distress Criteria

2.2 ACCOUNTING FOR THE EFFECT OF GUSTS

Pedestrian comfort and pedestrian distress are not only affected by the mean wind velocity but also by shorter timescale wind gusts due to the turbulent nature of wind. Therefore, in this study wind gust speed is accounted for by calculating the equivalent mean wind speed, considering the standard deviation of the mean wind speed, in particular the turbulent kinetic energy, k:

$$\sigma_U = \sqrt{k * {}^2/_3}$$

Based on the work of Melbourne [4], the peak gust wind speed is derived as:

$$\hat{U} = U_{MEAN} + 3.5\sigma_U$$

And the Gust Equivalent Mean (GEM) is derived as:

$$U_{GEM} = \hat{U}/1.85$$

The pedestrian wind speed is defined as:

$$\max(U_{MEAN}, U_{GEM})$$

2.3 MODEL GEOMETRY

Figures 1 to 6 show the CFD model geometry used in the study for the existing and proposed site conditions. The geometry of the surroundings and terrain were built from Google Earth data using photogrammetry techniques to digitise points that define the geometry over which a surface mesh was generated. Further details of the CFD geometry, mesh and solution method are given in Appendix C: CFD Modelling Methodology.

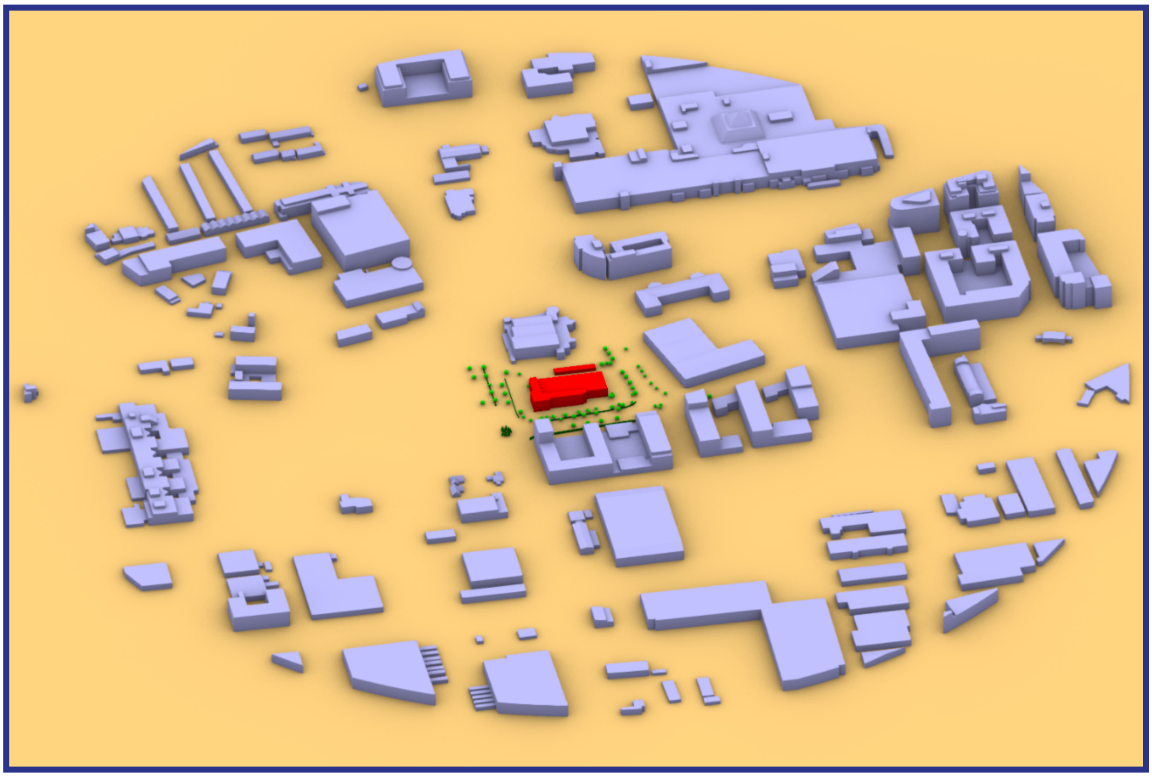

Figure 1: CFD Model Geometry for the Existing Site

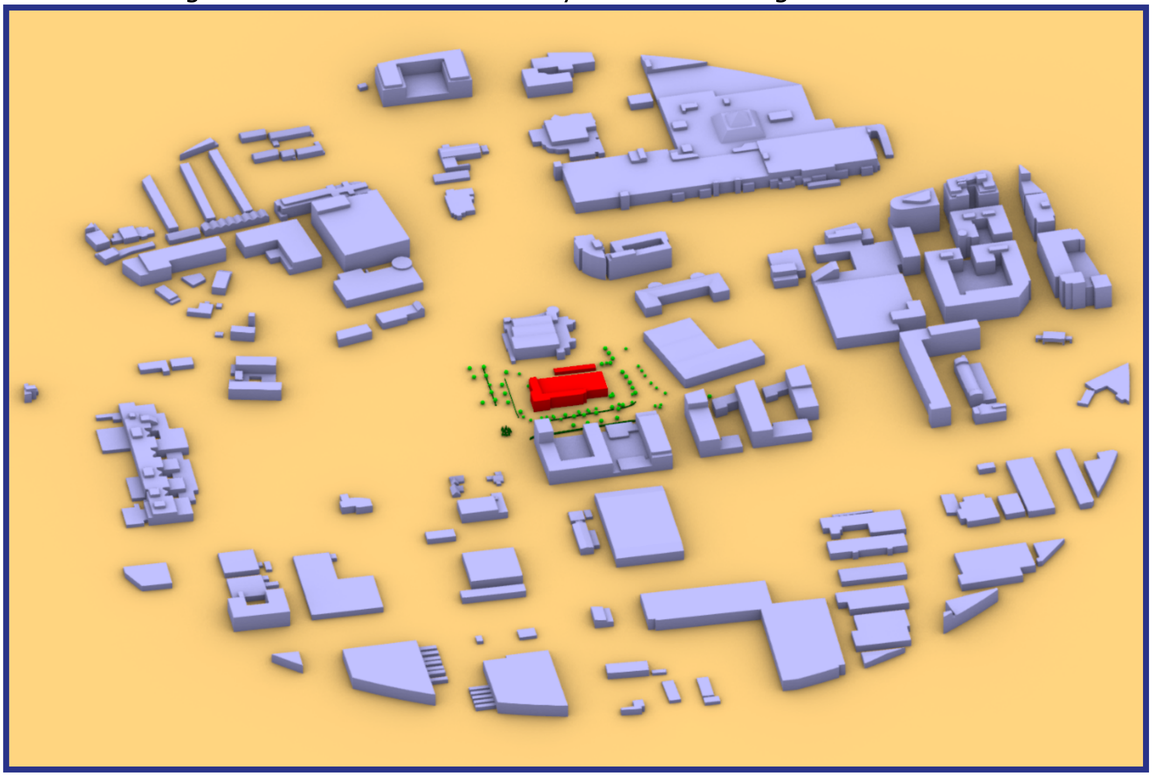

Figure 2: CFD Model Geometry for the Existing Site, Close-up from North

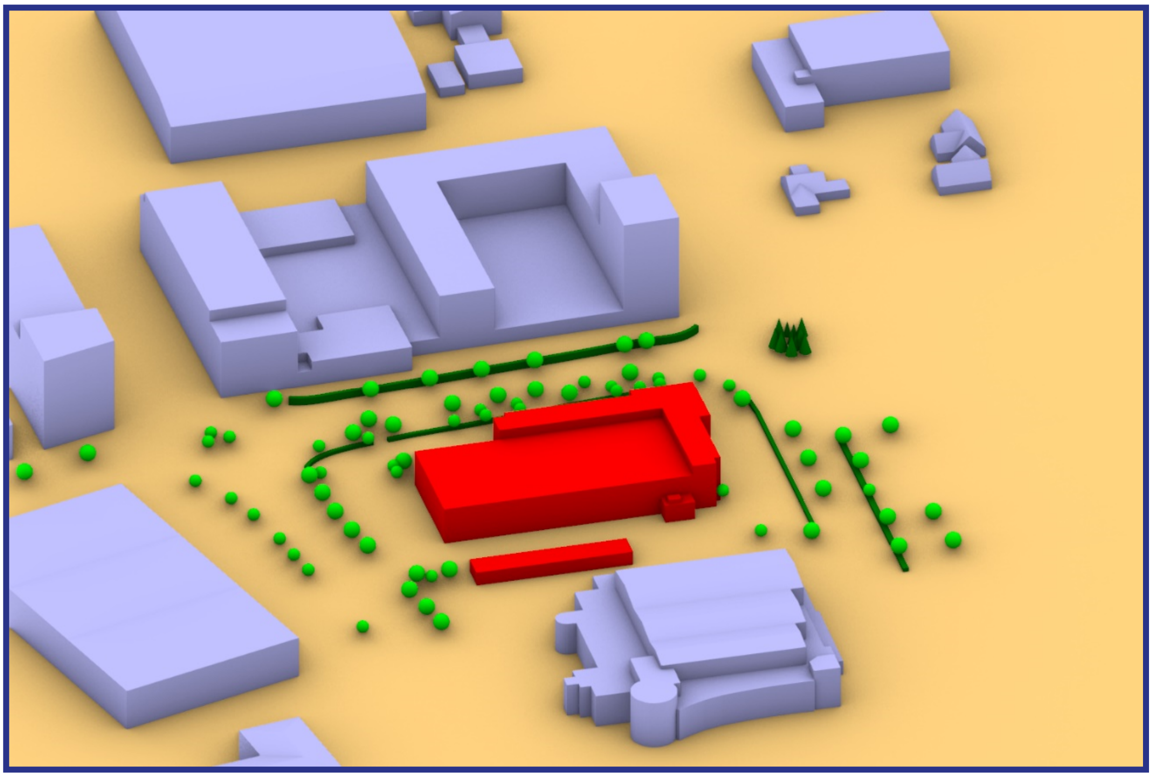

Figure 3: CFD Model Geometry for the Existing Site, Close-up from South

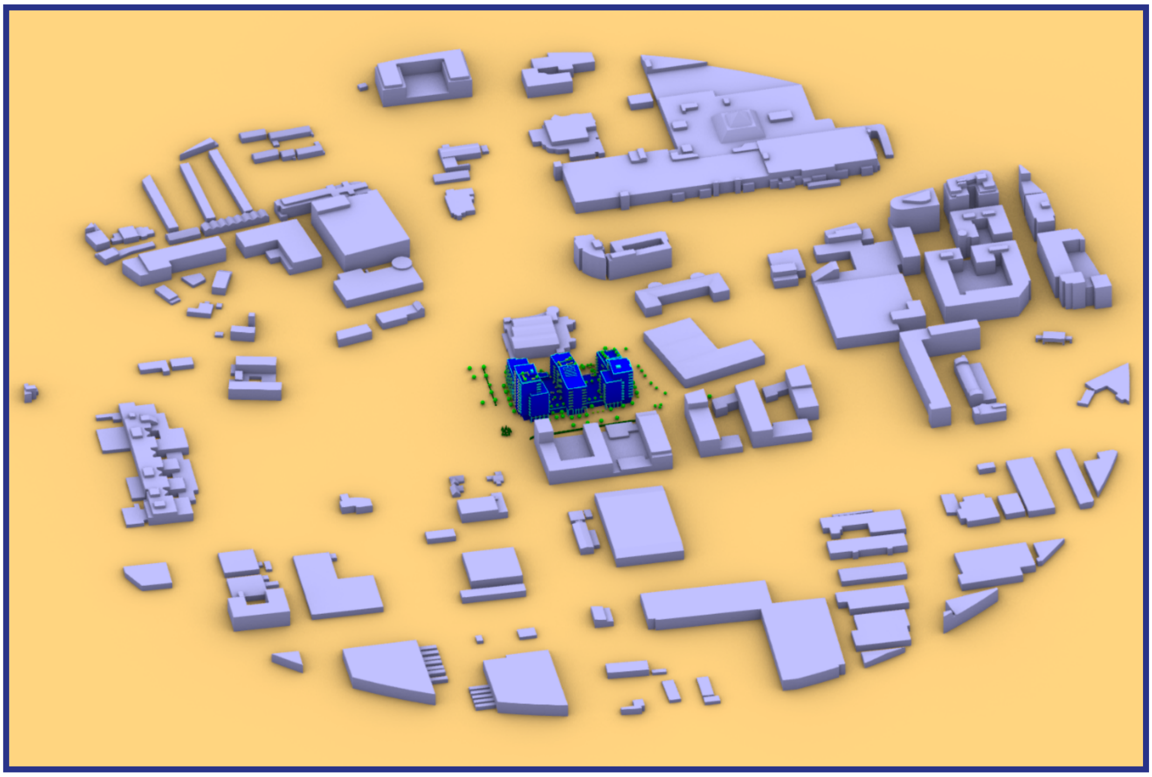

Figure 4: CFD Model Geometry for the Proposed Site

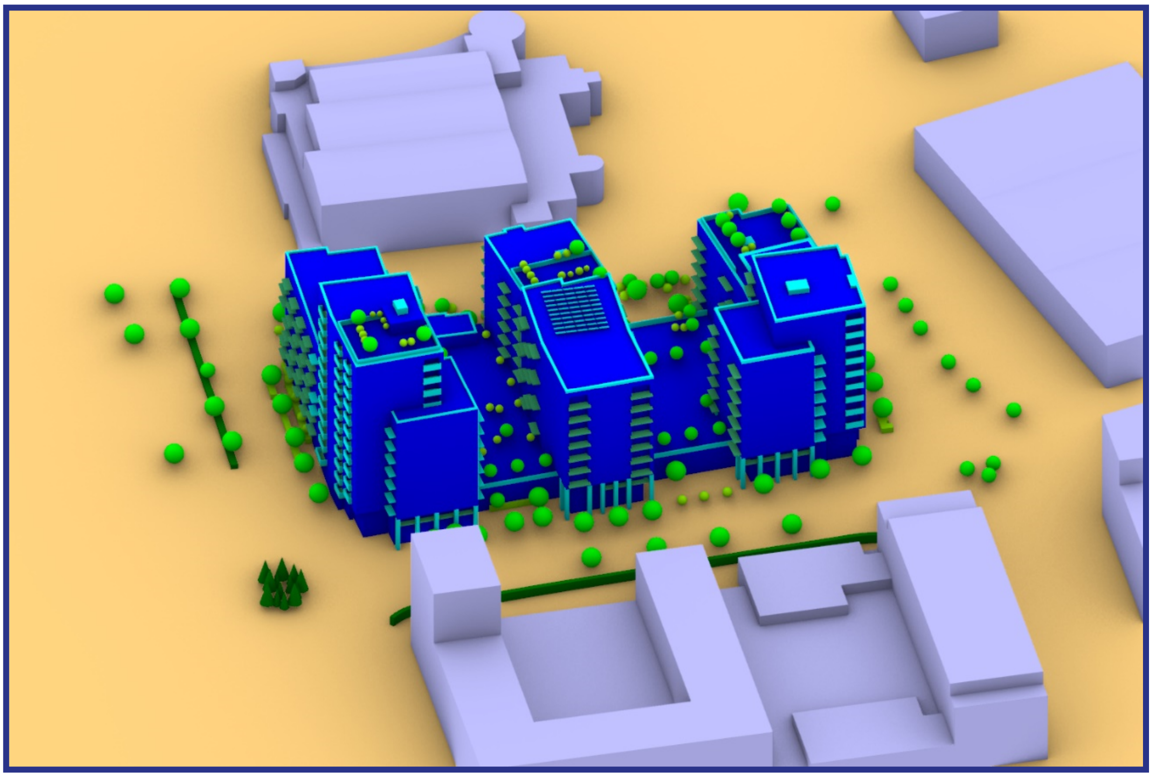

Figure 5: CFD Model Geometry for the Proposed Site, Close-up from North

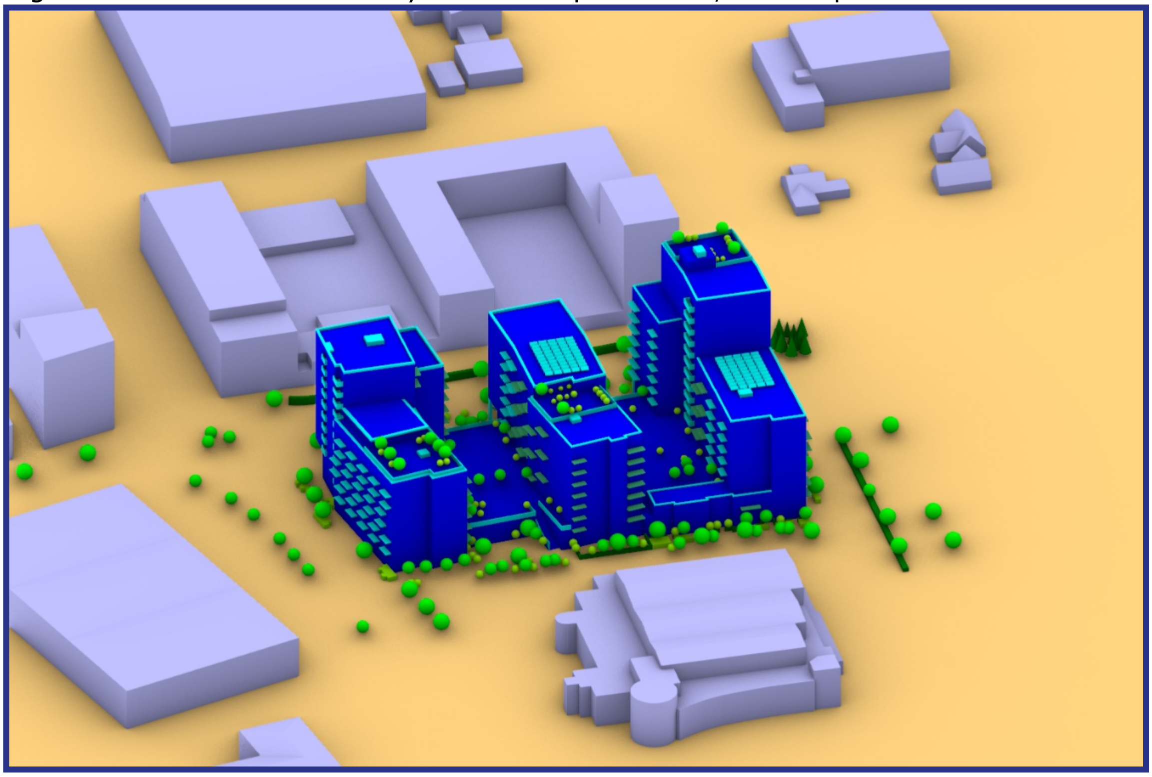

Figure 6: CFD Model Geometry for the Proposed Site, Close-up from South

2.4 SITE AND SURROUNDINGS

An aerial view of the site of the proposed development at Belgard Road can be seen in Figure 7.

Figure 8 and Figure 9 show the landscaping plan for the proposed development at Belgard Road.

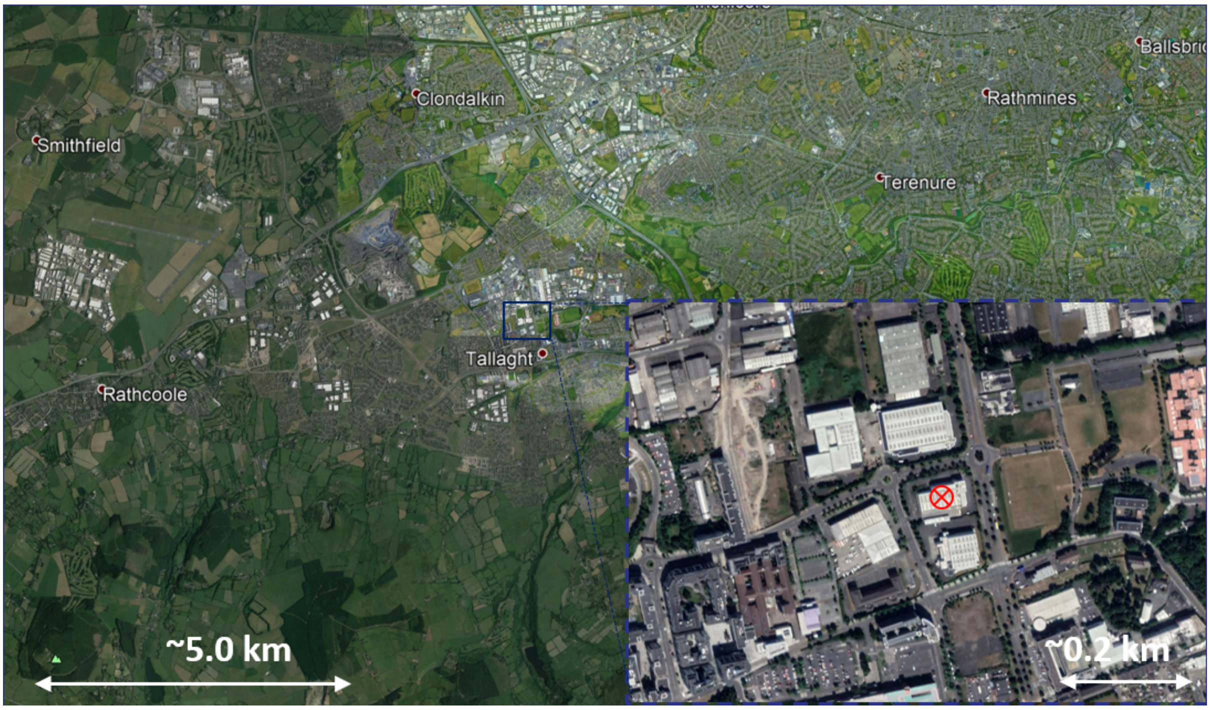

Figure 7: Site Location

Figure 8: Ground and Podium Level Landscaping Plan

Figure 9: Roof Level Landscaping Plan

2.5 SITE WIND MICROCLIMATE ASSESSMENT

Figures 10, 11 and 12 show wind roses for the proposed development at Belgard Road site at the reference height of 100m for the annual, summer and winter periods respectively. Additionally, spring and autumn period wind roses are shown in Appendix B Additional Wind Data.

The wind roses were calculated using wind data from Casement Aerodrome adjusted for the site location based on terrain analysis using the EDSU methodology [6].

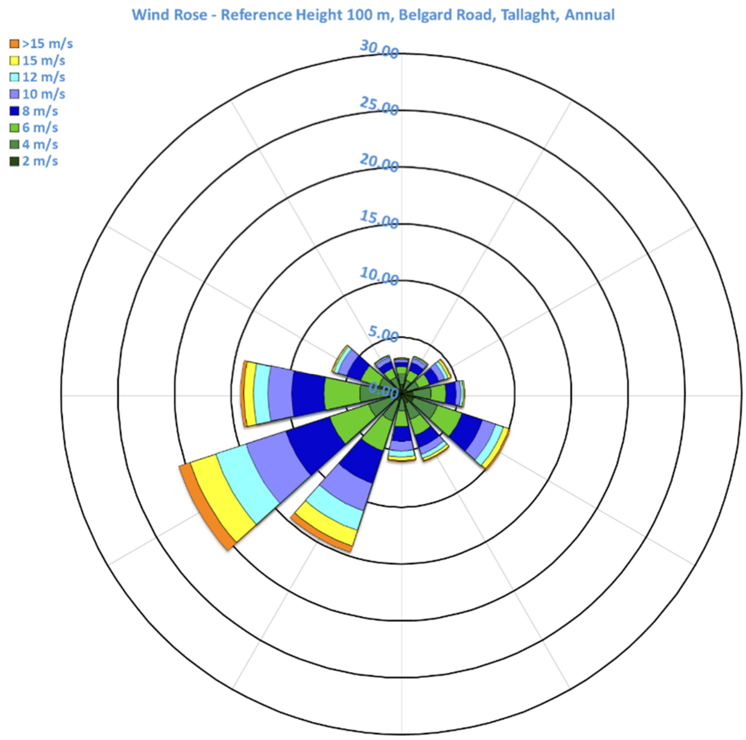

Figure 10: Annual Period Wind Rose at Reference Height for the Site

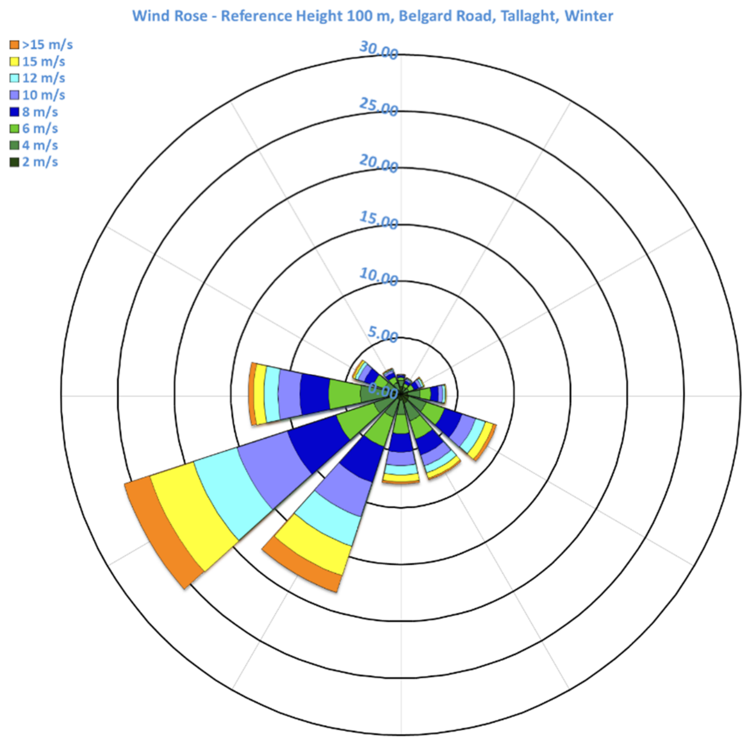

Figure 11: Winter Period Wind Rose at Reference Height for the Site

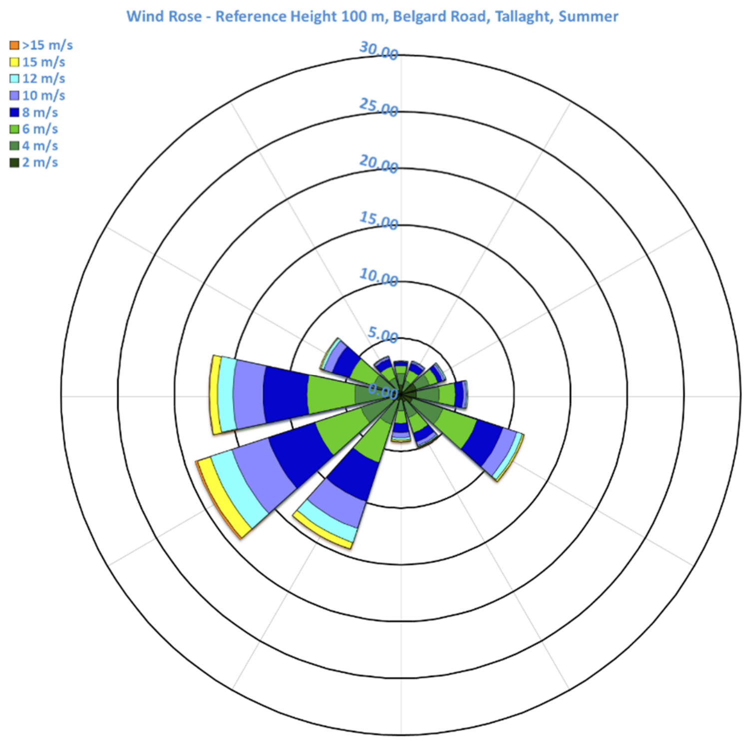

Figure 12: Summer Period Wind Rose at Reference Height for the Site

3.0 RESULTS OF THE ASSESSMENT

The main body of the report contains results for Pedestrian Comfort and Pedestrian Distress. Additionally, plots of velocity ratio for each of the 12 wind directions modelled are provided in Appendix A Velocity Ratio.

3.1 PEDESTRIAN COMFORT

Figure 13 shows a plot of Pedestrian Comfort rating at 1.5m above ground level for the worst seasonal conditions, which at this site occurs during winter. Figure 14 shows a plot of Pedestrian Comfort for the summer period.

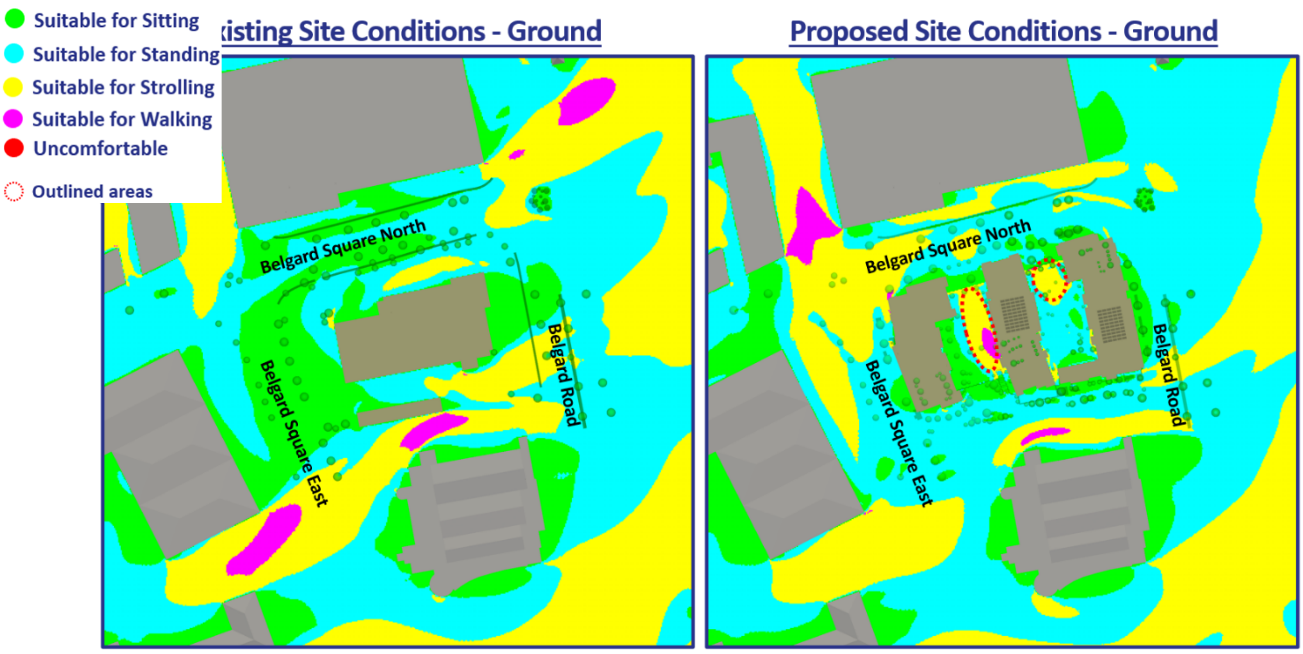

Figure 13: Pedestrian Comfort Rating for Worst Seasonal Conditions

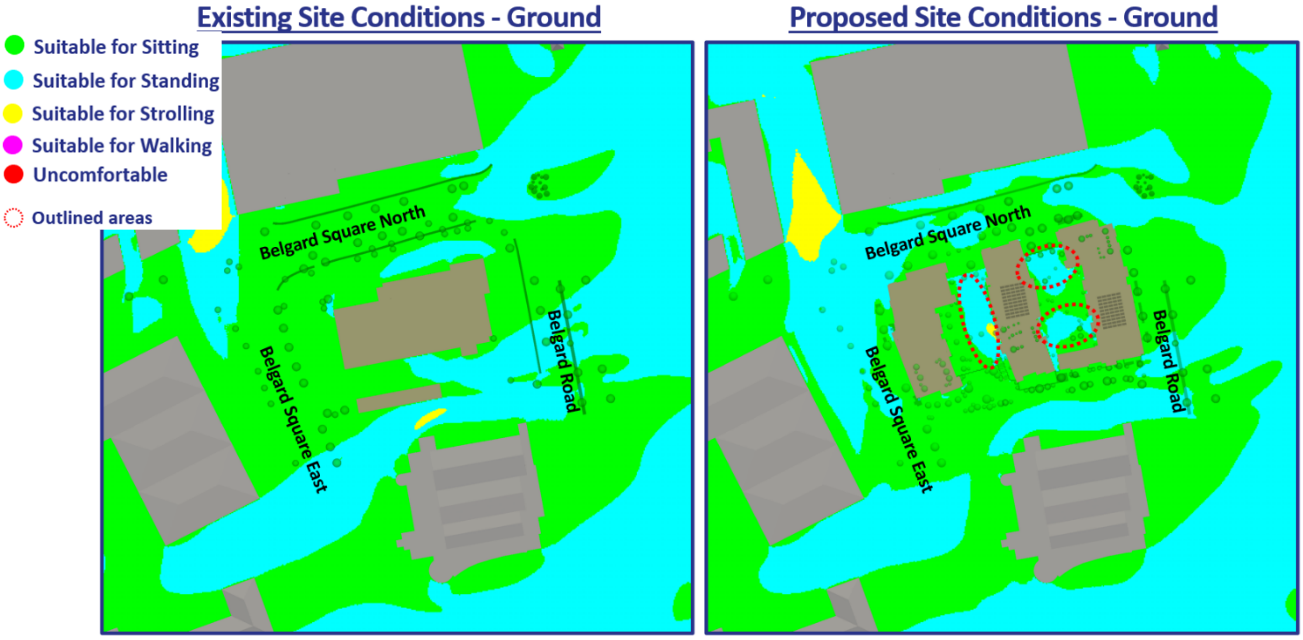

Figure 14: Pedestrian Comfort Rating for Summer Period

3.2 PEDESTRIAN DISTRESS/SAFETY

Figure 15 shows a plot of Pedestrian Distress/Safety Rating at 1.5m above ground level, where the Lawson Pedestrian Distress/Safety Criterion of 15m/s is exceeded, based on an exceedance probability of 0.022% [1].

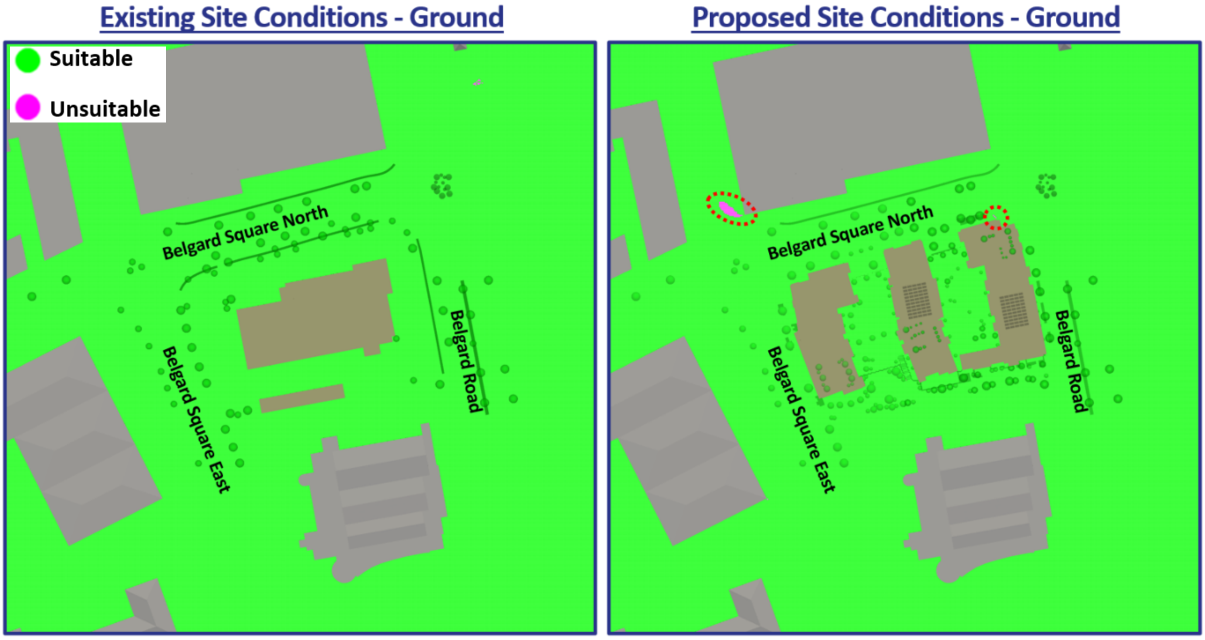

Figure 15: Pedestrian Distress Rating

4.0 SERVICING APPROACH

4.1 GENERAL OBSERVATIONS

The proposed development at Belgard Road constitutes a significant increase in the overall massing at the site. It is relatively exposed to the prevailing south-westerly winds and is thus at risk of downdraft/downwash causing wind acceleration at pedestrian level.

4.2 PEDESTRIAN COMFORT

The wind microclimate assessment for the proposed development identified the following regarding pedestrian comfort:

- Pedestrian comfort was achieved in all locations within and adjacent to the development with the following exceptions:
  - In summer, most of the podium was rated as suitable for sitting or standing, but a small area of the podium was rated as suitable for strolling. A general target rating of standing is recommended for the podium. A rating of sitting should be targeted in the vicinity of areas with seating.
  - In winter, some areas of the podium were rated as suitable for strolling or walking, above the recommended target of suitable for standing.

4.3 PEDESTRIAN DISTRESS/SAFETY

With regards to pedestrian distress/safety, the assessments key findings were as follows:

- Pedestrian safety was achieved at ground level within the proposed site and adjacent public spaces with the following exceptions:
  - At the southwest corner of the adjacent development located on the opposite side of Belgard Square North Road.
  - A small area at the northeast corner of the development, along Belgard Square North Road, which is a borderline failure.

4.4 MITIGATION

Mitigation is recommended in the form of solid and porous screens, and evergreen soft landscaping in the areas shown in Figure 16, which have been incorporated by the Landscape Architect and Architect. With introduction of the recommended mitigation, it is expected all pedestrian spaces outlined above will be safe and comfortable for their intended purpose.

Mitigation for the area where the pedestrian distress/safety criteria is exceeded on the opposite side of Belgard Square North Road should be in the form of large evergreen trees along Belgard Square East, at a minimum in the areas highlighted in Figure 16. A tree height of 6m or above is recommended in the more southerly area along Belgard Square East indicated in Figure 16.

At the northeast corner of the development, which is a borderline failure for pedestrian safety, the soft landscaping should be evergreen trees and hedges.

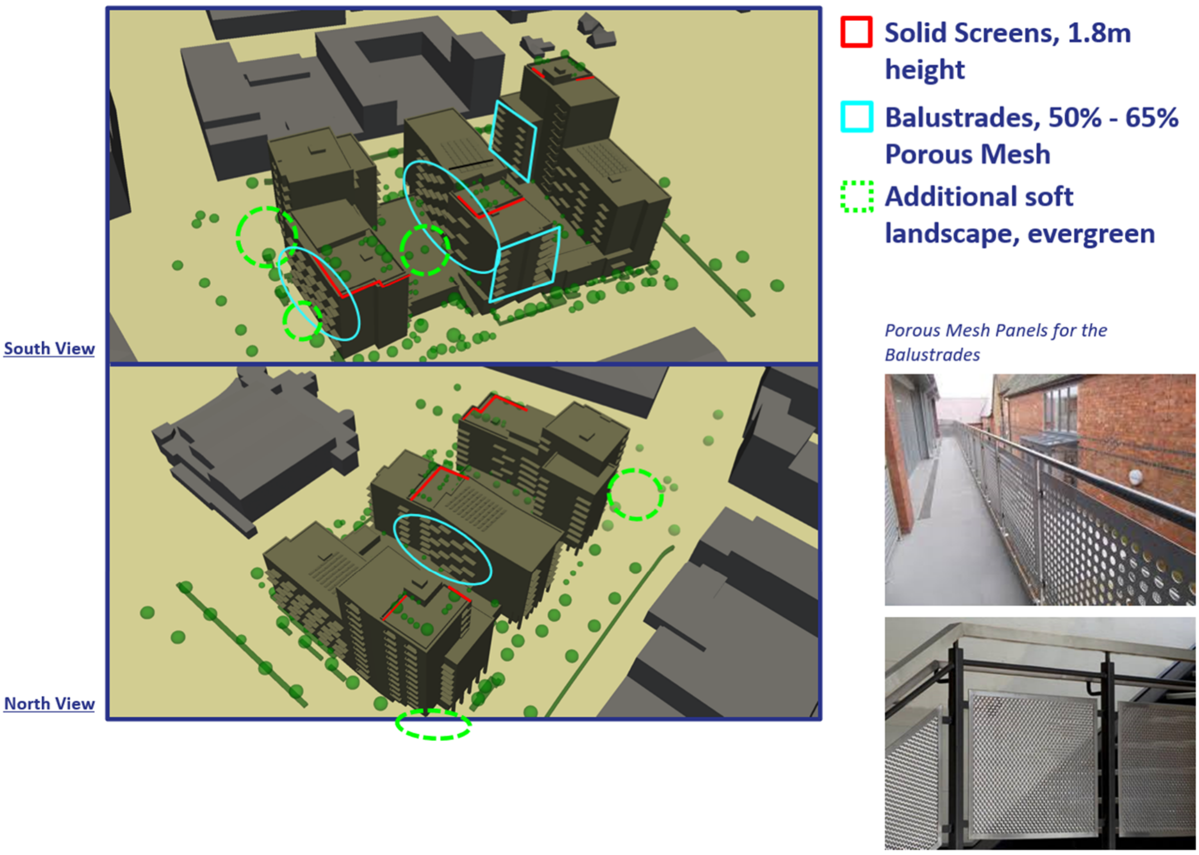

Figure 16: Recommended Mitigation Measures

APPENDIX A – VELOCITY RATIO

Figure A1 to Figure A12 show contour plots of velocity magnitude ratio in and around the existing and proposed site for each of the 12 wind directions modelled. The velocity magnitude is calculated by dividing the local air speed by the reference air speed: the wind speed at 35m above ground level at the start of the explicitly modelled inner area of the domain as calculated by terrain and wind profile analysis using the EDSU methodology [6].

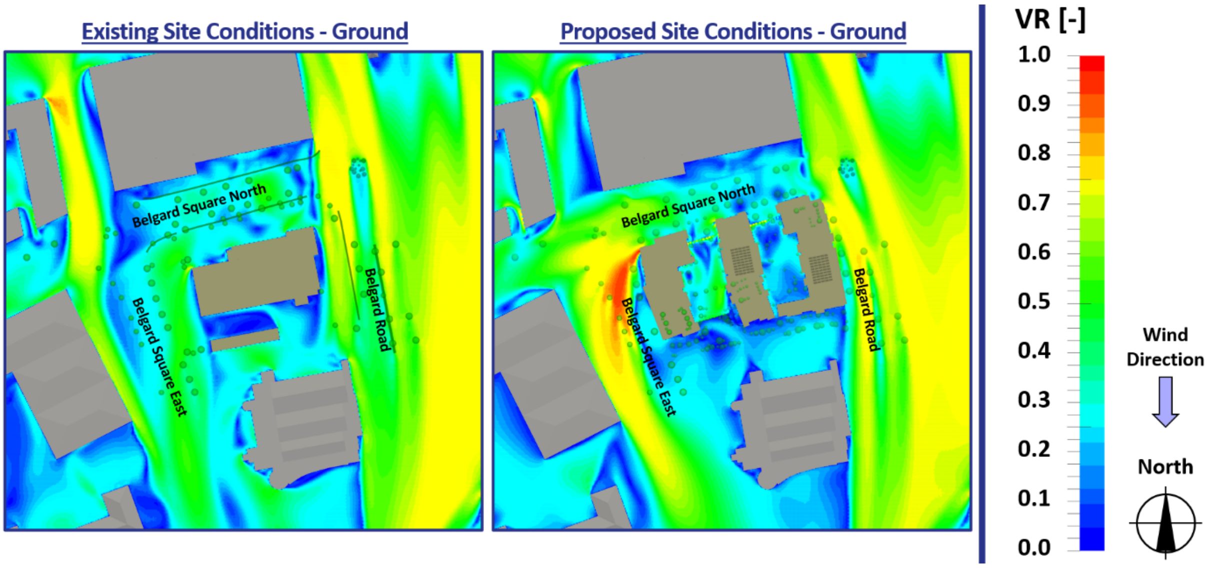

Figure A1: Velocity Ratio, Wind Direction of 0 Degrees (Northerly)

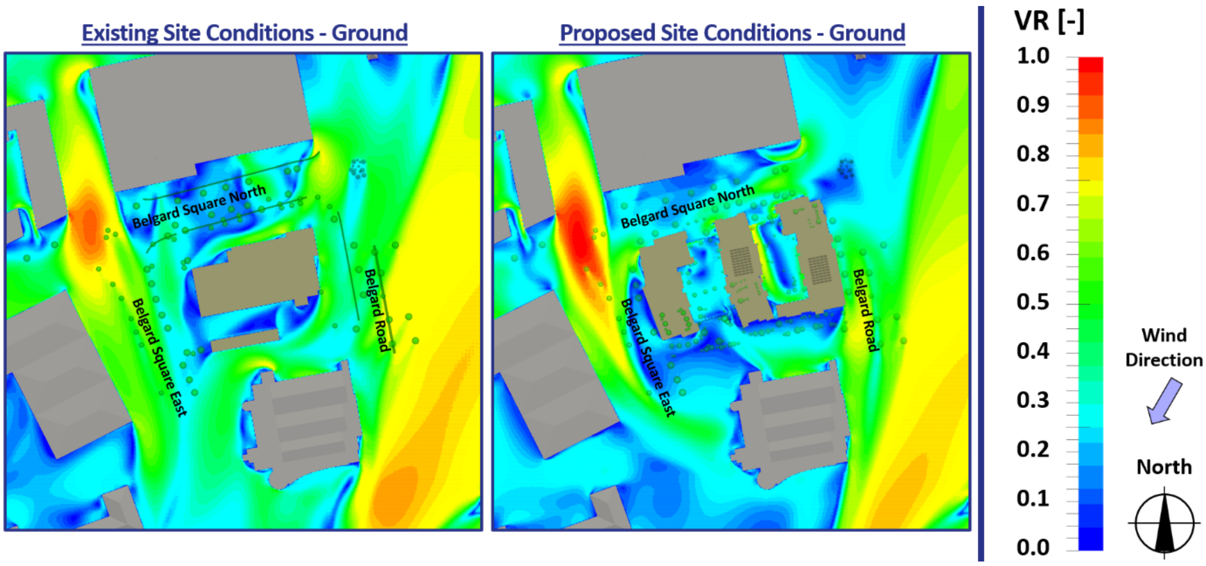

Figure A2: Velocity Ratio, Wind Direction of 30 Degrees

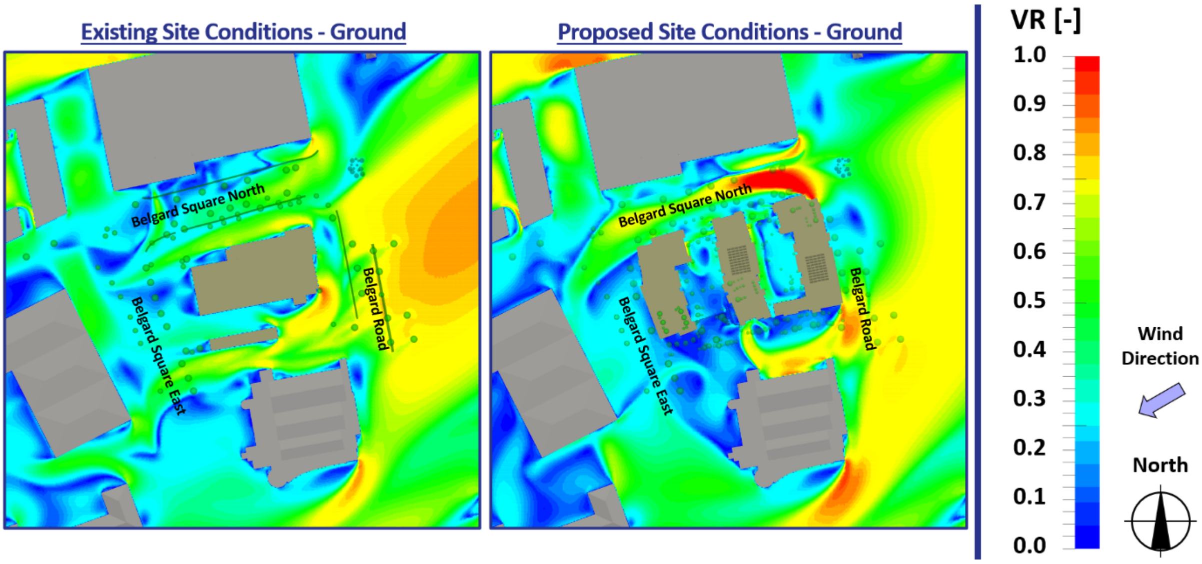

Figure A3: Velocity Ratio, Wind Direction of 60 Degrees

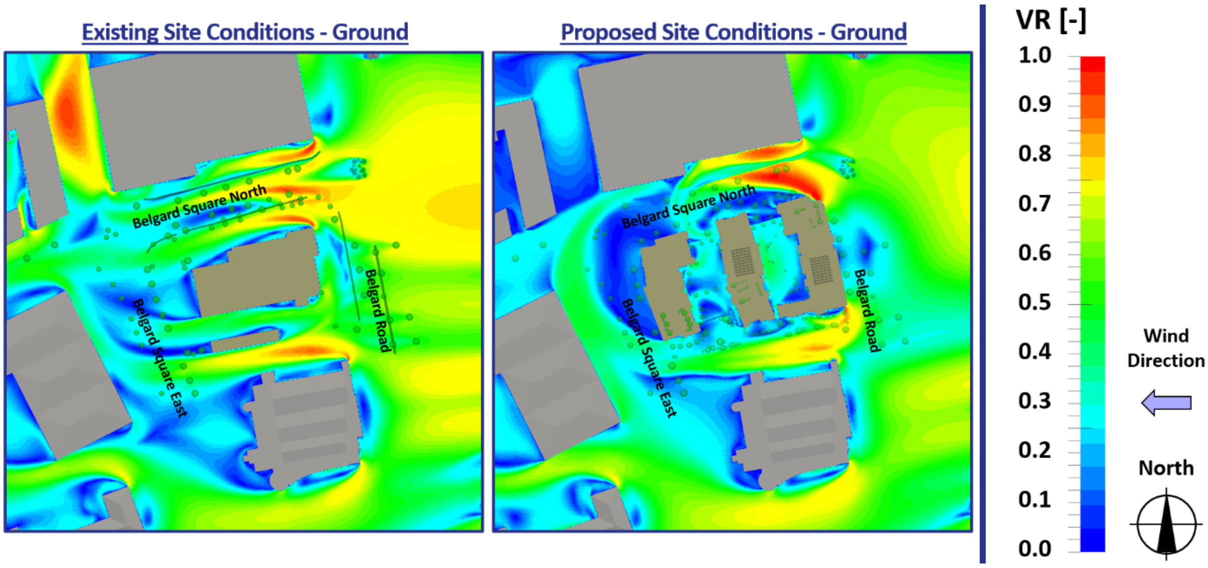

Figure A4: Velocity Ratio, Wind Direction of 90 Degrees (Easterly)

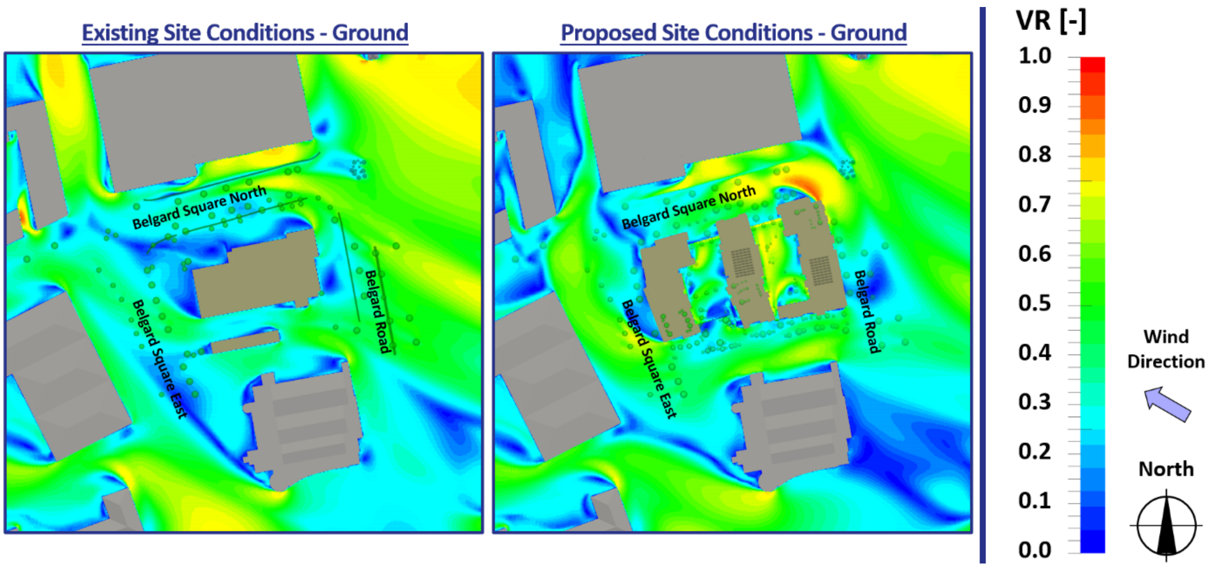

Figure A5: Velocity Ratio, Wind Direction of 120 Degrees

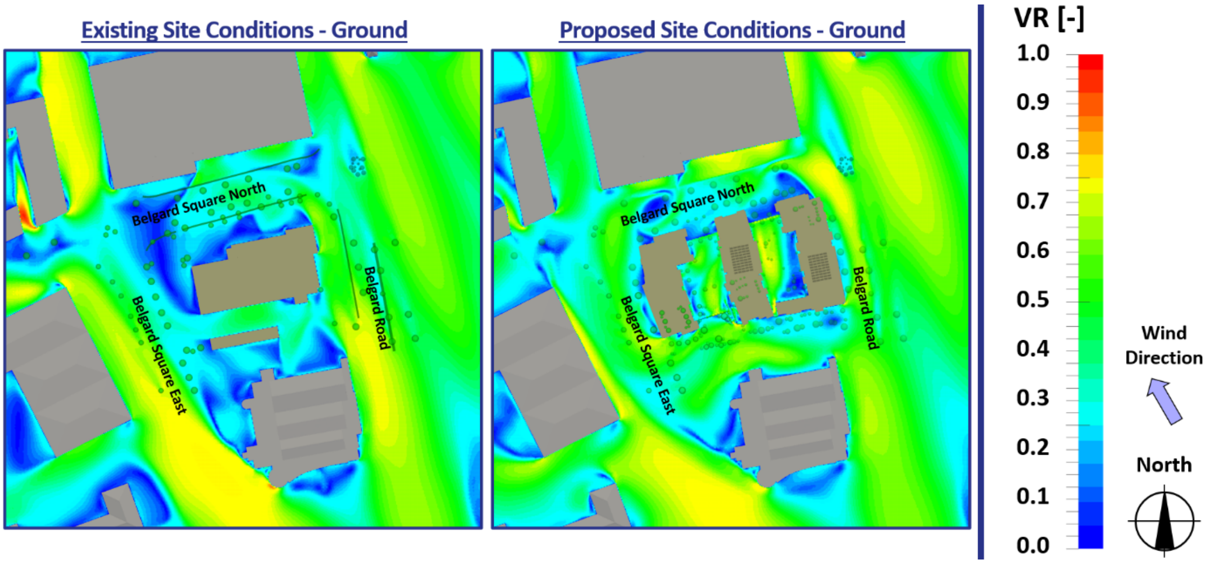

Figure A6: Velocity Ratio, Wind Direction of 150 Degrees

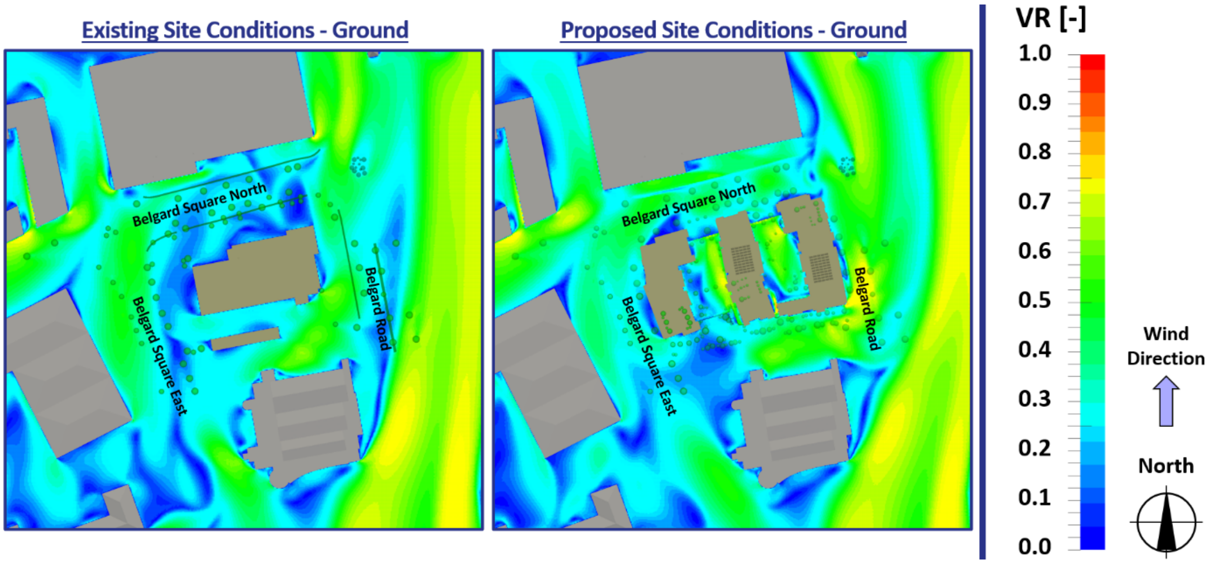

Figure A7: Velocity Ratio, Wind Direction of 180 Degrees (Southerly)

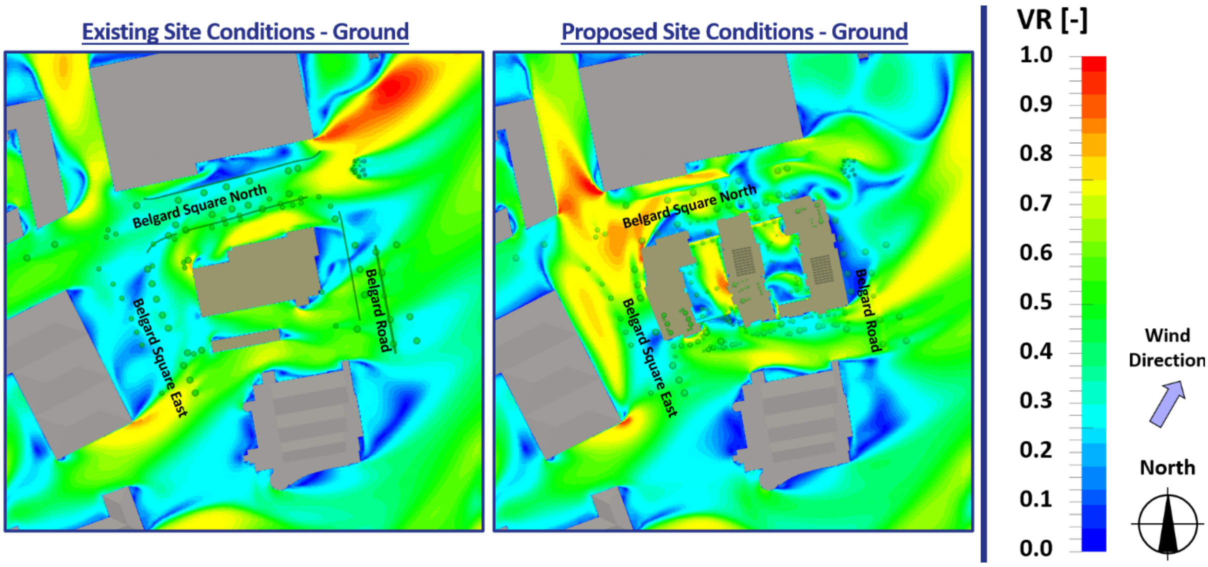

Figure A8: Velocity Ratio, Wind Direction of 210 Degrees

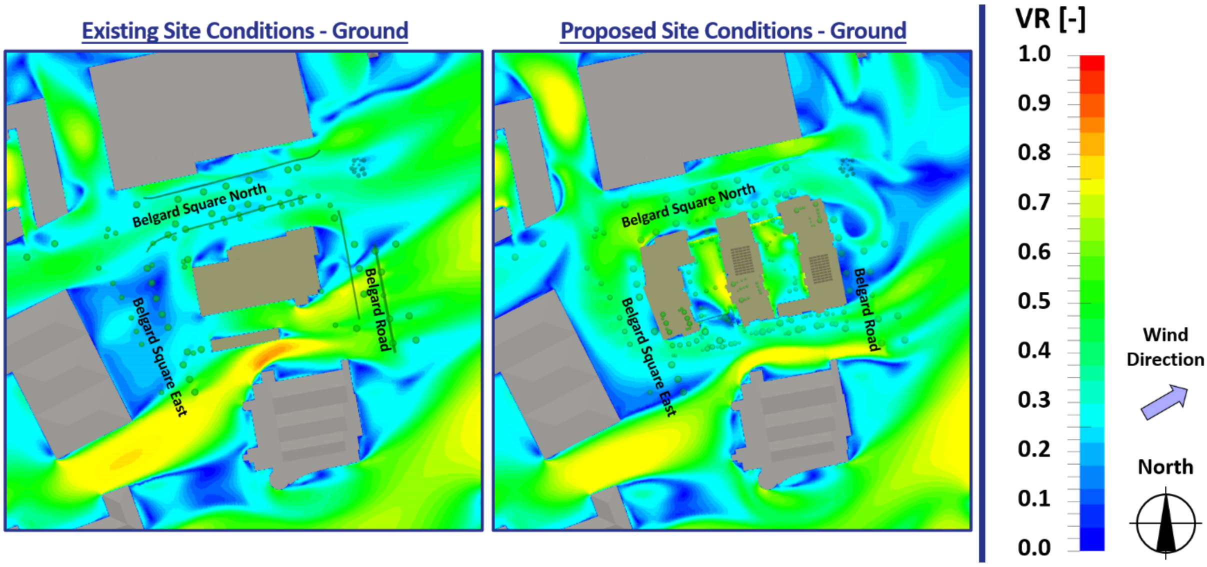

Figure A9: Velocity Ratio, Wind Direction of 240 Degrees

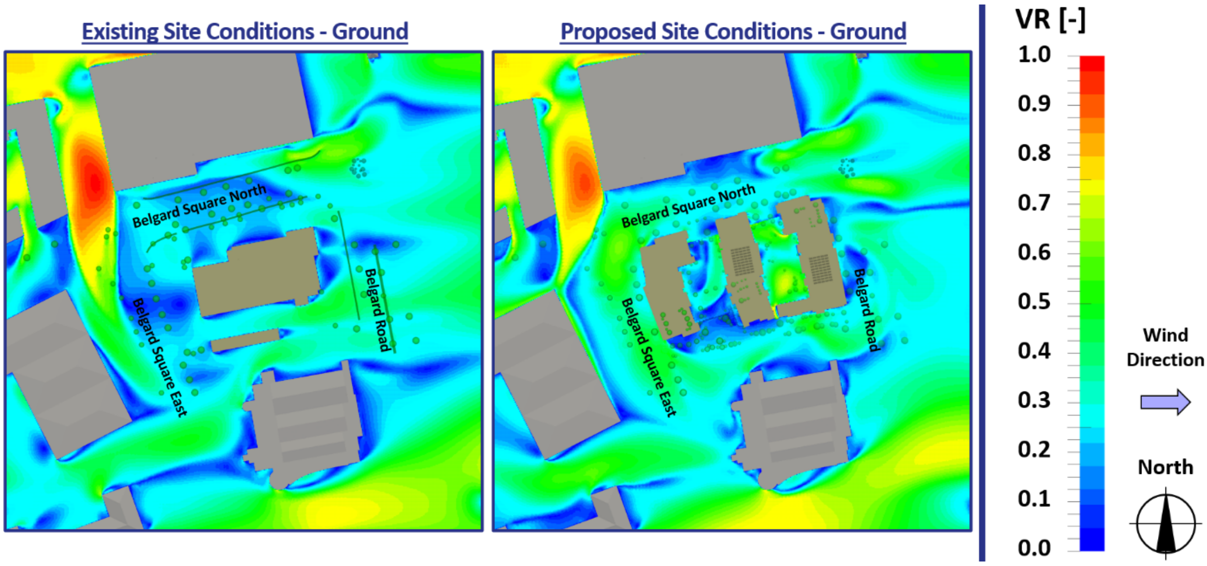

Figure A10: Velocity Ratio, Wind Direction of 270 Degrees (Westerly)

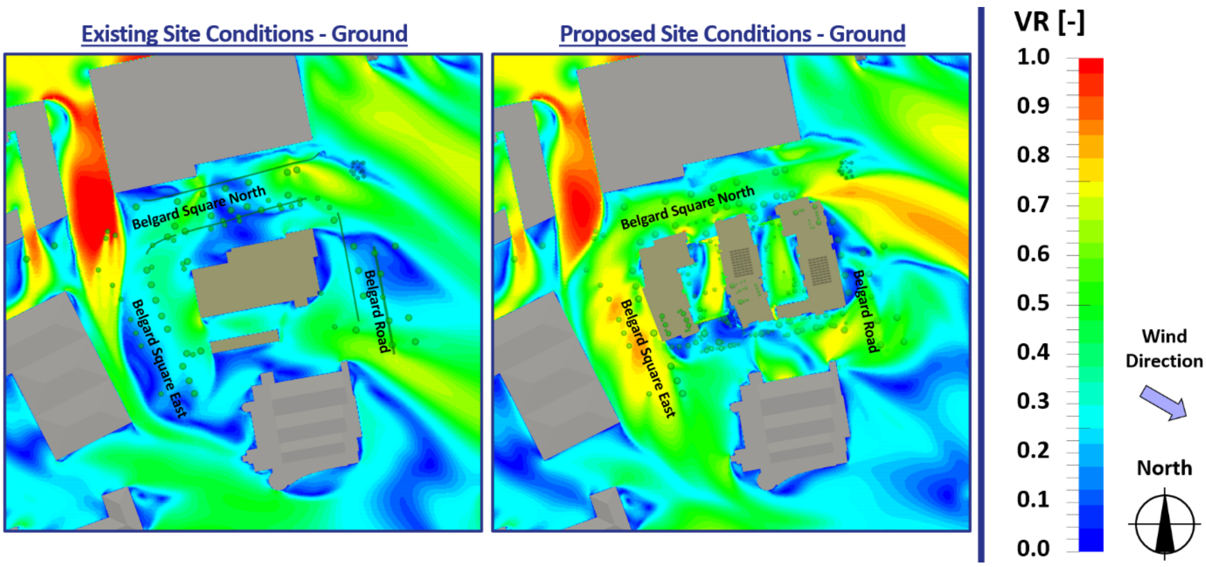

Figure A11: Velocity Ratio, Wind Direction of 300 Degrees

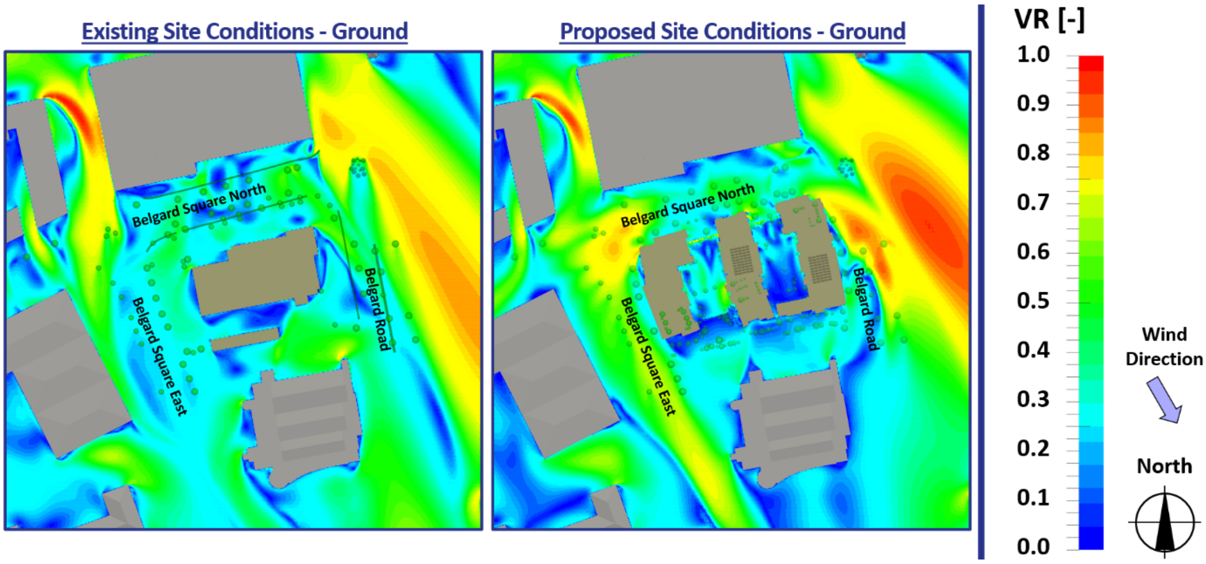

Figure A12: Velocity Ratio, Wind Direction of 330 Degrees

APPENDIX B – ADDITIONAL WIND DATA

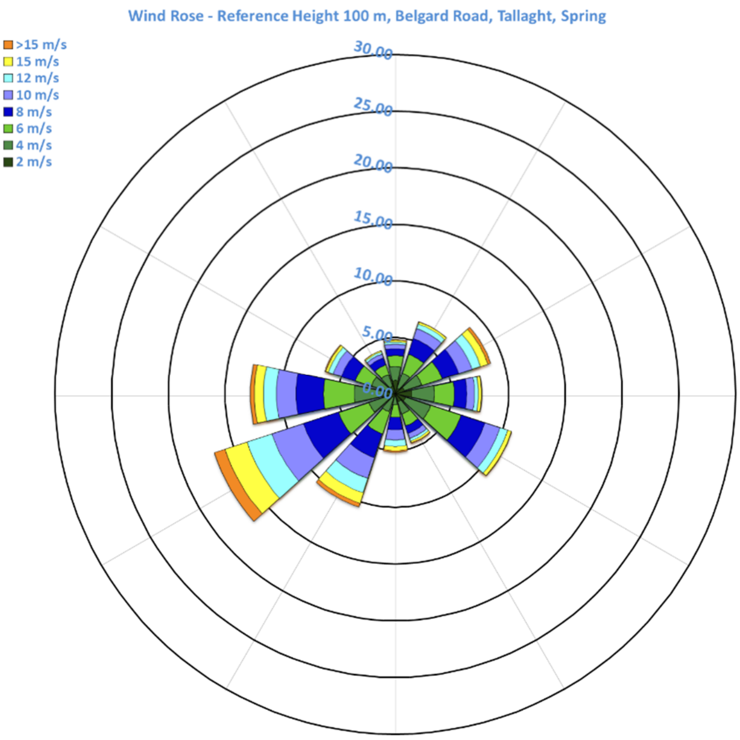

Figure B1: Spring Period Wind Rose at Reference Height for the Development Site

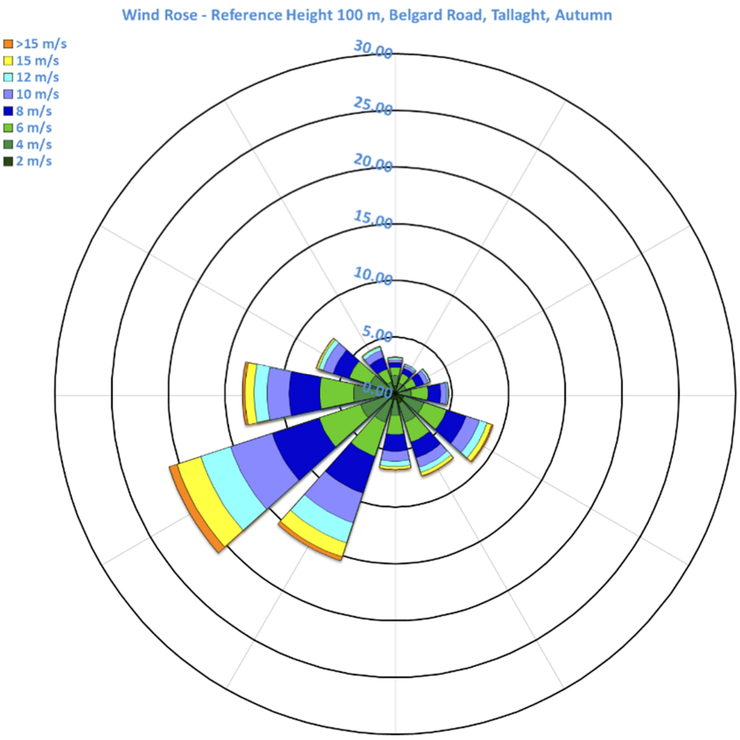

Figure B1: Autumn Period Wind Rose at Reference Height for the Development Site

APPENDIX C – CFD MODELLING METHODOLOGY

GENERAL

The multi-purpose CFD software Helyx® (https://engys.com/products/helyx, version 3.2) was used for the wind environment simulations. A total of 24 steady state atmospheric boundary layer simulations were completed for the assessment, covering two site configurations and 360 degrees of approaching winds, with a wind sector increment of 30 degrees.

SPATIAL DISCRETIZATION

The spatial discretization of the 3D model was completed with snappyHexMesh utility, part of the CFD code OpenFoam®. Computational meshes, consisting of approximately 14 million hexahedral and polyhedral elements, were constructed for two site configurations:

- The existing site within the existing surrounds,
- The proposed site within the existing surrounds.

The computational domain included the proposed development site, the surrounding buildings and terrain explicitly modelled to approximately 500 m from the development, 1000 m in radius ground surface and the outer boundaries (side and upper at 1000 m height from the ground).

The base cell size in the numerical grid was 32.0 m. The refinement level increased to 0.1 m in the zone closest to the proposed site, to capture the detailed geometrical features. Additionally, 5 prism surface layers were introduced to all pedestrian ground level surfaces, with the first layer height of approximately 0.4 m.

SOLUTION METHOD

The RANS (Reynolds-averaged Navier–Stokes) CFD simulations were performed using the simpleFoam solver. The modelling of an incompressible fluid flow was completed using the semi-implicit method for pressure-linked equations (SIMPLE) algorithms. The resulted flow turbulent features were modelled using the Shear Stress Transport (SST) k-ω turbulence model. This model by Menter [2] and is based on a two-equation eddy-viscosity approach, where the SST model formulation combines the use of a k-ω 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 [3].

BOUNDARY CONDITIONS

The atmospheric boundary layer flow was simulated by implementing a logarithmic velocity profile model presented by Richards and Hoxey [4], 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:

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

where:

κ - is the von Karman's constant.

z - is the distance from the ground surface in vertical direction.

z_o - is the ground surface roughness length in meters.

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

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

where:

z_{ref} – is the reference height in meters.

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:

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

where:

$C_\mu = 0.09$ - is the usual k-ε turbulence model constant.

Within the inner region of the domain (i.e., where the development, surrounding buildings, and terrain were modelled) all surface boundary conditions were modelled as smooth walls with a no-slip condition. On the surface representing the ground in the outer region of the domain (i.e., the region without explicitly modelled building geometry) a no-slip wall boundary condition with a varying roughness length based on the terrain analysis for that region was applied.

POROUS MEDIA MODEL

The permeability of existing and proposed vegetation within vicinity of the site was modelled by introduction of a volumetric source term in the momentum equation applied at two different cell zones defined within the CFD model:

- Deciduous trees
- Hedges

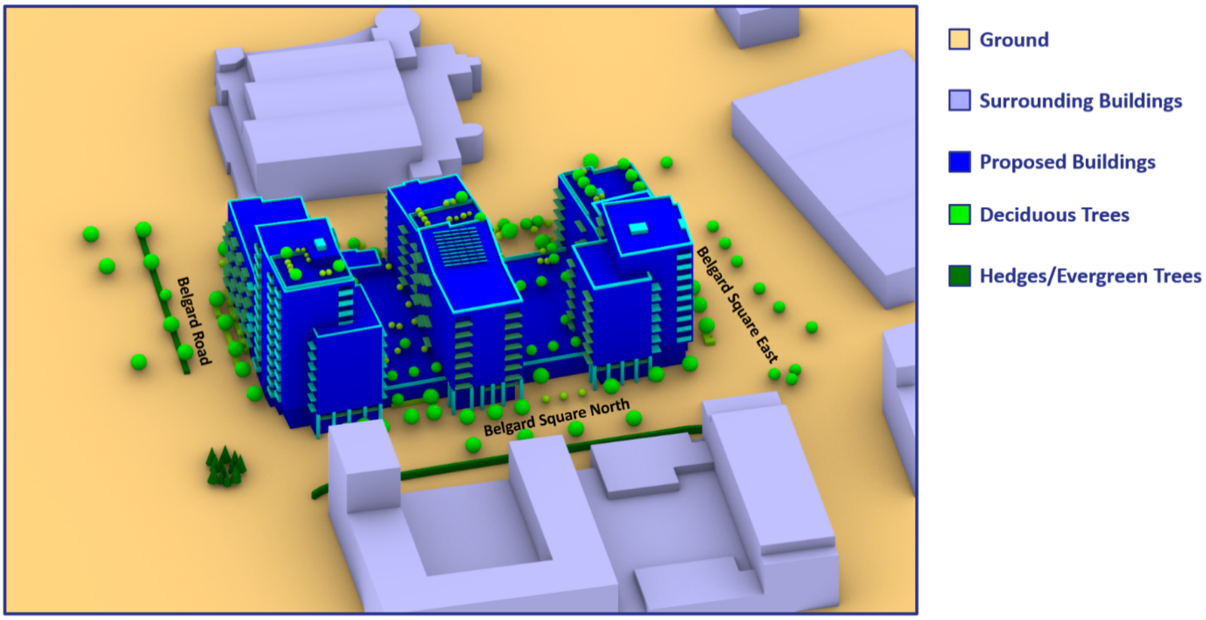

Figure C3 – 3D Model of the proposed and existing vegetation

The model is based on the Darcy-Forchheimer formula, implementing full scale wind tunnel experimental data [7]. The numerical model is based on the conservative assumption of winter leaf cover.

APPENDIX D – WIND MICROCLIMATE ON BALCONIES AND TERRACES

Though they are intended for analysis of public spaces rather than balconies, here we apply pedestrian comfort and distress criteria to quantify the wind conditions experienced on the balconies and terraces of the proposed development. Although there are no strict criteria for balconies, the generally accepted industry norm is to target a summer comfort rating of Suitable for Sitting, and that the annual pedestrian safety criterion should be met.

Figures D1, D2 and D3 show contour plots of pedestrian comfort in winter, pedestrian comfort in the summer, and pedestrian distress/safety on the balconies and terraces of the proposed development respectively.

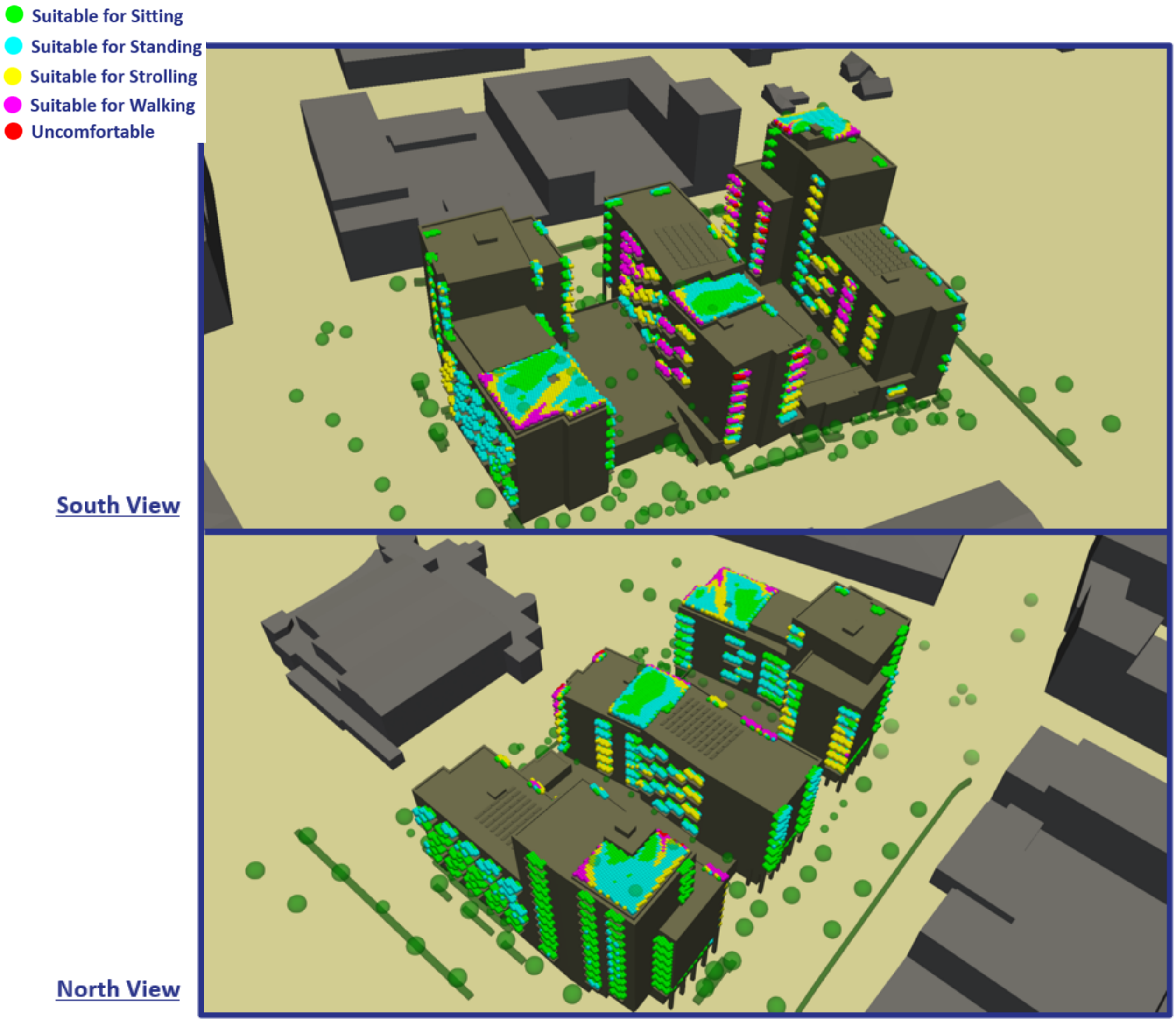

Figure D1: Pedestrian Comfort Rating for Worst Seasonal Conditions

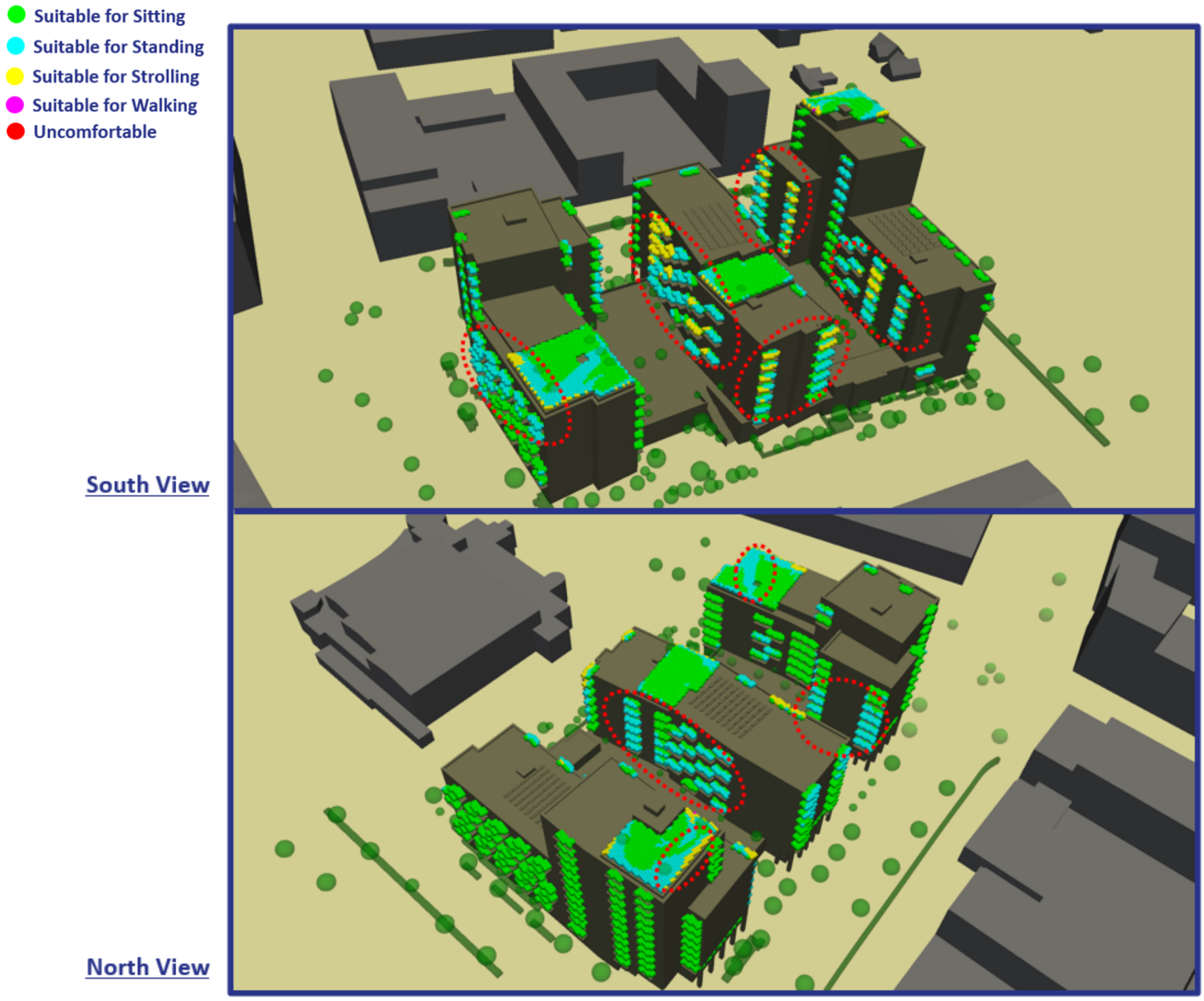

Figure D2: Pedestrian Comfort Rating for Summer Period

Figure D2 highlights balconies and roof terrace areas where the summer period target rating of suitable for sitting is exceeded.

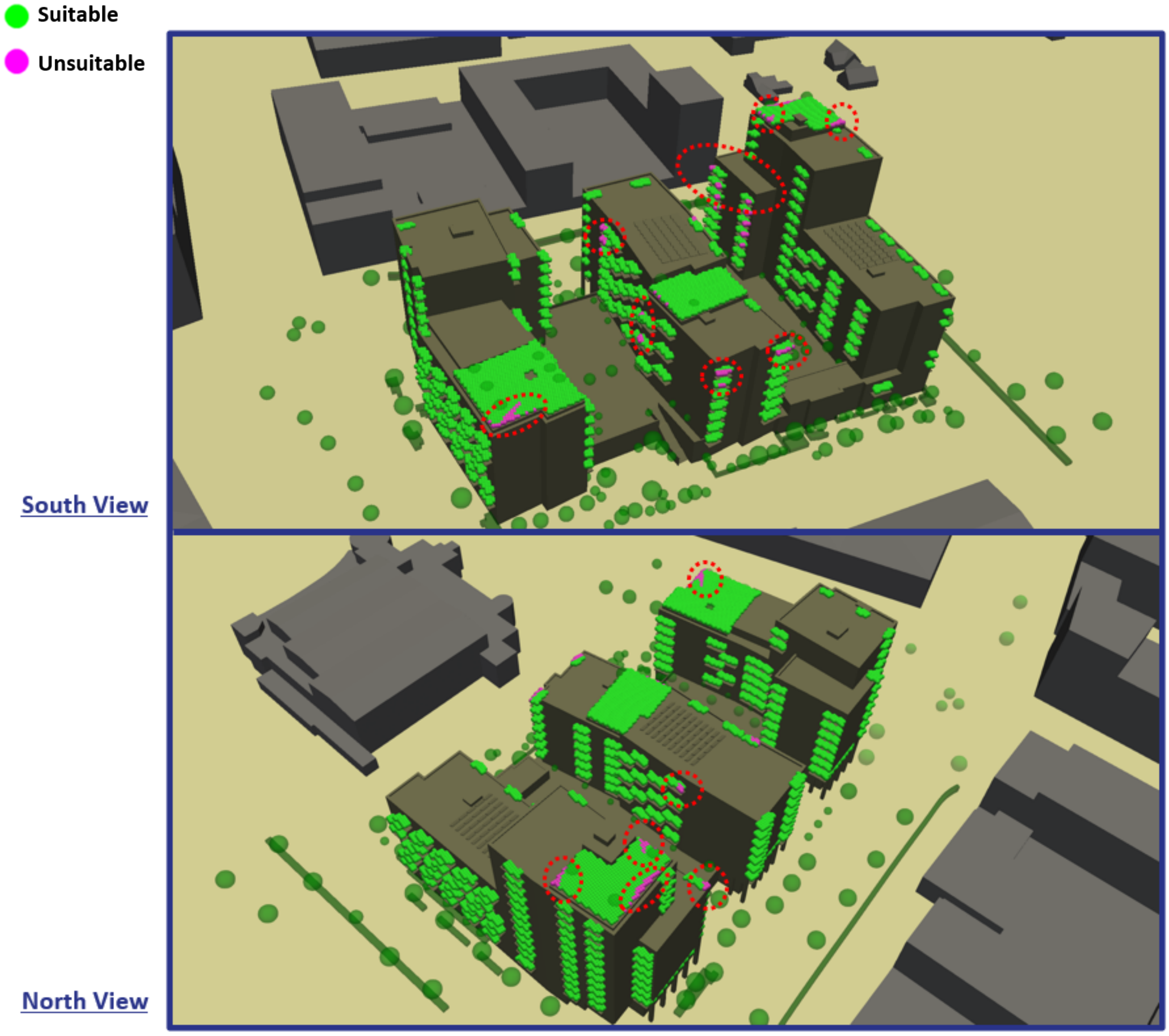

Figure D3: Pedestrian Distress/Safety Rating

Figure D2 highlights balconies and roof terrace areas where wind speeds exceed the pedestrian safety criterion.

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