AECOM

Hillingdon Hospital

Wind Microclimate Study
P01
THHR_01-ACM-ZZ-XX-RP-Y-000022

11th May 2022

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Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
P01	11/05/2022	First Issue	RWM	Robert Murphy	TD

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1. Executive Summary

1.1 This report assesses the likely significant effects on wind microclimate due to the proposed developments at Hillingdon Hospital.

1.2 The assessment involves simulations of the following scenarios/cases:

1. **Baseline** – existing hospital buildings, tower, and low-rise post-war ancillary buildings,
2. **New Hospital** – existing hospital and new hospital (replacing the low-rise ancillary buildings within in the phase 1 boundary),
3. **Old Demolished** – new hospital only (remaining existing hospital buildings and tower demolished for new developments), and
4. **Proposed** – new hospital and the proposed mixed-use developments.

1.3 The immediate surroundings of the bus shelters were found to be comfortable for sitting; this matches their anticipated intended use of sitting (and standing) and is acceptable according to the Lawson criteria.

1.4 The perimeters of buildings were found to be comfortable for sitting and standing; this matches their anticipated intended use as entrances and is acceptable according to the Lawson criteria.

1.5 The ambulance loading bays and adjacent access road for the new hospital building, towards its south eastern corner, was found to have a region comfortable for walking; this matches the anticipated intended use of walking or being inaccessible to the public and is acceptable according to the Lawson criteria.

1.6 The designated pedestrian terraces were found to be comfortable for sitting and standing; this matches their anticipated intended use as incidental seating/standing waiting areas and is acceptable according to the Lawson criteria.

1.7 The remainder of the site was found to be mostly comfortable for sitting, but no less comfortable than for standing (i.e. no other regions not suitable for either sitting or standing); this matches the anticipated intended use as pedestrian thoroughfare (walking) and incidental seating and is acceptable according to the Lawson criteria.

1.8 The present study did not find indication of distress regions with a 20 m/s threshold for any scenario at 1.5 m above ground or 1.5 m above the designated pedestrian terraces of the new hospital building; the wind microclimate can be considered safe for able-bodied pedestrians according to the Lawson criteria.

1.9 The present study did not find indication of distress regions with a 15 m/s threshold for any scenario at 1.5 m above ground or 1.5m above the pedestrian terraces except for the scenario following demolition of the old hospital (03 Old Demolished – Figure 5-3), and only when the mitigating effect of trees beyond the boundary of the development site are omitted. Lack of distress with a 15 m/s threshold can be considered safe for all pedestrians (including the frail, elderly, or infirm, and even cyclists) according to the Lawson criteria.

1.10 The conditions following completion of all proposed works in this application are represented by the scenario: 04 Proposed. The results of this investigation show that the wind microclimate conditions for this scenario are comfortable for their anticipated intended pedestrian uses and are acceptable according to the Lawson criteria. The conditions can also be considered safe according to the Lawson criteria.

2. Introduction

2.1 The Hillingdon Hospitals NHS Trust (collectively referred to as the 'Applicant' or 'Client') has commissioned AECOM Limited to provide an Environmental Wind Assessment to accompany a hybrid planning application for Hillingdon Hospital (hereafter referred to as 'the [development] site').

2.2 The hybrid planning application includes:

1. *FULL application seeking planning permission for demolition of existing buildings and redevelopment of the site to provide the new Hillingdon Hospital, multi-storey car part and mobility bub, vehicle access, highway work, associated plant, generators, substation, new internal roads, landscaping and public open space, utilities, servicing area, surface car park/ expansion space, and other works incidental to the proposed development.*
2. *OUTLINE planning application (all matters reserved, except for access) for the demolition of buildings and structures on the remaining site (excluding the Grade II Furze and Tudor Centre) for a mixed-use development comprising residential (Class C3) and supporting Commercial, Business and Service uses (Class E), new pedestrian and vehicular access; public realm, amenity space, car and cycling parking.*

2.3 This report assesses the likely significant effects on wind microclimate due to the proposed developments at Hillingdon Hospital.

2.4 The purpose of this report is to assess the local wind conditions due to the proposed changes at key stages during the development in terms of comfort and safety and demonstrate whether they are acceptable with regard to the proposed use of the external areas throughout the development site.

2.5 This assessment involves simulations of the likely wind conditions at the Hillingdon Hospital site for the following scenarios/cases:

1. **Baseline** – existing hospital buildings, tower, and low-rise post-war ancillary buildings,
2. **New Hospital** – existing hospital and new hospital (replacing the low-rise ancillary buildings within the phase 1 boundary),
3. **Old Demolished** – new hospital only (remaining existing hospital buildings and tower demolished for new developments), and
4. **Proposed** – new hospital and the proposed mixed-use developments.

2.6 Simulations of the wind microclimate around the area of the development were conducted to quantitatively assess the effect on pedestrian comfort and distress (safety) levels in and around the development area.

2.7 The assessment was undertaken through Computational Wind Engineering (CWE) which uses Computational Fluid Dynamics (CFD) techniques to model the wind conditions at full scale and simulate conditions around the site. This report contains the methodology, inputs, and results from these simulations.

2.8 The aim of the simulations was to reproduce the macro-level wind regime around the buildings. 36 wind directions (every 10° clockwise around the compass from due north) were analysed using representative strong winds applied to a full-scale 3D model of the development within the local built environment. Turbulence has also been accounted for in the Lawson analysis.

2.9 Further analysis was also undertaken to assess compliance with Lawson comfort criteria. Interpolating steady-state CFD simulations of the site allows the frequencies with which wind speeds occur across the site to be calculated. This analysis used 20 years of historic weather data from London Heathrow to calculate the prediction.

Legislation and Planning Policy

National legislation

2.10 There is no national legislation which specifically covers wind microclimate planning policy.

National planning policy

National Planning Policy Framework (2021)

2.11 The National Planning Policy Framework (DCLG, National Planning Practice Framework and Guidance, 2021) does not specifically reference wind or microclimate.

Regional Planning Policy

The London Plan 2021

15.1.1 The London Plan 2021 (Greater London Authority (GLA), 2021) is the Spatial Development Strategy for Greater London, setting out a framework for development and a policy framework for local plans across London. The following policies apply in relation to Wind Microclimate:

- Paragraph 3.3.8:

  Buildings should be of high quality and enhance, activate and appropriately frame the public realm. Their massing, scale and layout should help make public spaces coherent and should complement the existing streetscape and surrounding area. Particular attention should be paid to the design of the parts of a building or public realm that people most frequently see or interact with in terms of its legibility, use, detailing, materials and location of entrances. Creating a ***comfortable pedestrian environment with regard to*** *levels of sunlight, shade,* ***wind****, and shelter from precipitation is important.*

- Policy D9 3) Environmental impact

  a) wind […] around the building and neighbourhood must be carefully considered and not compromise comfort and the enjoyment of open spaces, including water spaces, around the building.

  b) *air movement affected by the building should […] not adversely affect street-level conditions*.'

- Policy D8: Public realm:

  Development Plans and development proposals should:

  ... ensure that appropriate shade, shelter, seating and, where possible, areas of direct sunlight are provided, with other microclimatic considerations, including temperature and wind, taken into account in order to encourage people to spend time in a place.

Local Planning Policy

London Borough of Hillingdon – Local Plan Pt. 2 (2020)

2.12 The Local Plan Part 2 contains Development Management Policies which determines the Council's decisions on individual planning applications. The following policies apply in relation to Wind Microclimate:

- Policy DMHB 10 – Hight Buildings and Structures:

  vi) ***not adversely impact*** *on the* ***microclimate*** *(****i.e. wind conditions*** *[…]) of the site and that of the surrounding areas, with particular focus on maintaining useable and suitable comfort levels in public spaces;*

The Proposed Development

2.13 Figure 2-1 shows the plan of the development site for the scenario following completion of the proposed mixed-use buildings (Proposed), including the landscape layout for trees.

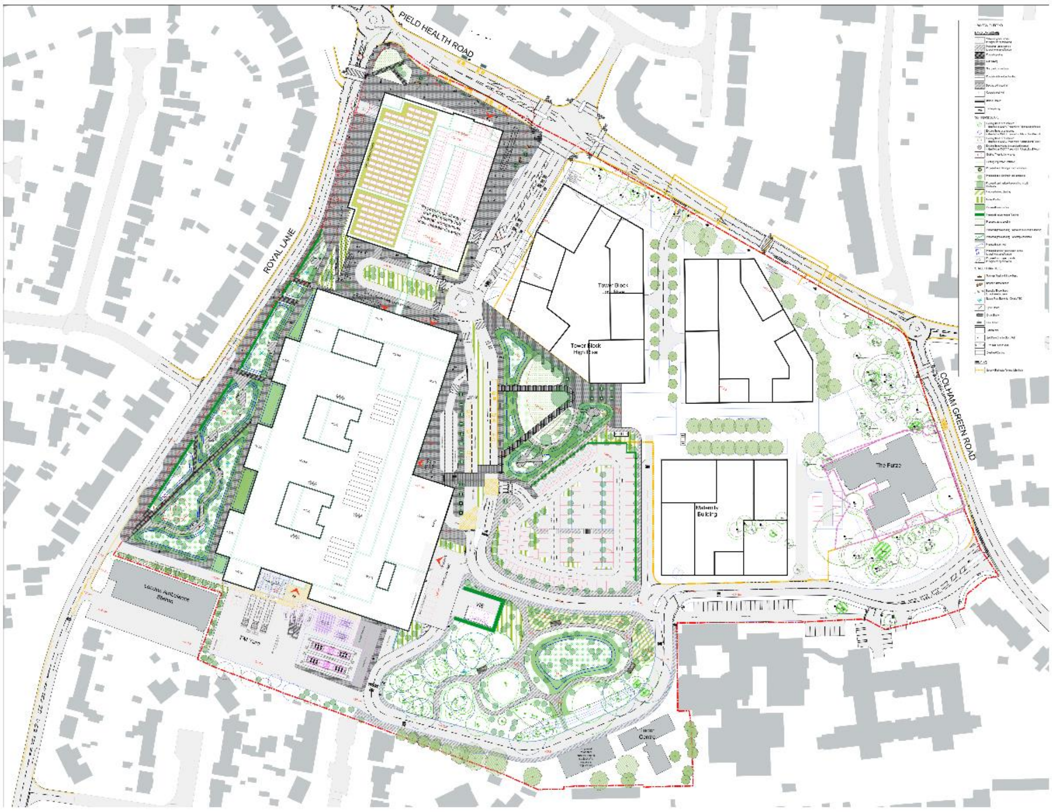

Figure 2-1: Plan of Development Site – Proposed

Limitations of Modelling

2.14 The use of CFD or wind tunnels for wind modelling is not an exact science. Although software or physical models can be used to demonstrate an improvement (or otherwise) in the wind microclimate around a development, like any modelling technique, absolute improvements cannot be guaranteed.

2.15 CFD simulation presents an efficient and comprehensive solution to predicting pedestrian comfort. Since the domain is divided into millions of separate cells, results can be reported in high resolution throughout the full 3D domain.

2.16 Methods that require physical measuring equipment, such as wind tunnel testing can provide a useful approach to corroborating results but only provide data at much reduced number of locations throughout the domain. For example, the CFD results presented in this report use tens of thousands of data points combined into an informative image displaying pedestrian wind comfort. A wind tunnel approach would use typically ~100-200 data points and as such may miss important flow features which CFD analysis is capable of interrogating.

2.17 In undertaking the wind microclimate assessment of the proposed development and wider surrounding area, the following limitations and constraints have been identified:

- This assessment considers wind pedestrian comfort in the general urban environment but does not consider more specialised wind design requirements.
- Necessary geometric simplifications are made to the building geometry.

- Intermediate construction models are not analysed, as these form a temporary state. Construction plant and any temporary buildings of significant massing required during construction are presumed to be below 10m.
- Interim uses are not assessed in this document. It is assumed that necessary precautions will be undertaken to provide an adequate wind microclimate as part of on-site health and safety during these periods.

2.18 It is assumed that all Proposed Development sites are hoarded off from public access when construction first begins, therefore comfort and safety in these areas are issues dealt with via the relevant construction procedures regarding health and safety.

2.19 This report is suitable for Lawson Pedestrian Comfort and Distress and is not intended to be used for any other purposes, e.g., structural loading, façade pressures, sports, particle transport and fire safety.

3. Assessment Methodology

3.1 This section presents the following:

- The methodology employed for the assessment of wind microclimate effects, including the determination of the significance of the receptor and the magnitude of change from the baseline condition;
- An explanation as to how the identification and assessment of potential wind microclimate effects has been reached;
- The significance criteria and terminology for assessment of the residual effects to the wind microclimate; and
- Limitations and assumptions that have been made in the modelling of wind microclimate for each scenario.

Lawson Criteria

3.2 The assessment of pedestrian level wind conditions requires a standard against which measured or expected wind velocities can be compared. The comfort and distress criteria used will be those described in “Building Aerodynamics” by T.V. Lawson as “The LDDC (London Docklands Development Corporation) method” (Lawson, 2001).

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

3.4 Pedestrian comfort criteria are assessed at 1.5m above the surface of interest. With exception of unusual circumstances, wind speeds at pedestrian level increase with height from the ground. Therefore, an assessment at 1.5m will be more onerous than one at 0.5m, for example.

3.5 The Lawson process is a methodology to predict how often a given wind speed will occur each year over a specified area, interpolating the results of steady state computational fluid dynamics simulations using weather data measured at an appropriate nearby location, in this case Heathrow Airport Weather Station.

3.6 Interpolating steady-state CFD simulations of the Application Site allows the frequencies with which wind speeds occur across the Development Site to be calculated. This analysis used 20 years of historic weather data from London Heathrow to calculate the prediction.

3.7 Pedestrian activity varies throughout the year. However, the Lawson criteria percentages consider activity across the whole year and assume that people will be suitably dressed according to the time of year and individual activity.

3.8 The LDDC method criteria are set out in Table 3-1 below.

Table 3-1: Lawson Comfort Criteria

Category	Comfort Category	Threshold Wind Velocity (m/s)	Colour Scale	Percentage of Exceedance
I	Pedestrian sitting	4		5%
II	Pedestrian standing & Entrances	6		5%
III	Pedestrian walking	8		5%
IV	Business walking & Cycling	10		5%
V	Unacceptable for Pedestrian Use	>10		>5%

3.9 If a category in Table 3-1 is shown in a Lawson comfort plot then that area will be acceptable for that category and all those with less onerous thresholds (i.e. those categories below it in the table). For example, if an area is coloured with yellow in the Lawson comfort plot, it will be acceptable if its proposed use is “Pedestrian walking" and/or "Business walking/Cycling", but not acceptable if the proposed use is "Pedestrian standing" and/or "Pedestrian sitting".

3.10 It is important that entrance doors be situated in areas that provide a slow transition from the calm indoor area to the windier exterior. Entrance doors should have an area acceptable for pedestrian standing directly outside.

3.11 As a guide to the experience of various wind speeds please refer to Table 3-2.

3.12 Distress caused by extreme winds was also considered. The Lawson LDDC method for the distress criteria was used, as set out in Building Aerodynamics (Lawson, 2001). Distress is considered to be when "*someone could find walking difficult or could even stumble or fall*". Furthermore, the Lawson distress criteria state that for elderly or infirm pedestrians and cyclists, the hourly mean wind speed should not exceed 15 m/s for more than 0.025% of the year (approximately 2 hours). For able-bodied pedestrians, the hourly mean wind speed limit should not exceed 20 m/s for more than 0.025% of the year.

Table 3-2 Description of Beaufort Scale

Beaufort Force	Hourly average wind speed (m/s)	Description of wind	Noticeable effect of wind
2	1.55 – 3.35	Light	Wind felt on faces: leaves rustle; wind vanes move
3	3.35 – 5.60	Light	Leaves and twigs in motion; wind extends a flag
4	5.60 – 8.25	Moderate	Raises dust and loose paper; small branches move
5	8.25 – 10.95	Fresh	Small trees in leaf sway
6	10.95 – 14.10	Strong	Large branches begin to move; telephone wires whistle

Computational Fluid Dynamics (CFD)

3.13 The assessment was undertaken through Computational Wind Engineering (CWE) which uses CFD techniques to model the wind conditions at full scale and simulate conditions around the proposed development site. Simulations of the Site's microclimate were conducted using ANSYS CFX CFD software.

3.14 The aim of the simulations was to reproduce the macro-level wind regime around the proposed buildings under the baseline and proposed scenarios. 36 wind directions (every 10° around the compass) were analysed using representative strong winds applied to a full 3D model of the baseline scenario and of the proposed development within the existing local built environment.

3.15 This is done through modelling a computational domain, divided into millions of separate cells, allowing results to be reported in high resolution.

3.16 It is recommended (Tominaga, 2008) that the domain should extend upstream by at least distance five times the height of the building being analysed. In this analysis, the heights of buildings on the development site were smaller than some of the upstream obstacles such as London Stadium. The domain extended to ~1.5km from the proposed development in all directions in order to include sufficient representation of the upstream terrain, including these larger buildings which would have a significant effect on flow towards the development site.

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

3.18 The dependent variables are as follows:

- Velocities in the three co-ordinate directions (U, V, W)
- Pressure (P)

- Turbulence Kinetic Energy (k)
- Turbulence Dissipation Rate (ε)
- Turbulence Specific Dissipation (ω)

3.19 To improve the resolution of the results, the mesh was concentrated in the areas of most interest (at pedestrian level around the proposed development) and around any significant small-scale flow features. This ensures greater accuracy of the variables under investigation.

Mesh

3.20 An example of a typical CFD mesh used in these types of study is shown below.

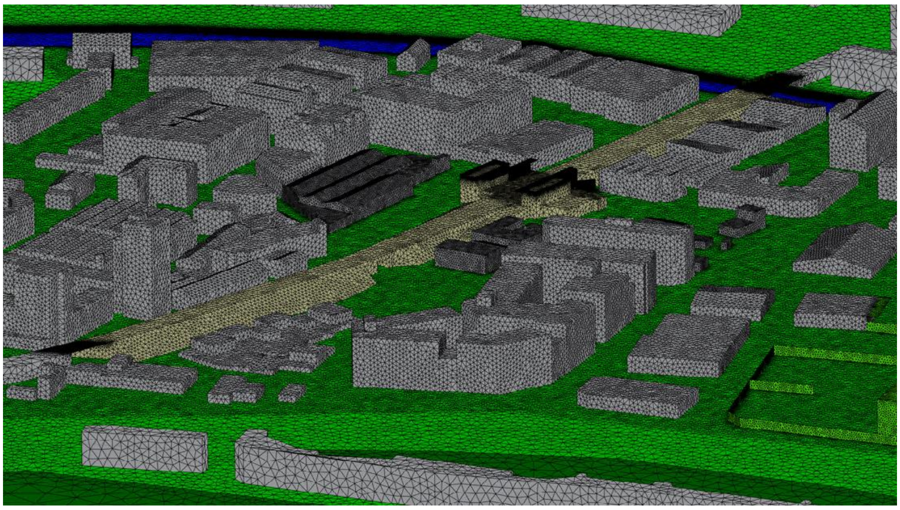

Figure 3-1: Example of a computational mesh

Boundary Conditions

3.21 Around the perimeter of the 3D domain, a profile for the velocity and turbulence parameters was specified to account for the variation in wind speed with height from the ground. Surfaces within the model were specified as having 'no slip'. This condition ensures that flow is brought to rest at the point where it meets the surface. In addition, an appropriate sand-grain roughness was specified on each surface to account for the roughness expected in practice.

Atmospheric Boundary Layer Profile

3.22 Accurate specification of the atmospheric boundary layer profile is crucial in correctly simulating the pedestrian level wind environment. For this reason, a logarithmic profile was assumed, which creates an atmospheric boundary layer profile based on the assumption that wind speed increases proportionally with the natural logarithm of the height from the ground. The upstream logarithmic velocity profile and turbulence profiles were applied for the simulations. This velocity profile is representative of most strong winds.

Trees and Vegetation

3.23 Vegetation was modelled by imposing a momentum loss through portions of the fluid domain occupied by such features. A loss coefficient per meter of impeded domain of 0.875 m^{-1} was used. Larger trees are able to provide greater resistance to incident flow.

3.24 The influence of trees has not been differentiated according to species and no seasonal changes have been considered.

Other Porous Obstacles

3.25 Fences in key locations such as the railing around the A&E ramp of the old hospital and the porous mitigation screen by the southern corner of the new hospital building which are not fully solid are modelled using a similar method to trees.

3.26 Experimental and theoretical data from (Idelchik, 2007) were used to estimate the loss coefficient per metre of impeded domain as 15 m^{-1} for lower half of the A&E ramp fence. As a conservative measure, the upper half was assumed fully permeable in the simulations.

3.27 Similarly, the loss coefficient per meter for the mitigation screen with a 50% porosity was estimated to be 18 m^{-1}.

Transient Effects

3.28 The standard industry method of assessing pedestrian comfort with computer simulations is to perform a series of steady-state simulations from different wind directions. These are then combined into ‘Lawson Comfort plots’.

3.29 The transient (varying in time) portion of the flow field is represented as a time-averaged turbulence at each point in the domain.

3.30 The velocity fluctuations, calculated from the recorded turbulent kinetic energy, have been included in the current Lawson study. All discussions of results include this consideration of turbulence.

3.31 Figure 3-2 shows an idealised diagram of airflow around a building block (Davidson, 2004). It is these mechanisms, amongst others, that introduce turbulence in the real world and the simulation.

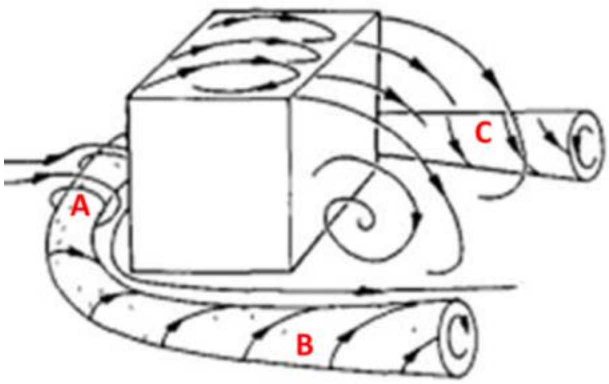

Figure 3-2: Schematic of turbulent airflow around a building block.

4. Assessment Inputs

4.1 This section presents the sources of information that have been consulted throughout the preparation of this assessment.

Input and information sources

4.2 The following sources of information that define the new hospital, proposed development and surrounding built area have been reviewed and form the basis of this assessment:

- 3D CAD model of New Hospital:
  - THHR_01-IBI-WB-ZZ-M3-A-0005_Ver25.rvt
- 3D CAD model of Multi-storey parking:
  - THHR_02-IBI-WB-ZZ-M3-A-0003_Ver20.rvt
- 3D CAD model of Proposed buildings and surroundings:
  - THHR_01-IBI-WS-ZZ-M3-A-0001_Ver3.rvt
- 2D Plan drawing of the landscape layout:
  - THHR_01-IBI-WS-XX-DR-L-700000_P03.pdf

4.3 The following sources of information were additionally consulted for this assessment:

- Lidar data of the existing surroundings from environment.data.gov.uk.

Geometry

4.4 Figure 4-1, Figure 4-2, Figure 4-3, and Figure 4-4 show the geometries for the four stages of progression through the development of the site as simulated in this study. The site boundary is demarcated with a red line in each figure.

4.5 Table 4-1 lists the sand-grain roughness values used for solid boundaries in the simulation. These boundaries are colour coded in the geometry images.

Table 4-1 Summary of sand-grain roughness values for CFD boundary conditions and surface colours in geometry figures

Surface	Ks, Sand-grain Roughness [m]	Colour in Geometry Figures
Buildings (on-site)	0.01	(White)
Buildings (surrounding)	0.01	
Ground	0.1	

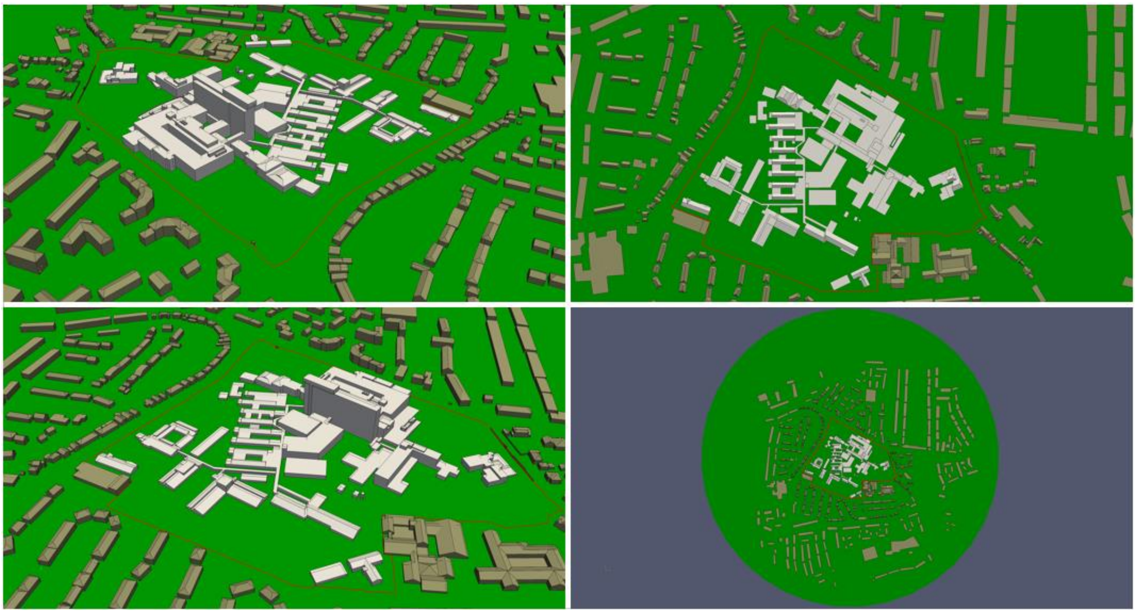

Figure 4-1: Geometry – 01 Baseline

4.6 Figure 4-1 shows the geometry as it exists before the commencement of any demolition or construction relating to the proposed developments. This forms the baseline geometry for this assessment – “01 Baseline” – and includes the main old hospital building towards the north east of the site and the low-rise, post-war ancillary buildings towards the west.

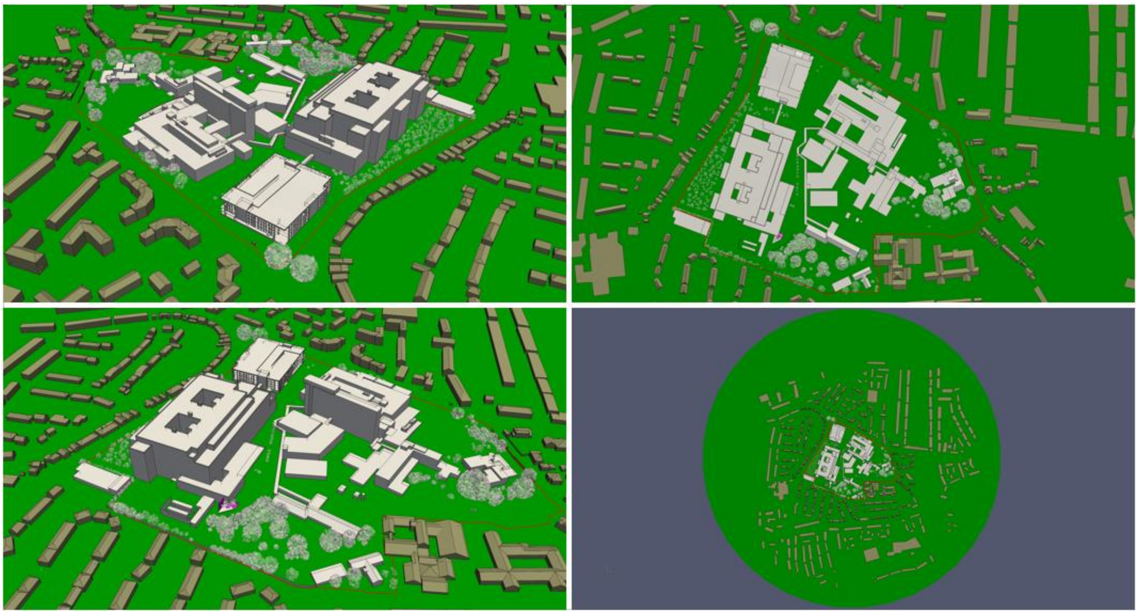

Figure 4-2: Geometry – 02 New Hospital

4.7 Figure 4-2 shows the geometry of the site following construction of the new hospital building and the adjacent multi-storey parking building. The low-rise, post-war ancillary buildings towards the west of the site have been demolished to make room for this new development. The main new hospital building is situated towards the south west of the site and the multi-story parking building towards the north. This is the second scenario/case in this investigation – “02 New Hospital”. This scenario represents the conditions for a limited time period, the duration of which is dependent on the time it takes to move all hospital operations from the old main building to the new main building.

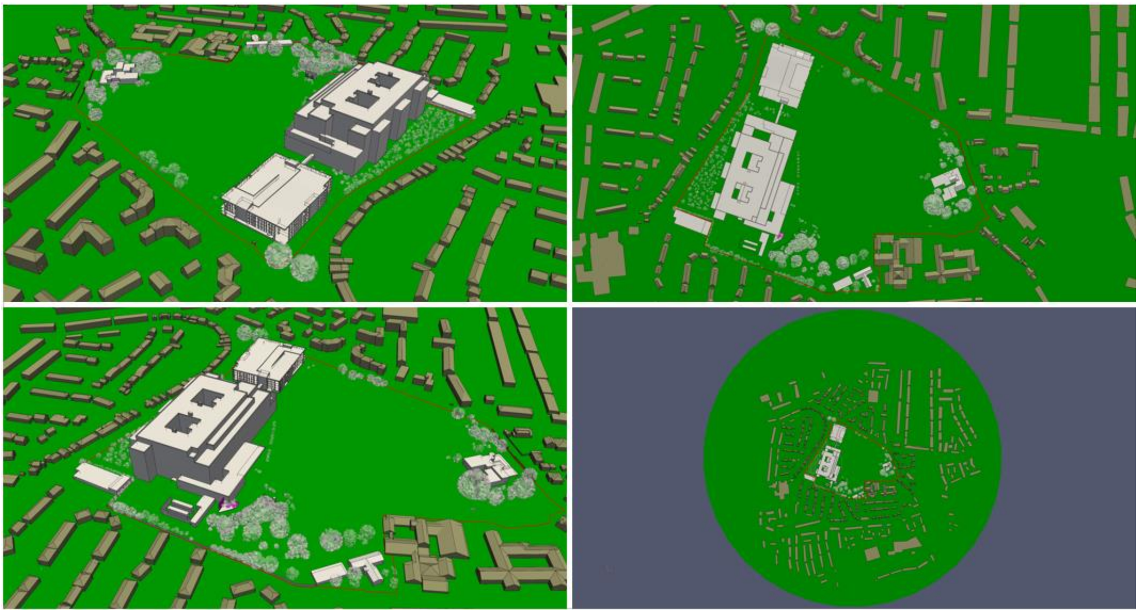

Figure 4-3: Geometry – 03 Old Demolished

4.8 Figure 4-3 shows the geometry of the site following demolition of the main old hospital building. The site is rendered largely empty, however it is not anticipated that the empty space would be opened to the public. This forms the third scenario/case in this investigation – "03 Old Demolished". This scenario represents the conditions only for a limited period of time and, as a conservative estimate, would last until the main external structures of the proposed mixed-use buildings are complete.

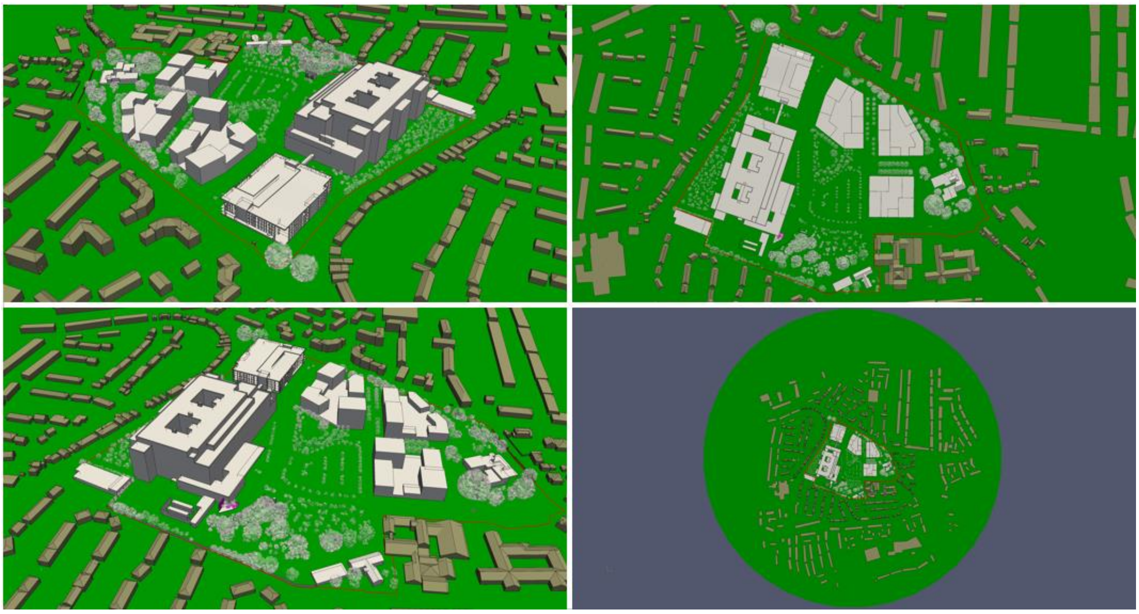

Figure 4-4: Geometry – 04 Proposed

4.9 Figure 4-4 shows the geometry of the site following completion of the proposed mixed-use buildings towards the north east of the site. This forms the fourth scenario/case in this investigation – "04 Proposed" – and represents the final/completed state of the proposed developments.

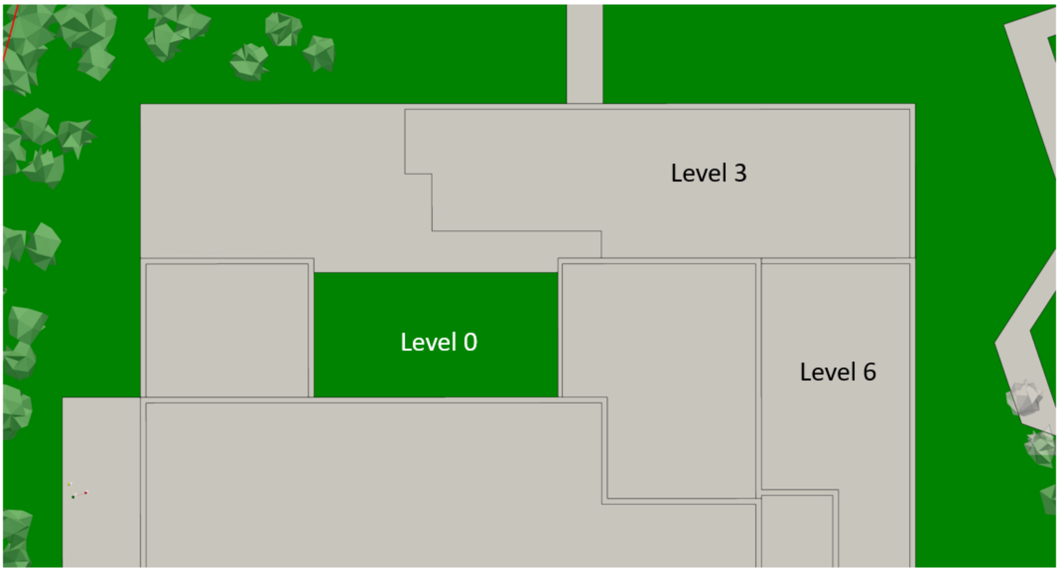

Figure 4-5: Geometry – Pedestrian Terraces on the New Hospital Building

4.10 Figure 4-5 indicates the locations of the pedestrian terraces (i.e. accessible to the public) of the new hospital building introduced in the second scenario.

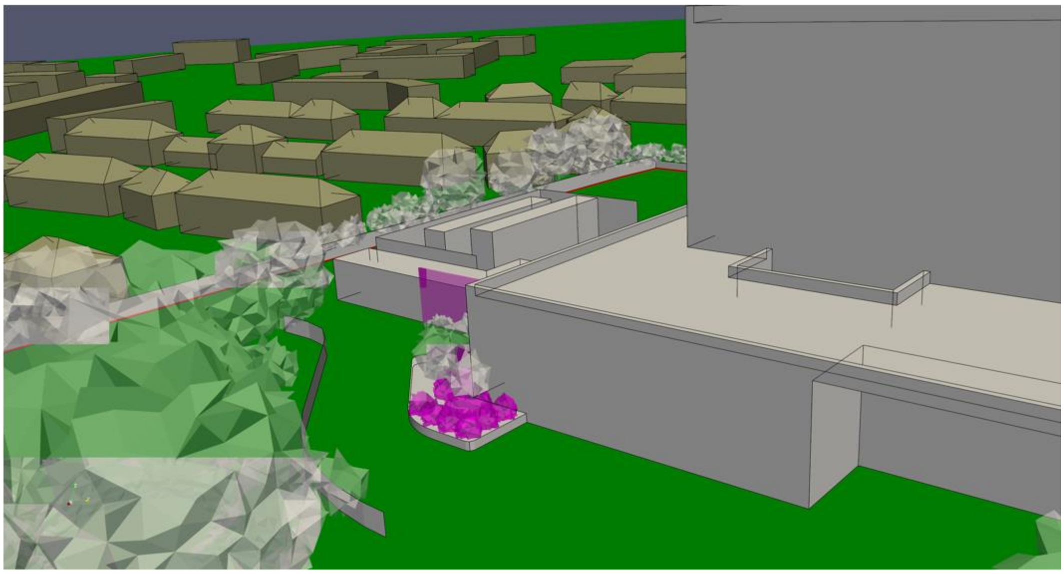

Figure 4-6 Geometry – Mitigation Features on the New Hospital Building

4.11 Figure 4-6 shows a closer perspective of the mitigation features on the southern/south eastern corner of the new hospital building. This includes a planter with trees (translucent white/grey) and shrubs (translucent magenta) as well as a porous screen (translucent magenta). This mitigation was included to alleviate a distress region indicated in this area during previous simulations. Note that this geometry represents the function of the space for simulation purposes and may not be indicative of the final aesthetics in practice.

Wind Data Analysis

4.12 The wind data used for the analysis was from Heathrow Airport, covering a period of 20 years. It is in the form of hourly-averaged wind velocities, measured at 10m above ground. A wind rose for Heathrow Airport is shown in Figure 4-7, which indicates that the prevailing wind direction is south-westerly (mode direction is 210° from north).

4.13 The input wind data was received in a format lumped by velocity and wind direction. The wind directions are measured in 22.5° increments. This data was interpolated and redistributed into a probability distribution for each of 36 wind directions (10° increments).

4.14 Average wind speed increases with distance from the ground and this, along with turbulence effects, has a significant impact on the resulting wind profiles around the buildings. When assessing pedestrian level wind speeds, wind data is modified to account for terrain roughness around the data source location and the resulting wind velocity profile.

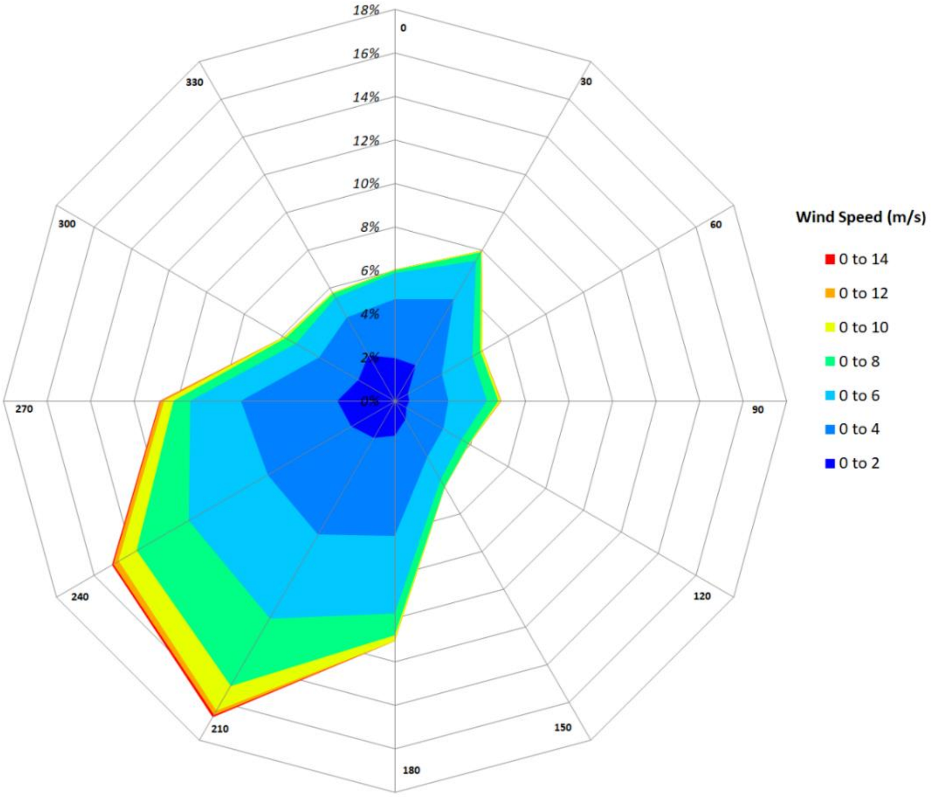

Figure 4-7: Wind Rose for Heathrow Airport

Roughness Values for Surrounding Terrain

Table 4-2: Terrain Categories and Related Parameters

Terrain Category		Z_0 [m]
0	Sea of coastal areas exposed to open sea.	0.003
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles.	0.01
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights.	0.05
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacles heights (such as villages, suburban terrain, permanent forest).	0.3
IV	Area in which at least 15% of the surface is covered with buildings and their average height exceeds 15 m	1.0

4.15 The roughness of the upwind ground surface is important in the formulation of the atmospheric boundary layer, and as a result will affect the wind velocity felt at pedestrian level on the site. Table 4-2 indicates the roughness, z0, appropriate for various terrains surrounding a site. An approaching terrain roughness is chosen, at 30° intervals, according to the method described in (BS EN, 2010).

4.16 The roughness values used to define the wind profile approaching the domain are as shown in Table 4-3.

Table 4-3: z0 roughness assigned to approaching atmospheric boundary layer.

Degrees east from north	Category	z0 (m)
000	II	0.05
030	III	0.3
060	III	0.3
090	III	0.3
120	II	0.05
150	II	0.05
180	II	0.05
210	III	0.3
240	II	0.05
270	II	0.05
300	II	0.05
330	II	0.05

Roughness Values for Modelled Obstacles

4.17 A sand-grain roughness is applied to each surface in the model to represent likely features on a surface. Figure 4-8 indicates the theory behind the value (Ansys CFX Theory Guide, Figure 2.6, 2015). The surfaces are assigned a sand-grain roughness as shown in Table 4-3.

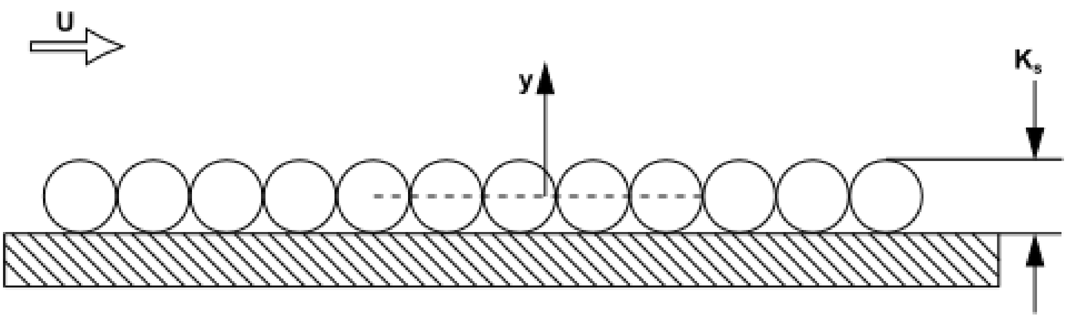

Figure 4-8: Diagram with value of sand-grain roughness labelled as K_s

Intended Pedestrian Uses

4.18 Levels of pedestrian comfort strongly depend on individual activity. Therefore, the Lawson Comfort criteria are defined for each activity in terms of a threshold wind speed, which should not be exceeded for more than 5% of the year. In addition, building entrances must experience wind conditions acceptable for pedestrian standing.

5. Results

5.1 Simulations were performed on the following scenarios/cases:

1. **Baseline** – existing hospital buildings, tower, and low-rise post-war buildings,
2. **New Hospital** – existing hospital and new hospital (replacing low-rise ancillary buildings within in the phase 1 boundary),
3. **Old Demolished** – new hospital only (remaining existing hospital buildings and tower demolished for new development), and
4. **Proposed** – new hospital and the proposed mixed-use developments.

5.2 Additional simulation with only key wind directions updated:

5. **Supplement** – Old Demolished, including off-site trees

5.3 Results are reported on planes 1.5m above the areas of interest.

Lawson Distress

5.4 None of the scenarios indicated any distress at 1.5 m above ground or the terraces for a 20 m/s wind speed threshold – this is representative of danger to able-bodied pedestrians according to the Lawson method.

5.5 Figure 5-1, Figure 5-2, Figure 5-3, and Figure 5-4 show the Lawson Distress results at 1.5 m above ground for a 15 m/s wind speed threshold – this is representative of danger to frail and elderly pedestrians according to the Lawson method.

5.6 Distress, plotted in red, indicates regions where the analysis predicts wind speeds of 15 m/s or greater for 2.19 hours (0.025%) or more of a typical year (as determined by historical weather data).

5.7 The site boundary is shown with the yellow line.

5.8 All scenarios, except the third (03 Old Demolished – Figure 5-3), did not indicate distress with a 15 m/s threshold.

5.9 Lawson Distress (15 m/s) results for the scenario following demolition of the old hospital (Figure 5-3) show a small region indicating potential distress. This is highlighted with the magenta rectangle.

5.10 This distress region is approximately 9.8 m^2 in size and winds exceeding the 15 m/s threshold are predicted to occur for at most 2.5 hours per year.

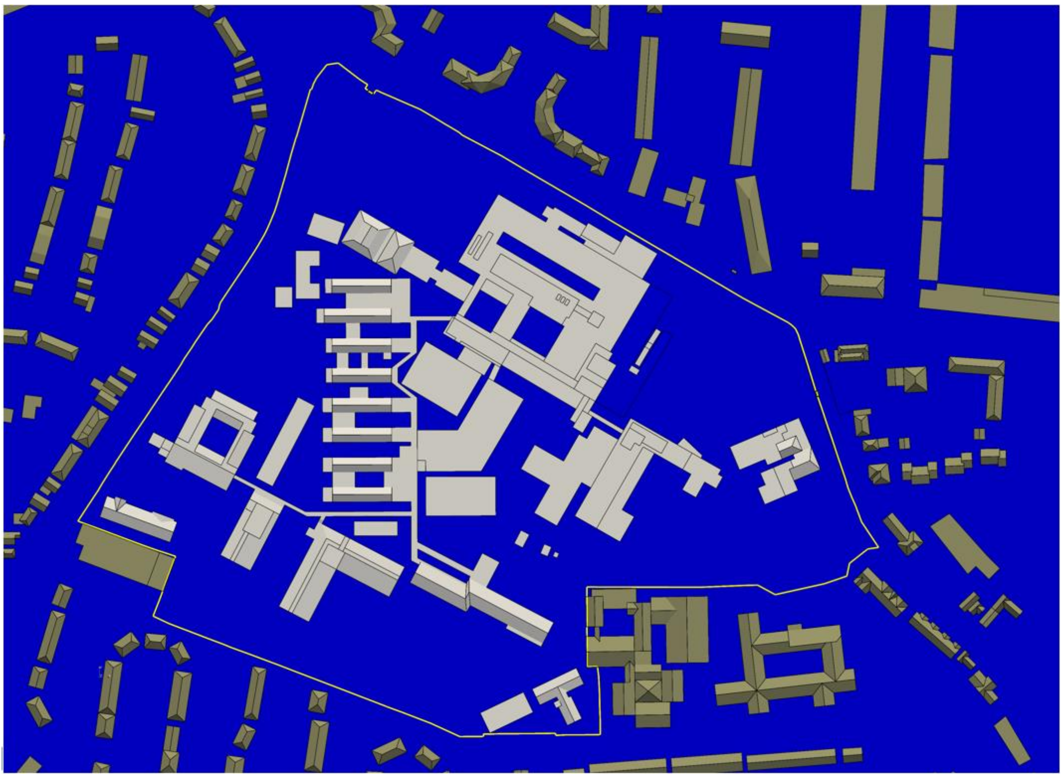

Figure 5-1: Lawson Distress (15 m/s) 1.5 m above Ground – 01 Baseline

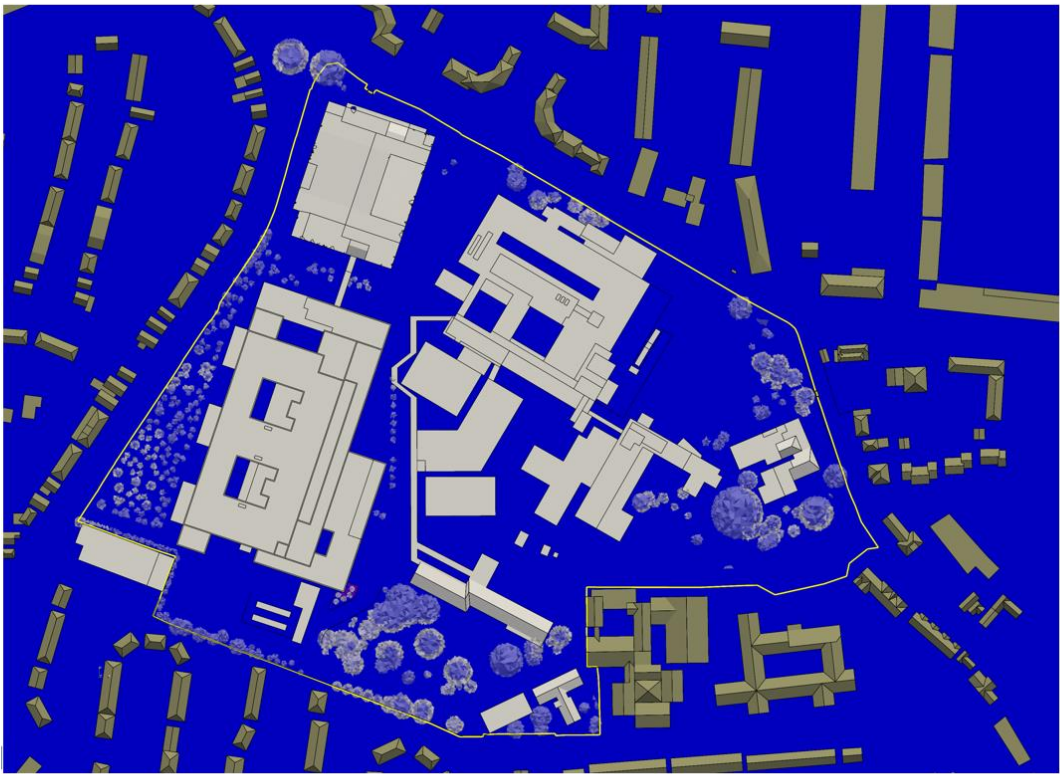

Figure 5-2: Lawson Distress (15 m/s) 1.5 m above Ground – 02 New Hospital

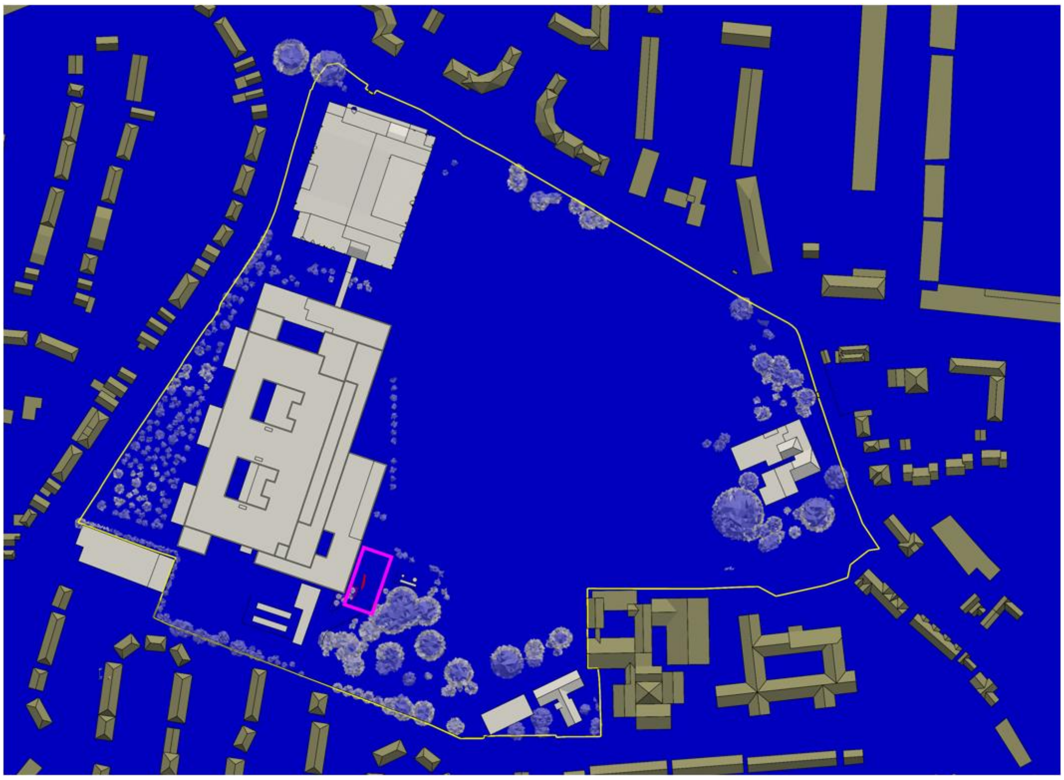

Figure 5-3: Lawson Distress (15 m/s) 1.5 m above Ground – 03 Old Demolished

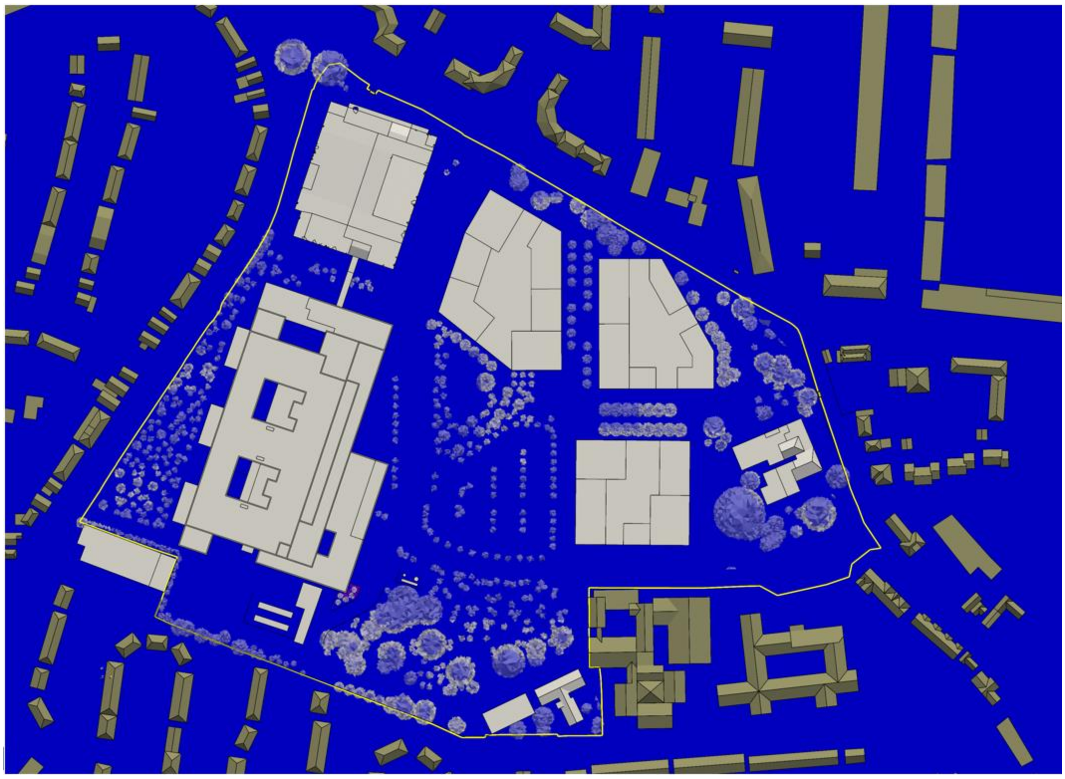

Figure 5-4: Lawson Distress (15 m/s) 1.5 m above Ground – 04 Proposed

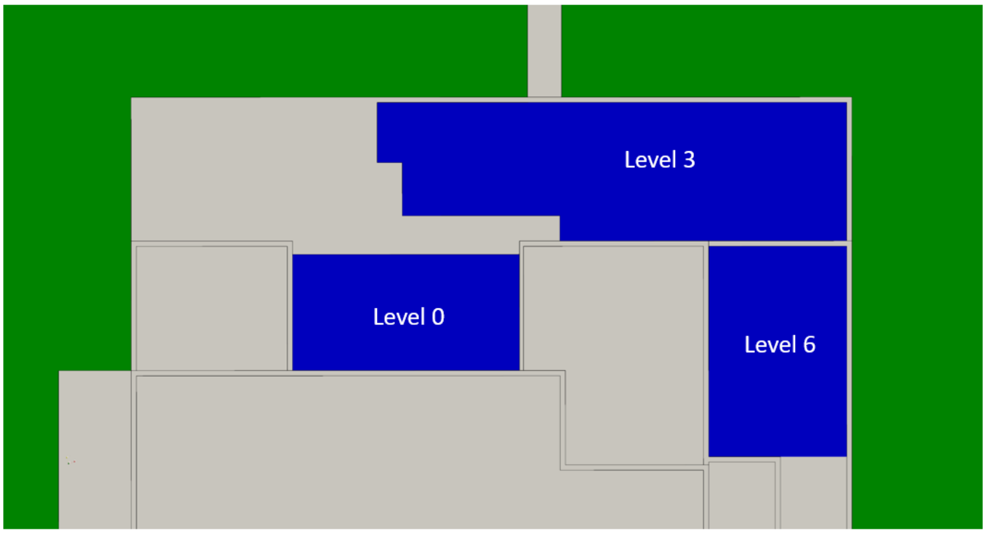

Figure 5-5: Lawson Distress 1.5 m above Terraces

5.11 Figure 5-5 shows the Lawson Distress results 1.5 m above the terraces of the New Hospital building for a 15 m/s wind speed threshold.

5.12 No distress is indicated on these Terraces for any of the scenarios.

Lawson Distress – Supplement

5.13 Figure 5-6 shows the Lawson Distress (15 m/s) results for the scenario following demolition of the old hospital where the simulation has been augmented to include the effect of trees lying beyond the development site (highlighted with the dashed yellow box – "off-site trees") for the most influential wind directions – "05 Supplement".

5.14 The region highlighted with the magenta rectangle in Figure 5-3 and Figure 5-6 was found to be most heavily influenced by wind angles from 210° to 260°, i.e. the strongest and most frequent winds emanate from these directions.

5.15 The supplementary result (Figure 5-6) combines simulations for wind angles from 210° to 260° including the off-site trees (a less conservative, but possibly more accurate estimate of wind conditions) with those of the remaining wind angles where the off-site trees are not included (a more conservative estimate, but possibly less accurate estimate of wind conditions).

5.16 No distress is indicated in this case.

5.17 These results show that the distress indicated in the scenario following complete demolition of the old hospital (03 Old Demolished) is small enough in size and benign enough in intensity that the inclusion of some surrounding off-site trees, giving a less conservative and possibly more accurate estimate of wind microclimate conditions, completely removes this distress. It is expected that the inclusion of even more of the surrounding off-site trees in simulations would have further beneficial mitigating effects.

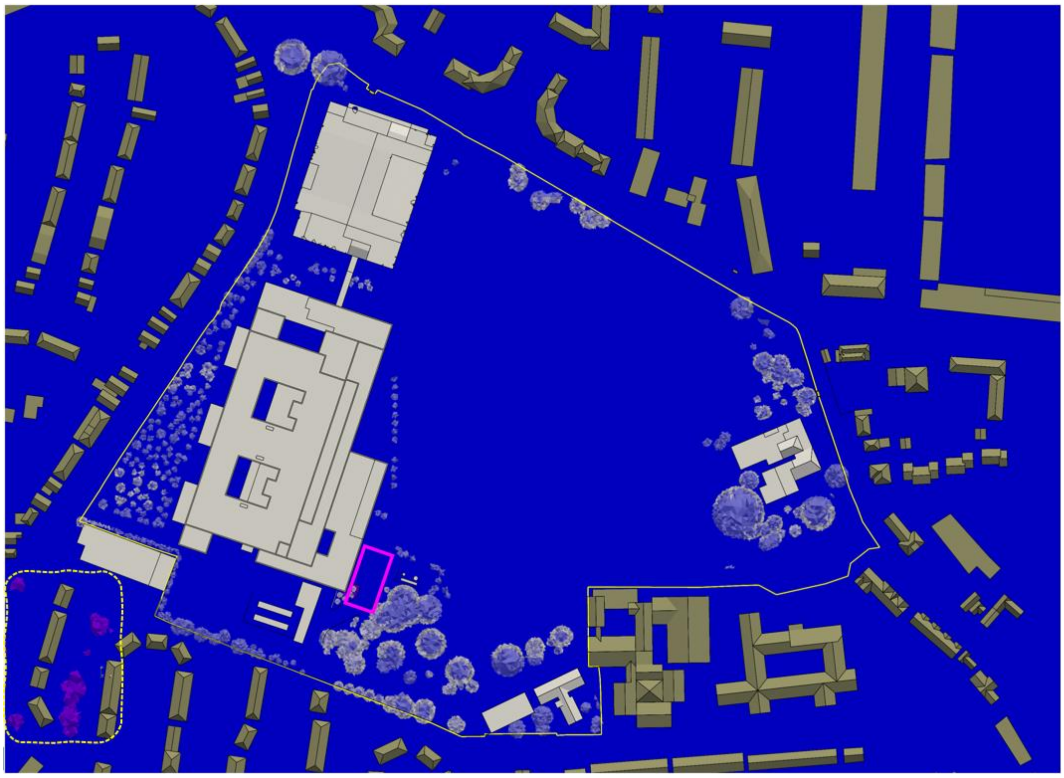

Figure 5-6: Lawson Distress (15 m/s) 1.5 m above Ground – 05 Supplement: Old Demolished, including off-site Trees

Lawson Comfort

5.18 Figure 5-7, Figure 5-8, Figure 5-9, and Figure 5-10 show the Lawson comfort results for the four scenarios of this study as reported 1.5 m above ground – a standard representative pedestrian height.

5.19 Refer to Table 3-1 for the interpretation of colours in terms of Lawson comfort categories.

5.20 Within each colour category, the brightness is graded to provide a finer scale – darker shades indicate windier/less comfortable conditions.

5.21 The site boundary is shown with the red line.

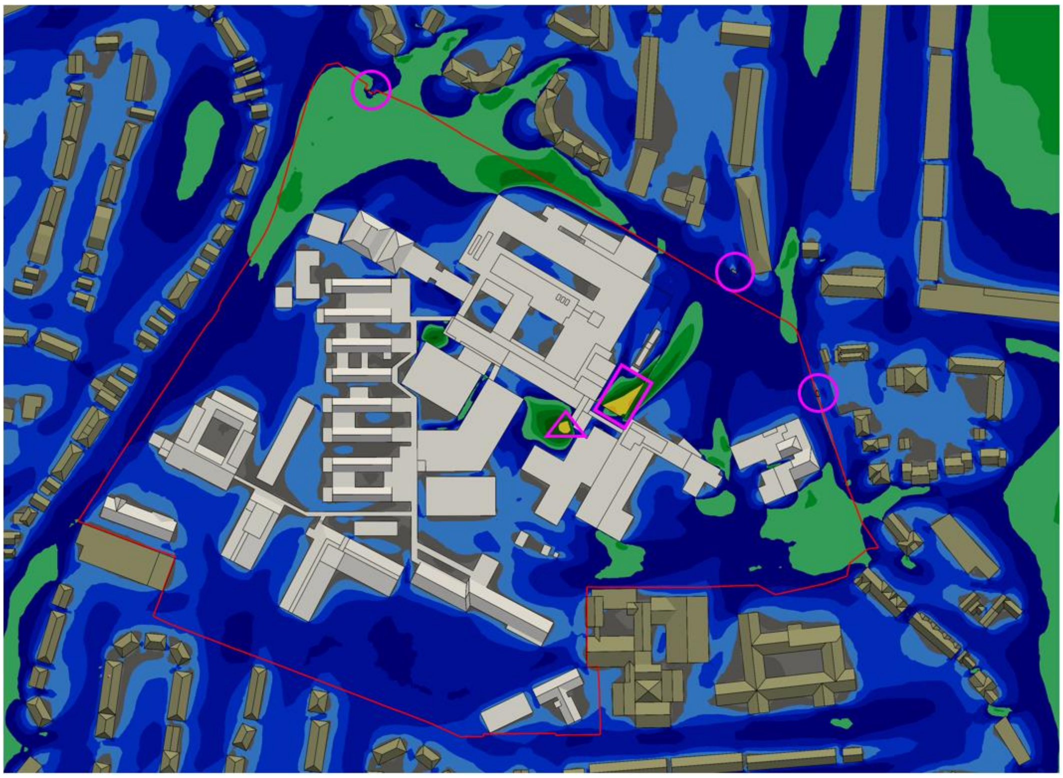

Figure 5-7: Lawson Comfort 1.5 m above Ground – 01 Baseline

0	Sheltered	<2.5	
I	Pedestrian sitting	4	
II	Pedestrian standing & Entrances	6	
III	Pedestrian walking	8	
IV	Business walking & Cycling	10	
V	Unacceptable for Pedestrian Use	>10	

5.22 Lawson comfort results for the baseline scenario (Figure 5-7) show that most areas are comfortable for sitting with some areas comfortable for standing and 2 locations identifiable as comfortable for walking.

5.23 The locations of the bus shelters are highlighted with magenta circles; results show that the immediate surroundings of all three are comfortable for sitting.

5.24 The magenta rectangle highlights the A&E entrance are which includes a region deemed comfortable for walking but not standing or sitting.

5.25 The magenta triangle highlights another region deemed comfortable for walking but not standing or sitting.

5.26 Trees and vegetation have been excluded from this simulation to provide a conservative estimate for wind microclimate results in this case – trees are expected to have a mitigating effect.

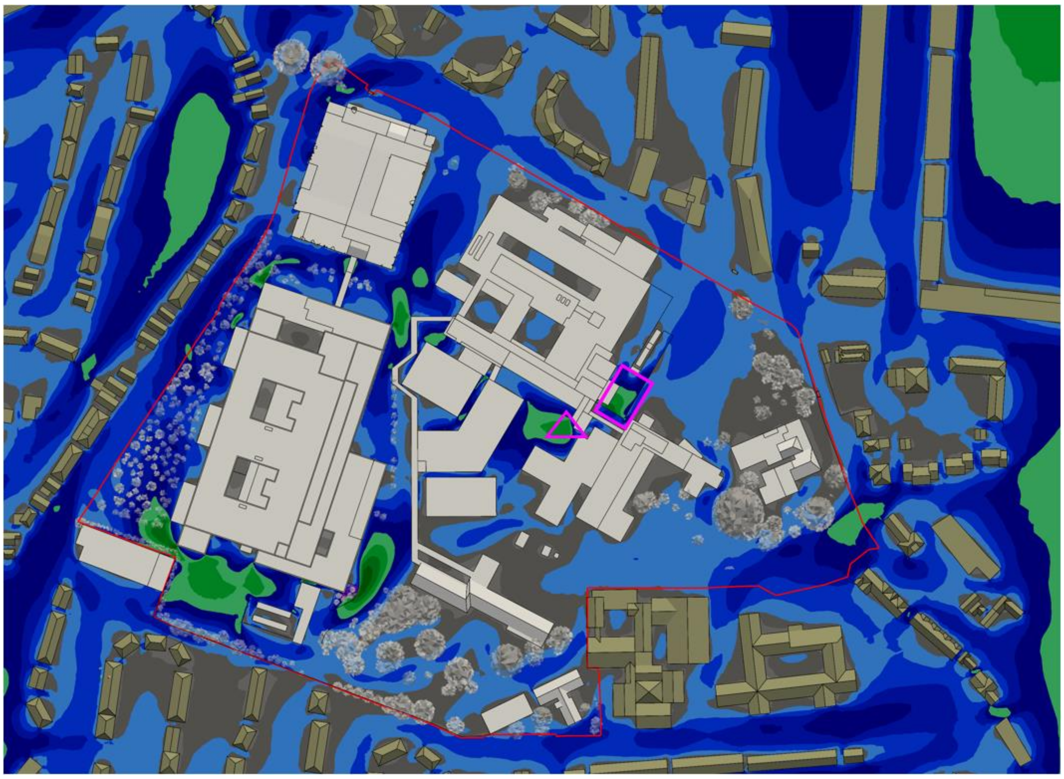

Figure 5-8: Lawson Comfort 1.5 m above Ground – 02 New Hospital

0	Sheltered	<2.5	
I	Pedestrian sitting	4	
II	Pedestrian standing & Entrances	6	
III	Pedestrian walking	8	
IV	Business walking & Cycling	10	
V	Unacceptable for Pedestrian Use	>10	

5.27 Lawson comfort results for the scenario following completion of the new hospital (Figure 5-8) shows improvements in comfort around the old hospital – the A&E entrance is now comfortable also for standing.

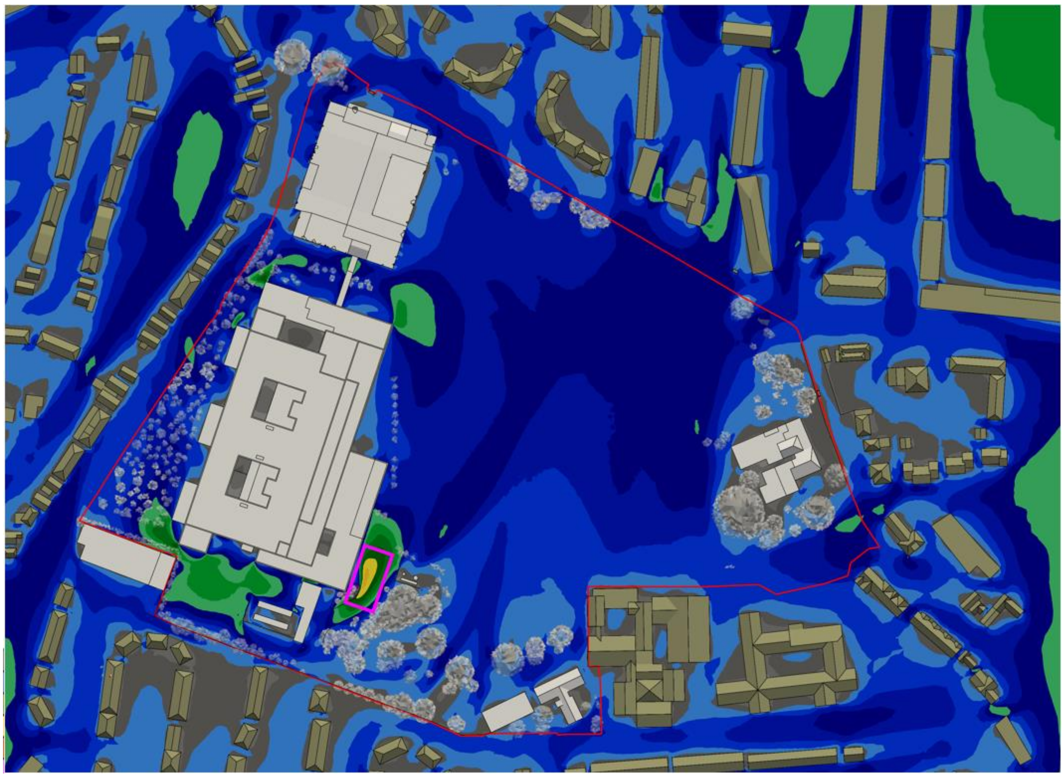

Figure 5-9: Lawson Comfort 1.5 m above Ground – 03 Old Demolished

0	Sheltered	<2.5	
I	Pedestrian sitting	4	
II	Pedestrian standing & Entrances	6	
III	Pedestrian walking	8	
IV	Business walking & Cycling	10	
V	Unacceptable for Pedestrian Use	>10	

5.28 Lawson comfort results for the scenario following demolition of the old hospital (Figure 5-9) shows a decrease in wind comfort compared to the scenario before demolition (Figure 5-8) as is indicated by darker colour shades.

5.29 The magenta rectangle highlights a region which has emerged to be comfortable for walking but not standing or sitting by the ambulance loading bays.

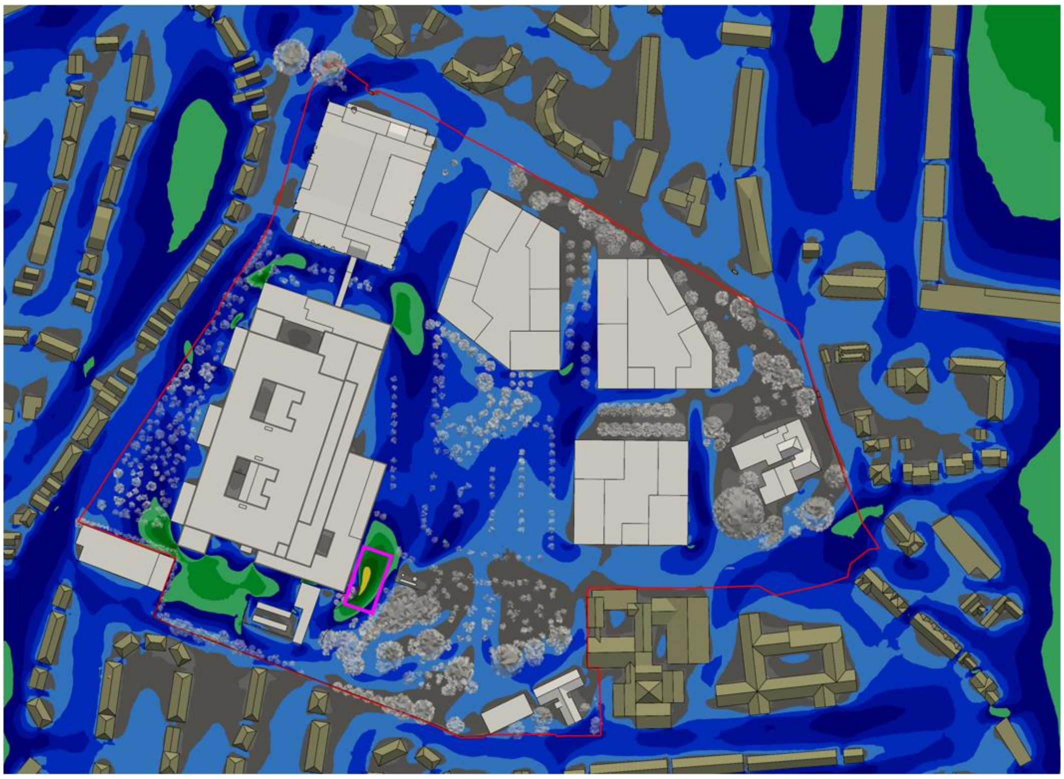

Figure 5-10: Lawson Comfort 1.5 m above Ground – 04 Proposed

0	Sheltered	<2.5	
I	Pedestrian sitting	4	
II	Pedestrian standing & Entrances	6	
III	Pedestrian walking	8	
IV	Business walking & Cycling	10	
V	Unacceptable for Pedestrian Use	>10	

5.30 Lawson comfort results for the scenario following completion of the proposed mixed-use buildings (Figure 5-10) show slightly improved comfort.

5.31 The magenta rectangle highlights the same region which is comfortable for walking but not standing or sitting by the ambulance loading bays, however it has reduced in size.

5.32 It can be observed from the comfort results that there is an asymmetry in wind representation with a bias towards the prevailing wind direction from historical data – this is expected since the Lawson method appropriately ascribes greater importance to more frequent wind conditions. Comparing Figure 5-7 (01 Baseline) and Figure 5-8 (02 New Hospital), the introduction of the new hospital building shields the old hospital from the prevailing wind direction but reduces comfort ahead of the new hospital walls which are facing the prevailing wind direction. This is characteristic of downwash on large flat faces.

5.33 Comparing Figure 5-8 (02 New Hospital) and Figure 5-9 (03 Old Demolish), demolition of the old hospital significantly reduces the blockage behind the new hospital building imposed on airflow from the prevailing wind direction. This increases the airflow rounding the corners of the new hospital building and is observed as reduced comfort conditions. The effect of blockage 'behind' the new hospital building in the direction of the prevailing wind is also observed with the improved comfort conditions in the Proposed scenario (Figure 5-10) compared to the Old Demolish scenario (Figure 5-9).

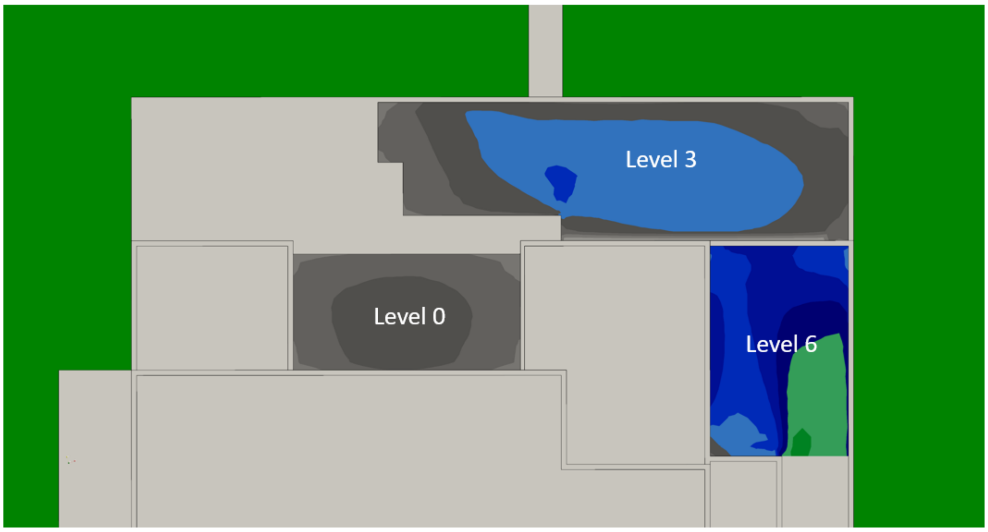

Figure 5-11: Lawson Comfort 1.5 m above Terraces – 03 Old Demolished

0	Sheltered	<2.5	
I	Pedestrian sitting	4	
II	Pedestrian standing & Entrances	6	
III	Pedestrian walking	8	
IV	Business walking & Cycling	10	
V	Unacceptable for Pedestrian Use	>10	

5.34 Figure 5-11 shows the Lawson comfort results 1.5 m above pedestrian terraces at various levels on the new hospital building for the scenario following demolition of the old hospital.

5.35 The results for the other scenarios were near identical – all terraces are comfortable for sitting, except a region on the level 6 terrace which is comfortable for standing.

5.36 Landscaping features such as planters, vegetation and seating have not been included to provide a conservative estimate of the comfort results – these features are expected to have a mitigating effect.

6. Conclusion

6.1 The following scenarios/cases have been simulated:

1. **Baseline** – existing hospital buildings, tower and low-rise post-war ancillary buildings,
2. **New Hospital** – existing hospital and new hospital (replacing the low-rise ancillary buildings within phase 1),
3. **Old Demolished** – new hospital only (remaining existing hospital buildings and tower demolished for new developments), and
4. **Proposed** – new hospital and the proposed mixed-use developments.

6.2 Additional simulation with only key wind directions updated:

5. **Supplement** – Old Demolished, including off-site trees.

6.3 Lawson comfort results for each scenario at 1.5 m above ground or 1.5 m above designated pedestrian terraces of the new hospital building showed that there were no regions which were completely uncomfortable for all pedestrian activities. The acceptability of the comfort results is dependent on the intended pedestrian uses.

6.4 The designated pedestrian terraces were found to be comfortable for sitting and standing; this matches their anticipated intended use as incidental seating/standing waiting areas and is acceptable according to the Lawson criteria.

6.5 A region not comfortable for sitting was observed on the level 6 terrace. The other terraces were consistently comfortable for sitting. level 6 terrace is anticipated to be managed as incidental seating (i.e. microclimate conditions would be acceptable for sitting depending on the calmness of a particular day rather than requiring long-term calm/sitting conditions). No intervention would be required since the region is safe (no distress indicated – see Figure 5-5) and the accepted level of comfort is at the discretion of the individual user.

6.6 The immediate surroundings of the bus shelters were found to be comfortable for sitting; this matches their anticipated intended use of sitting (and standing) and is acceptable according to the Lawson criteria.

6.7 The perimeters of buildings were found to be comfortable for sitting and standing; this matches their anticipated intended use as entrances and is acceptable according to the Lawson criteria.

6.8 The ambulance loading bays and adjacent access road for the new hospital building, towards its south eastern corner, was found to have a region comfortable for walking; this matches the anticipated intended use of walking and is acceptable according to the Lawson criteria.

6.9 The remainder of the site was found to be mostly comfortable for sitting, but no less comfortable than for standing (i.e. no other regions not suitable for either sitting or standing); this matches the anticipated intended use as pedestrian thoroughfare (walking) and incidental seating and is acceptable according to the Lawson criteria.

6.10 The present study did not find indication of distress regions with a 20 m/s threshold for any scenario at 1.5 m above ground or 1.5 m above the designated pedestrian terraces of the new hospital building; the wind microclimate can be considered safe for able-bodied pedestrians according to the Lawson criteria.

6.11 The present study did not find indication of distress regions with a 15 m/s threshold for any scenario at 1.5 m above ground or 1.5m above the pedestrian terraces except for the scenario following demolition of the old hospital (03 Old Demolished – Figure 5-3), and only when the mitigating effect of trees beyond the boundary of the development site are omitted. Lack of distress with a 15 m/s threshold can be considered safe for all pedestrians (including the frail, elderly, or infirm, and even cyclists) according to the Lawson criteria.

6.12 The scenario prior to commencing any works on the site (01 Baseline) did not indicate any distress; the wind microclimate can be considered safe according to the Lawson criteria.

6.13 The scenario following completion of the new hospital (02 Hew Hospital) did not indicate any distress; the wind microclimate can be considered safe according to the Lawson criteria for the duration of this scenario.

6.14 The scenario following complete demolition of the old hospital did not indicate any distress if the mitigating effects of surrounding off-site trees were included (05 Supplement), however a small region of distress was indicated in the conservative estimate where no surrounding off-site trees were included (03 Old Demolished); provided the effect of surrounding trees can be relied on for the duration that this scenario represents the state of the site, the wind microclimate could be considered safe according to the Lawson criteria.

6.15 This distress region is small, approximately 9.8 m^2, where winds exceeding the 15 m/s threshold are predicted to occur for at most 2.5 hours per year. Durations greater than 2.19 h (0.025% of a typical year) are considered distressful. This result represents a conservative estimate of the likely wind microclimate conditions.

6.16 It has been shown that the inclusion of surrounding off-site trees in simulations have beneficial mitigating effects. It is expected that the inclusion of even more of the surrounding off-site trees in simulations would demonstrate calmer wind microclimate condition, giving a less conservative but possibly more accurate estimate.

6.17 The scenario following completion of the proposed mixed-use buildings (04 Proposed) did not indicate any distress; the wind microclimate can be considered safe according to the Lawson criteria.

6.18 The conditions following completion of all proposed works in this application are represented by the scenario: 04 Proposed. The results of this investigation show that the wind microclimate conditions for this scenario are comfortable for their anticipated intended pedestrian uses and are acceptable according to the Lawson Criteria. The conditions can also be considered safe according to the Lawson criteria.

7. References

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