



WIND MICROCLIMATE ASSESSMENT REPORT

Piccadilly Wharf, Manchester

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APPENDIX 01 DETAILED METHODOLOGY

1 INTRODUCTION

This report outlines the results of a wind microclimate analysis of the proposed Piccadilly Wharf development in Manchester, UK.

1.1 SUMMARY

This report outlines the results of a wind microclimate analysis of the proposed Piccadilly Wharf development in Manchester, UK.

Wind microclimate conditions for the proposed redevelopment of Piccadilly Wharf were assessed using high resolution CFD.

There are no wind safety or distress exceedances at ground level anywhere in the site of surrounding area.

There are no significant wind safety or distress exceedances on any of the building terraces for the proposed development.

All ground level comfort conditions are suitable for their intended use.

The level 1 north, level 2 and level 13 north terraces are suitable for any intended use.

The level 1 south, level 12, level 13 south and roof terraces are suitable for occasional use, such as break out terraces, but may require local mitigation measures such as baffles or planting if they are to be used as long term dwell spaces.

1.2 GUIDANCE

The assessment was performed using the LDDC variant of the Lawson Comfort Criteria. The Lawson Criteria are well-established in the UK for quantifying wind conditions in relation to build developments and, although not a UK 'standard', the criteria are recognised by local authorities as a suitable benchmark for wind assessments. The Lawson Criteria have been adopted for this assessment.

Planning Practice Guidance 6th March 2014. The Department for Communities and Local Government (DCLG) web based Planning Practice Guidance resource includes a section on design and sets out how a building's size and shape can affect the wind microclimate. The section addressing Design - How should buildings and the spaces between them be considered? 'Consider scale' Paragraph O26, states that: "Account should be taken of local climatic conditions, including daylight and sunlight, wind, temperature and frost pockets."

2 METHOD

To identify the likely effect of the proposed development on the pedestrian level wind environment, a 3D CFD model of the development and surrounding site was created. This section describes the methodology for the creation of this model and the inputs used.

2.1 ASSESSMENT METHODOLOGY

The assessment was performed using GIA's high-resolution Computational Fluid Dynamics (CFD) modelling.

CFD is a digital modelling technique, which simulates the effect of wind for the built environment. The air is divided into hundreds of millions of "cells", within which the equations of motion are solved. GIA uses cloud computing from Amazon Web Services (AWS) to run the simulations, to ensure vast scalability and appropriate resource availability for any project.

A full description of the test methodology is included in Appendix 01.

2.2 ESTABLISHING MICROCLIMATE CONDITIONS

Microclimate conditions were established using a high resolution CFD model, extending 400m radius from the Site.

A model of the Development was included within the CFD model and tested to determine the conditions at and around the Site. The model used is shown in Figure 1 and Figure 2.

The model was run at full scale from 18 wind angles, spaced using 10° or 30° increments such that no sector contributes more than 10% of the annual wind. The wind angles which were run are indicated in Appendix 01.

Wind speeds were measured at 1.5m above any surfaces expected to be used for pedestrian activity.

On-site and local wind speeds were combined with 30 years-worth of weather data for Manchester International Airport, corrected for terrain local to the airport and the Site, to obtain annual and seasonal frequency and magnitude of wind speeds across the model. This allows the 'grading' of the pedestrian level winds according to the Lawson Comfort Criteria, which are explained later in this chapter.

Seasonal wind roses for the airport are shown in Appendix 01. The dominant wind direction is from the south.

The correction factors between the airport (measured 10m above ground) and the Site (at a reference height of 120m) are shown in Table 1. It should be noted that the terrain analysis has been performed using sectors of 30°, which is presented here.

The wind microclimate effects are assessed annually and for the winter months (December, January and February). Winter conditions are reported as this is the season when the strongest winds are expected, summer conditions are reported as this is the season when pedestrian usage of outdoor spaces is expected to be highest.

Table 01: Site Wind Correction Factors

DIRECTION (°N)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Corr. Factor	1.56	1.48	1.48	1.44	1.35	1.32	1.32	1.32	1.32	1.29	1.42	1.40



Fig. 01: 3D View of Proposed Development

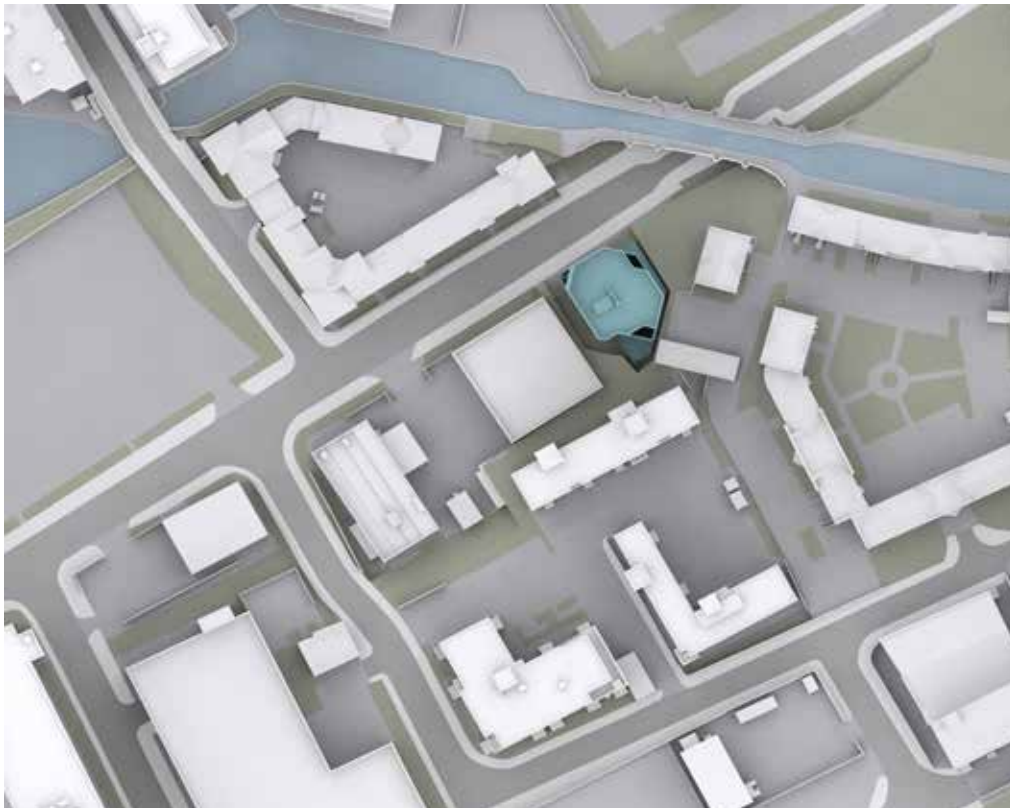


Fig. 02: Plan View of Proposed Development

2.3 TARGET CONDITIONS

For a mixed-use urban area within which the Site is located, the desired wind microclimate would typically need to have areas acceptable for sitting, standing (including at entrances of buildings) and walking use. A description of the comfort categories to classify wind conditions in accordance with are shown in Table 2 and 3.

Any areas which show up as either unsafe (annually) or uncomfortable (for winter) will require mitigation, unless they are in locations where pedestrian access can be controlled in the event of strong winds. This applies to all thoroughfares (for pedestrians) and roads (for cyclists) around the Development.

The areas immediately outside any building entrances should be suitable for standing use during winter to provide a “buffer” between the still conditions in interior spaces and the general thoroughfare.

Any amenity spaces are targeted to be suitable for standing in summer conditions, with some regions also suitable for occasional sitting. There are seven terraces on the proposed development:

- Level 1 north (covered terrace)
- Level 1 south
- Level 2
- Level 12
- Level 13 north
- Level 13 south
- Roof

It should be noted that conditions on the level 1 south terrace and level 2 terrace are inferred from surrounding conditions in this report.

2.4 TEST SCENARIOS

The purpose of these tests was to ensure that target conditions could be achieved when the proposed development is operational with its current surroundings.

The following scenarios were tested:

- Baseline: The site (as existing) with the existing surrounds.
- Proposed Site, Existing Surrounds: The completed and operational development with the existing surrounds.
- Proposed Site, Cumulative Surrounds: The completed and operational development with the existing surrounds, plus cumulative schemes.

Trees and soft landscaping have not been included in the model, to ensure that conditions represent a reasonable worst-case scenario.

Planning consented schemes within 400m radius of the site were included in the study. The following schemes were either completed or under construction at the time of the assessment, so were included in the existing surrounds:

- 126608/FO/2020: Land to the South of Store Street
- 115545/FO/2017: Oxygen Tower
- 109676/FO/2015/N2: Islington Wharf Phase III
- 113363/FO/2016: Crusader Works
- 115178/FO/2017: Eider House
- 106021/FO/2014/C2: Burlington House
- 122599/FO/2019: Adair Street Hotel

The following planning consented schemes were only included in the cumulative surrounds:

- 126669/FO/2020: Old Mill Street
- 121099/FO/2018: Portugal Street East (Plots A&B)
- 127317/FO/2020: Heyrod Street
- 122000/FO/2018: Victoria House
- 120149/FO/2018: Lomax Street

2.5 **LIMITATIONS AND ASSUMPTIONS**

The accuracy of the results is dependent upon the accuracy of the CAD used to construct the model.

There is an inherent assumption that on-site wind speeds will scale linearly with the measured wind speeds at the airport.

There is an inherent assumption that the wind speed statistics for the past 30 years will remain applicable for the foreseeable future.

Table 02: Lawson Comfort Criteria (LDDC variant)

KEY	COMFORT CATEGORY	MEAN WIND SPEED (5% EXCEEDANCE)	DESCRIPTION
	Sitting	4 m/s	Acceptable for outdoor sitting use (e.g. cafés, benches, balconies)
	Standing	6 m/s	Acceptable for main building entrances, pick-up/drop-off points and bus stops
	Walking (leisure)	8 m/s	Acceptable for strolling
	Walking (business)	10 m/s	Acceptable for external pavements, walking purposefully without lingering
	Uncomfortable	>10 m/s	Not comfortable for regular pedestrian access

Table 03: Lawson Safety Criteria (LDDC variant)

KEY	SAFETY CATEGORY	MEAN WIND SPEED (0.022% EXCEEDANCE)	DESCRIPTION
	No Safety Exceedance	<15 m/s	
	S15 (Distress)	>15 m/s	Unsafe for frail individuals, or cyclists
	S20 (Safety)	>20m/s	Wind conditions considered unsafe for all users

3 RESULTS

3.1 BASELINE CONDITIONS

Annual safety for the baseline is shown in Figure 3. Winter comfort for the baseline is shown in Figure 4. Summer comfort for the baseline is shown in Figure 5.

There are no safety or distress exceedances anywhere within the site or surrounding area.

Winter conditions range between sitting and standing, with some small localised regions of leisure walking off-site. Summer conditions range between sitting and standing throughout the study area.

No regions of leisure walking are adjacent to any buildings, so all entrances are suitable for either sitting or standing, which is suitable for the intended use.

3.2 PROPOSED DEVELOPMENT WITH EXISTING SURROUNDS

Annual safety for the proposed development with existing surrounds is shown in Figure 6. Winter comfort for the proposed development with existing surrounds is shown in Figure 7. Summer comfort for the proposed development with existing surrounds is shown in Figure 8.

There are no safety or distress exceedances anywhere within the site or surrounding area.

Winter conditions range between sitting and standing, with some small localised regions of leisure walking off-site. Summer conditions range between sitting and standing throughout the study area.

No regions of leisure walking are adjacent to any buildings, so all entrances are suitable for either sitting or standing, which is suitable for the intended use.

All ground level conditions are suitable for the intended use.

3.3 TERRACE LEVEL CONDITIONS

Annual safety for the terraces is shown in Figure 9 and Figure 10. Winter comfort for the proposed development with existing surrounds is shown in Figure 11 and Figure 12. Summer comfort for the terraces is shown in Figure 13 and Figure 14.

There are small regions of S15(distress) at the extremities of the roof and level 12 terraces. These regions, however, are tight to the wall and not substantial, so the risk to terrace users is not significant.

The level 1 north, level 2 and level 13 north terraces are all suitable for sitting in either summer or winter conditions, so are suitable for any activity.

The level 1 south and level 13 south terraces are suitable for standing in summer conditions, and for a mixture of standing and leisure walking in winter conditions. These terraces will be suitable for occasional use, such as break out terraces, but may require local mitigation measures such as baffles or planting if they are to be used as long term dwell spaces.

The level 12 and roof terraces are suitable for a mixture of standing and leisure walking in summer conditions, and for a mixture of standing, leisure walking and business walking in winter conditions. These terraces will be suitable for occasional use, such as break out terraces, but may require local mitigation measures such as baffles or planting if they are to be used as long term dwell spaces.

3.4 PROPOSED DEVELOPMENT WITH CUMULATIVE SURROUNDS

Annual safety for the proposed development with cumulative surrounds is shown in Figure 15. Winter comfort for the proposed development with cumulative surrounds is shown in Figure 16. Summer comfort for the proposed development with cumulative surrounds is shown in Figure 17.

There are no safety or distress exceedances anywhere within the site or surrounding area.

Winter conditions range between sitting and standing, with some small localised regions of leisure walking off-site. Summer conditions range between sitting and standing throughout the study area.

No regions of leisure walking are adjacent to any buildings, so all entrances are suitable for either sitting or standing, which is suitable for the intended use.

All ground level conditions are suitable for the intended use.

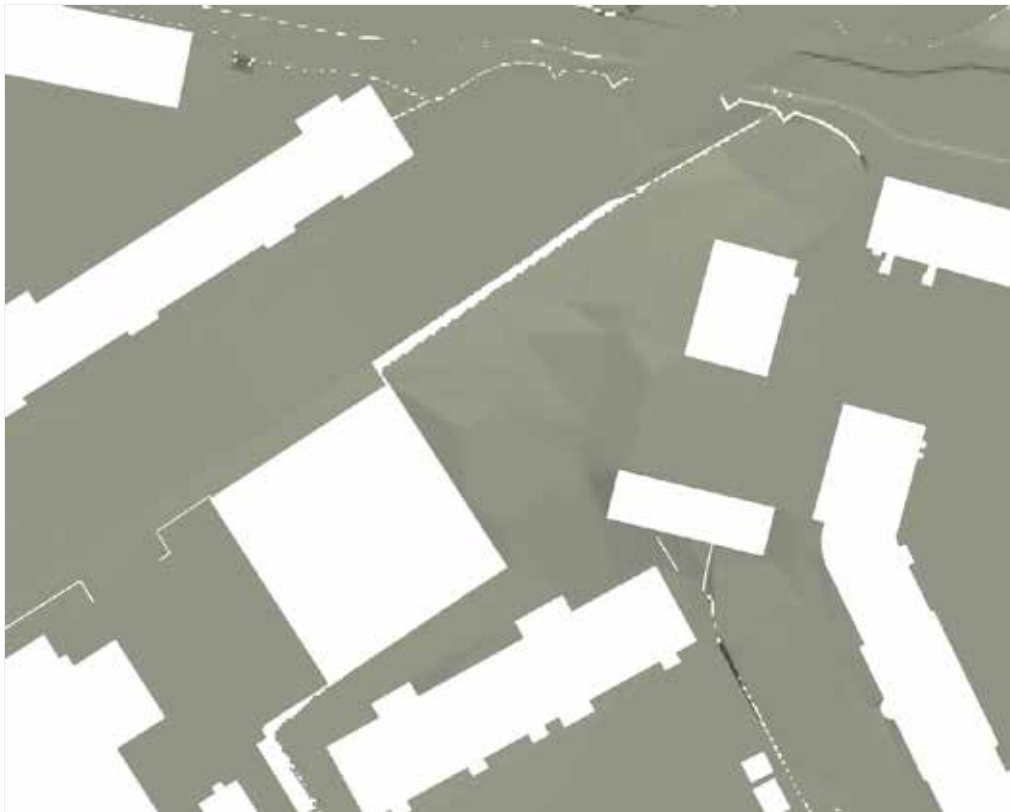


Fig. 03: Annual Safety, Baseline

KEY	SAFETY CATEGORY
	No Safety Exceedance
	S15 (Distress)
	S20 (Safety)

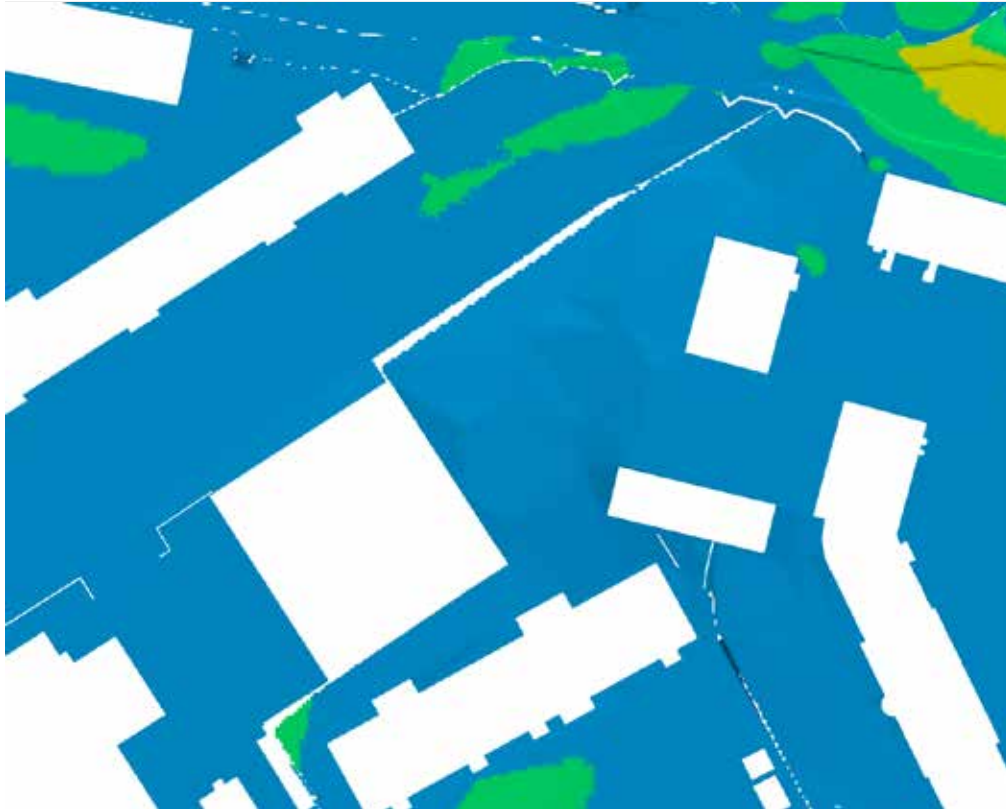


Fig. 04: Winter Comfort, Baseline

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

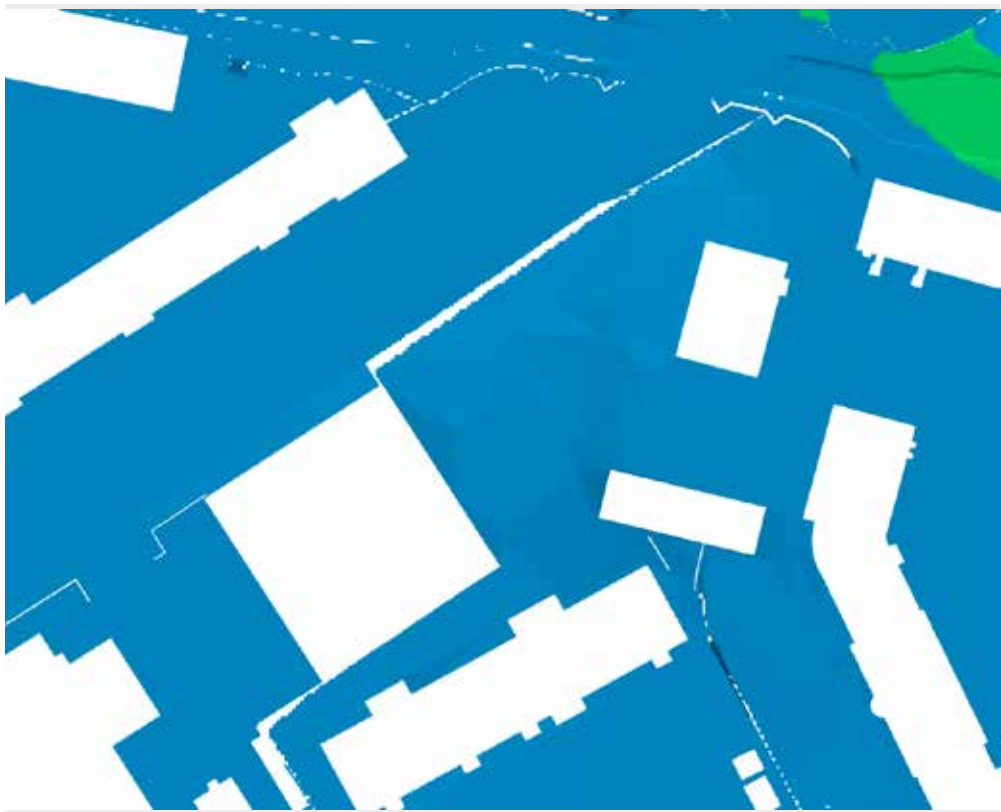


Fig. 05: Summer Comfort, Baseline

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

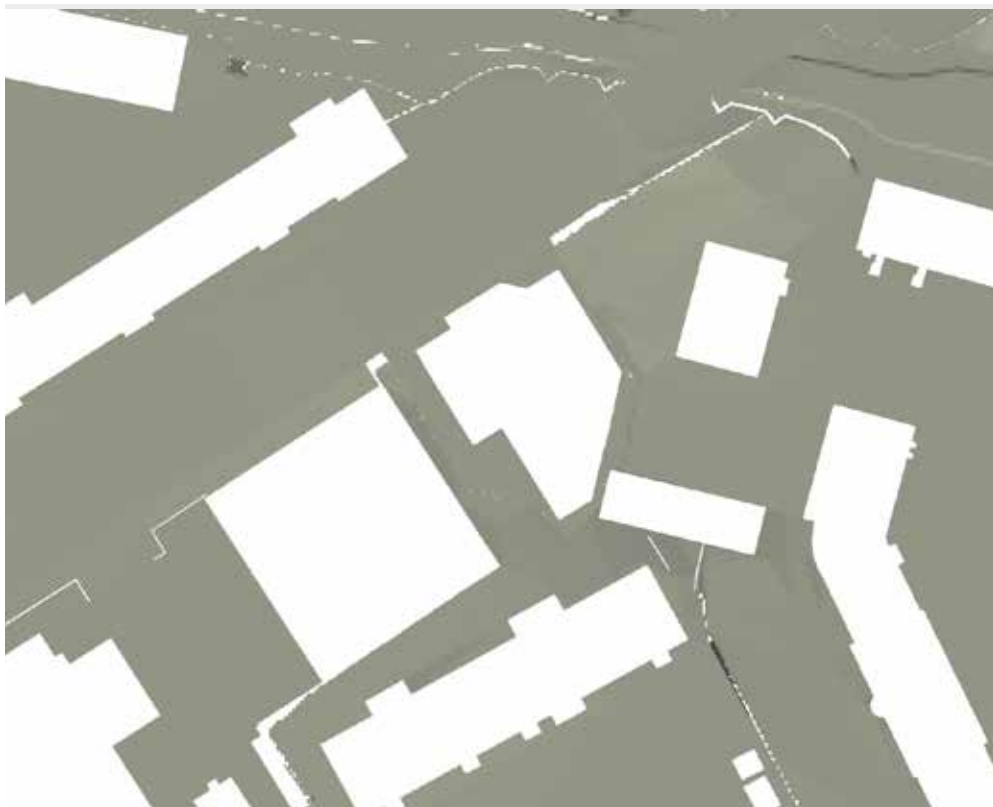


Fig. 06: Annual Safety, Proposal with Existing Surrounds

KEY	SAFETY CATEGORY
	No Safety Exceedance
	S15 (Distress)
	S20 (Safety)

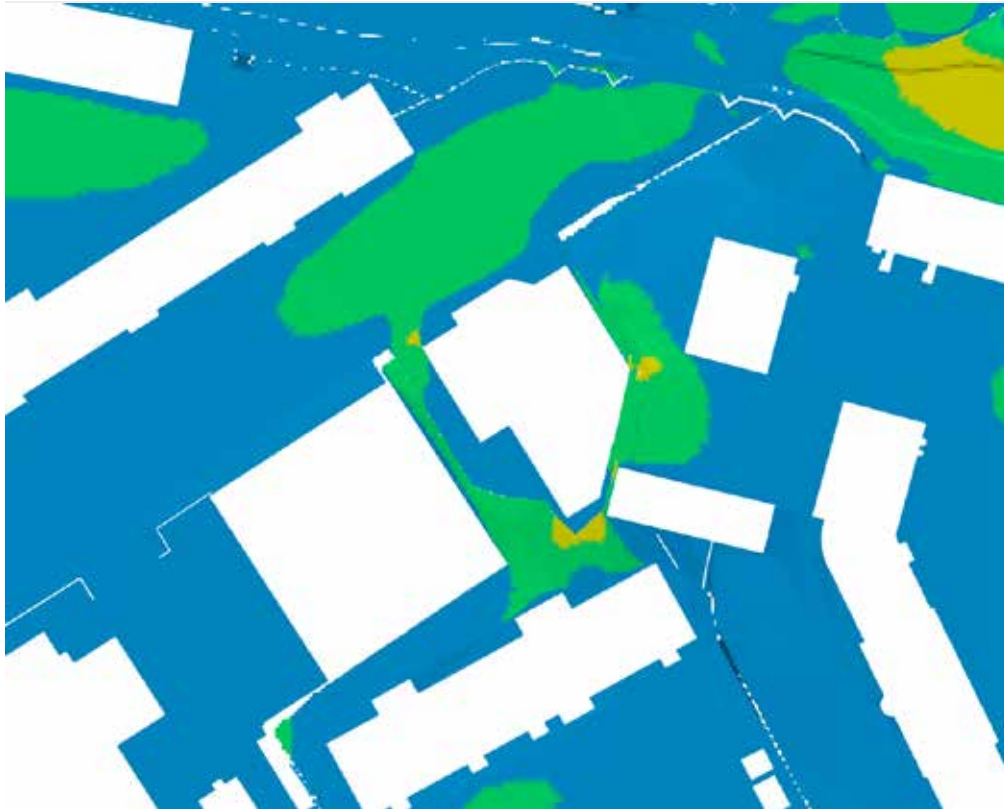


Fig. 07: Winter Comfort, Proposal with Existing Surrounds

KEY	COMFORT CATEGORY
■	Sitting
■	Standing
■	Walking (leisure)
■	Walking (business)
■	Uncomfortable

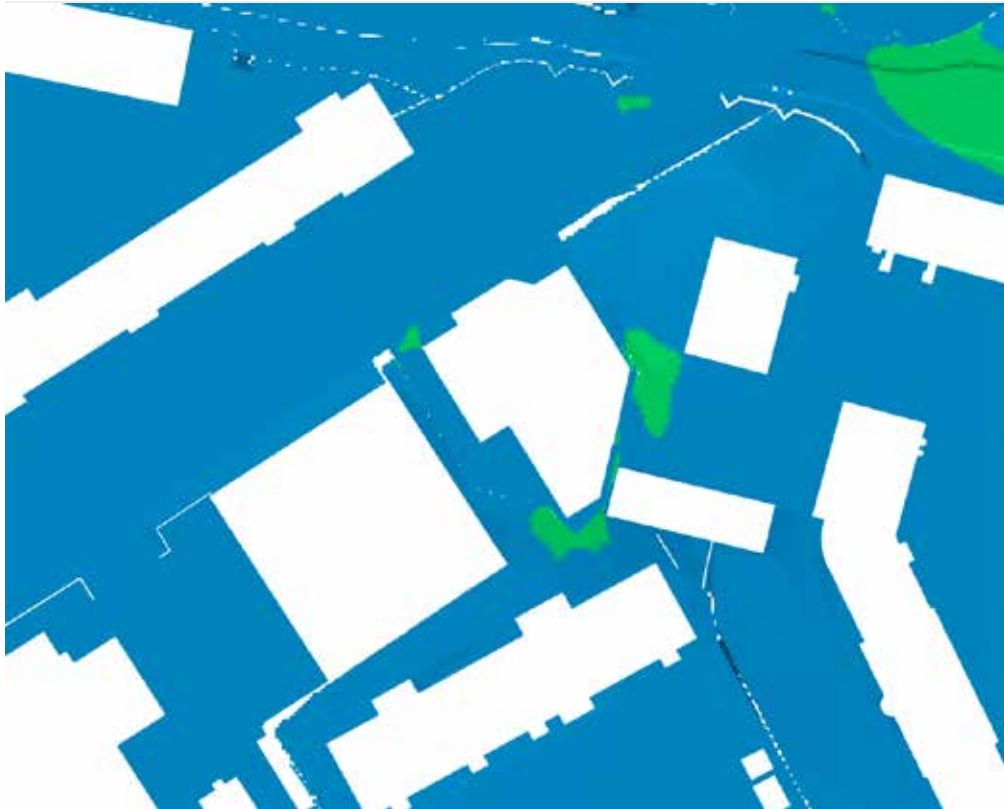


Fig. 08: Summer Comfort, Proposal with Existing Surrounds

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

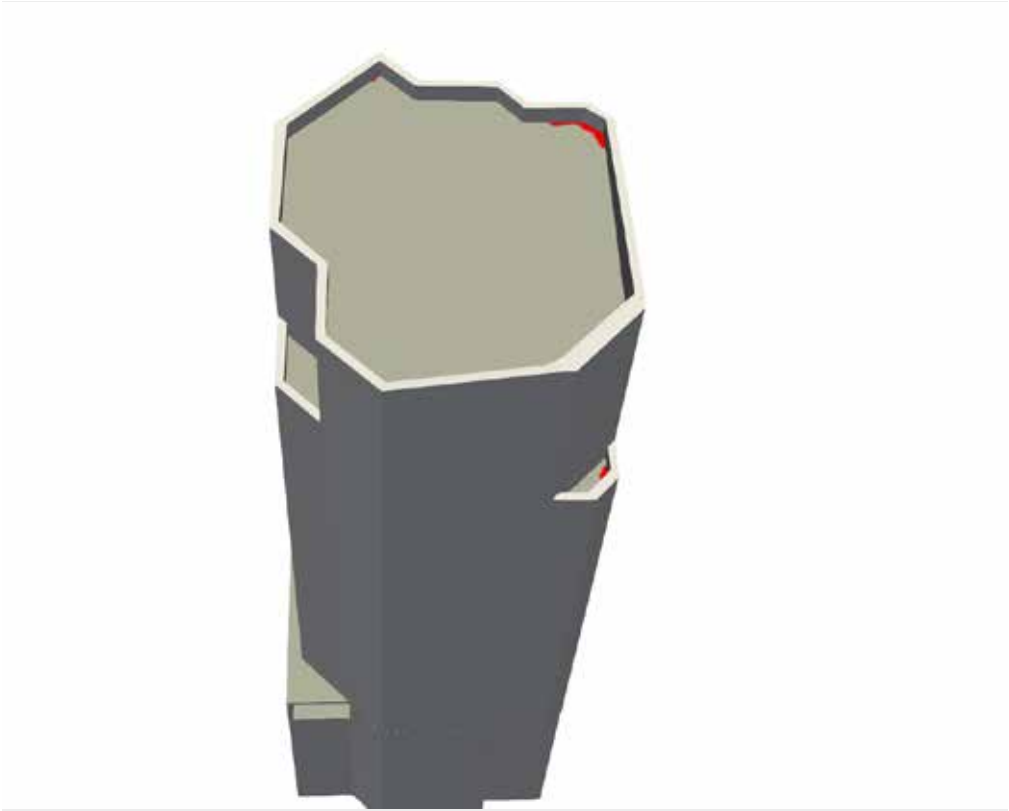


Fig. 09: Annual Safety, Terraces (viewed from north)

KEY	SAFETY CATEGORY
	No Safety Exceedance
	S15 (Distress)
	S20 (Safety)



Fig. 10: Annual Safety, Terraces (viewed from south)

KEY	COMFORT CATEGORY
■	Sitting
■	Standing
■	Walking (leisure)
■	Walking (business)
■	Uncomfortable

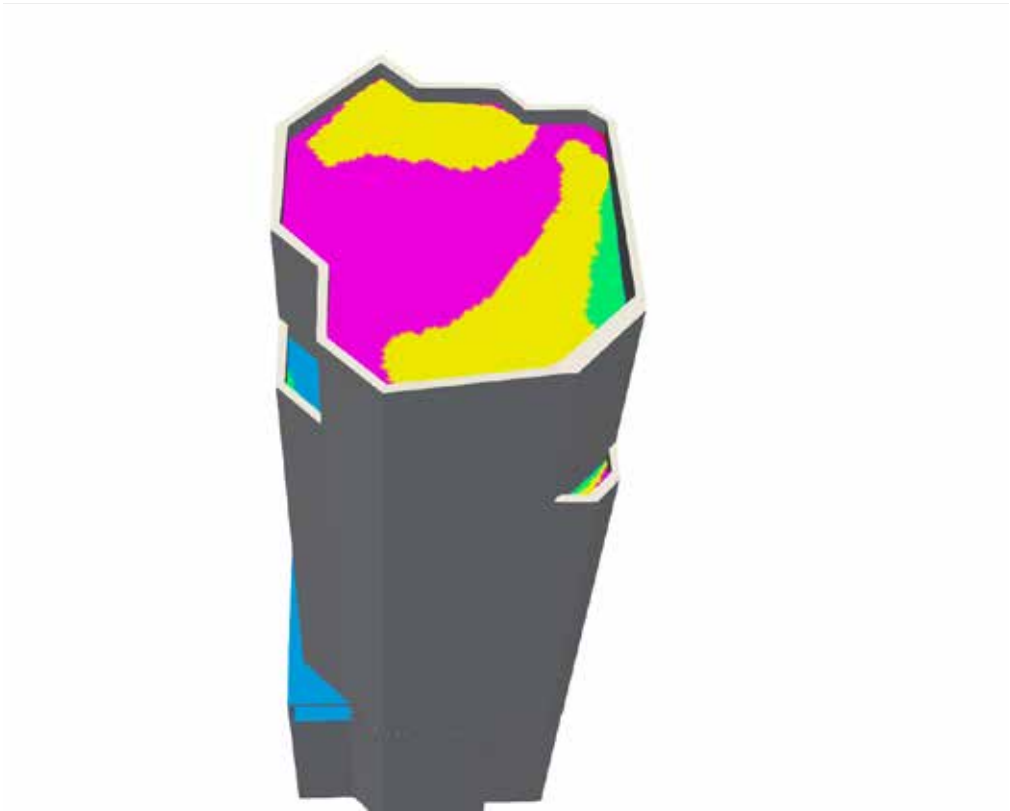


Fig. 11: Winter Comfort, Terraces (viewed from north)

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

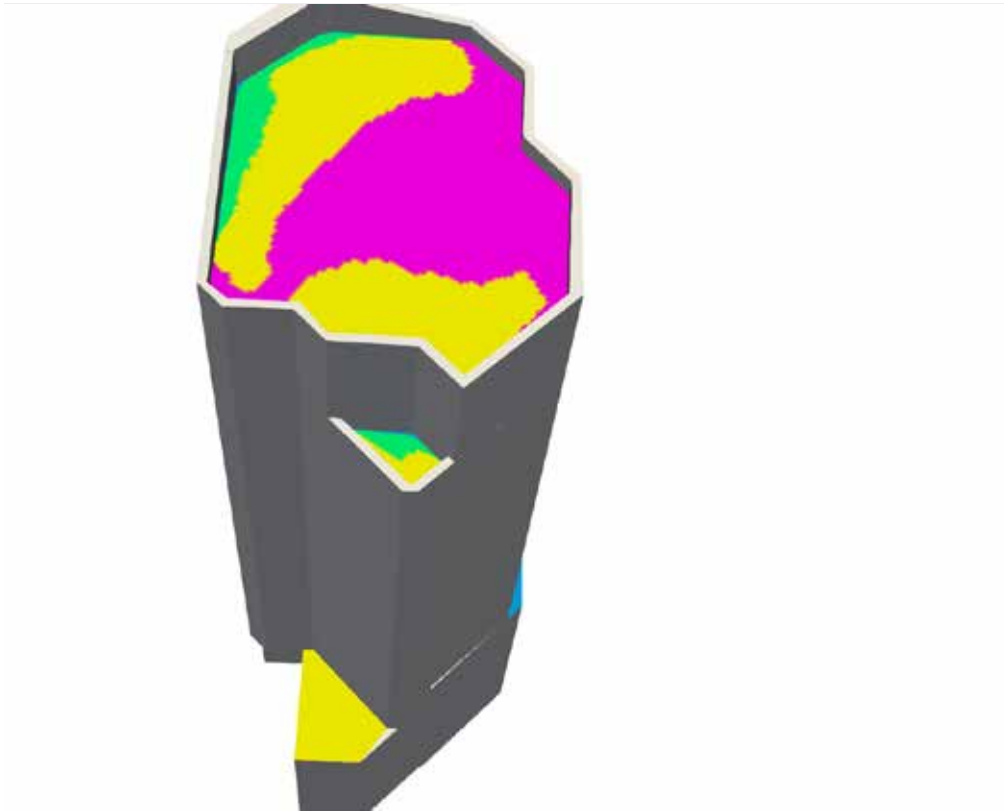


Fig. 12: Winter Comfort, Terraces (viewed from south)

KEY	SAFETY CATEGORY
	No Safety Exceedance
	S15 (Distress)
	S20 (Safety)

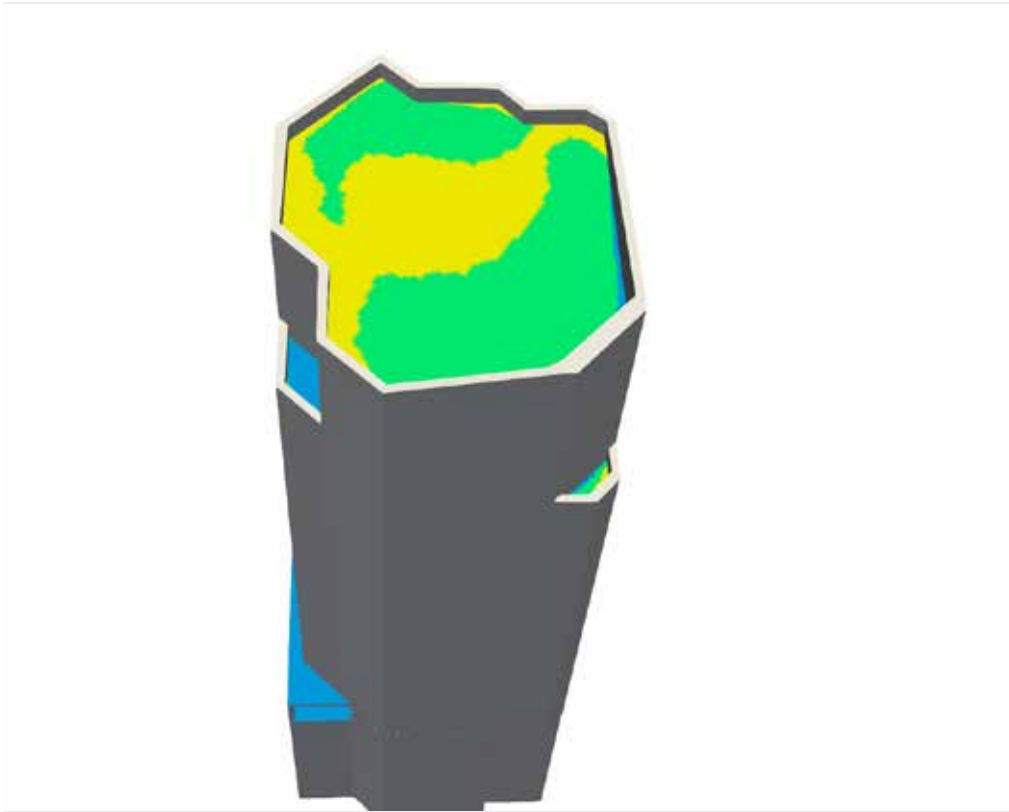


Fig. 13: Summer Comfort, Terraces (viewed from north)

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

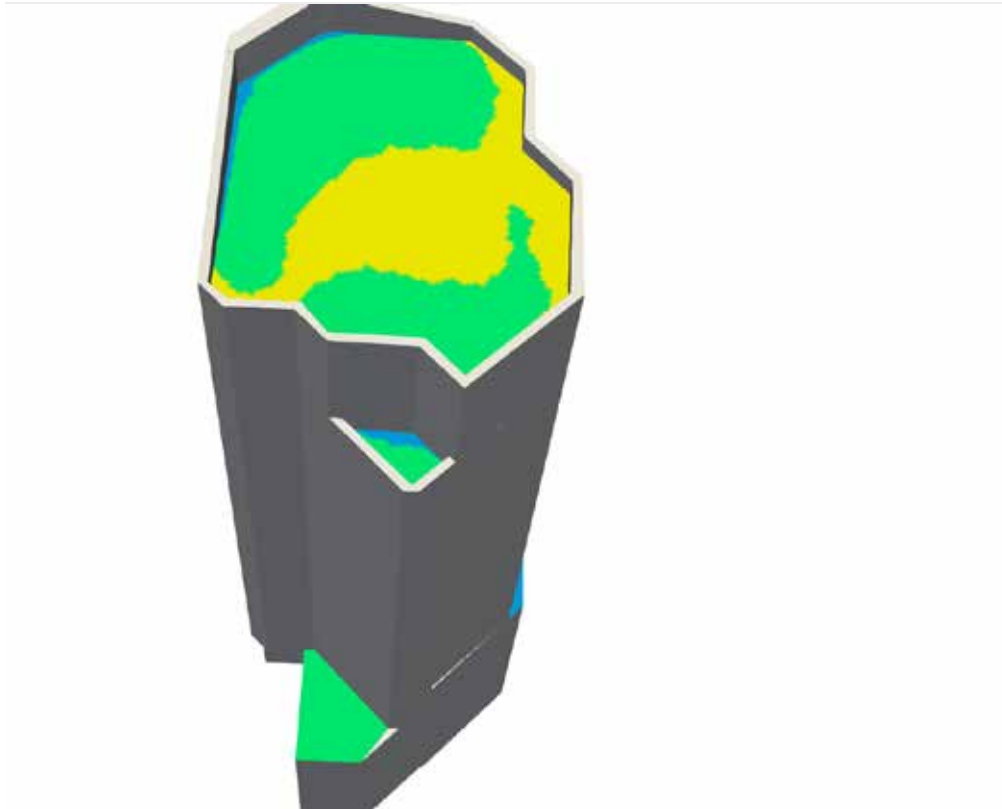


Fig. 14: Summer Comfort, Terraces (viewed from south)

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

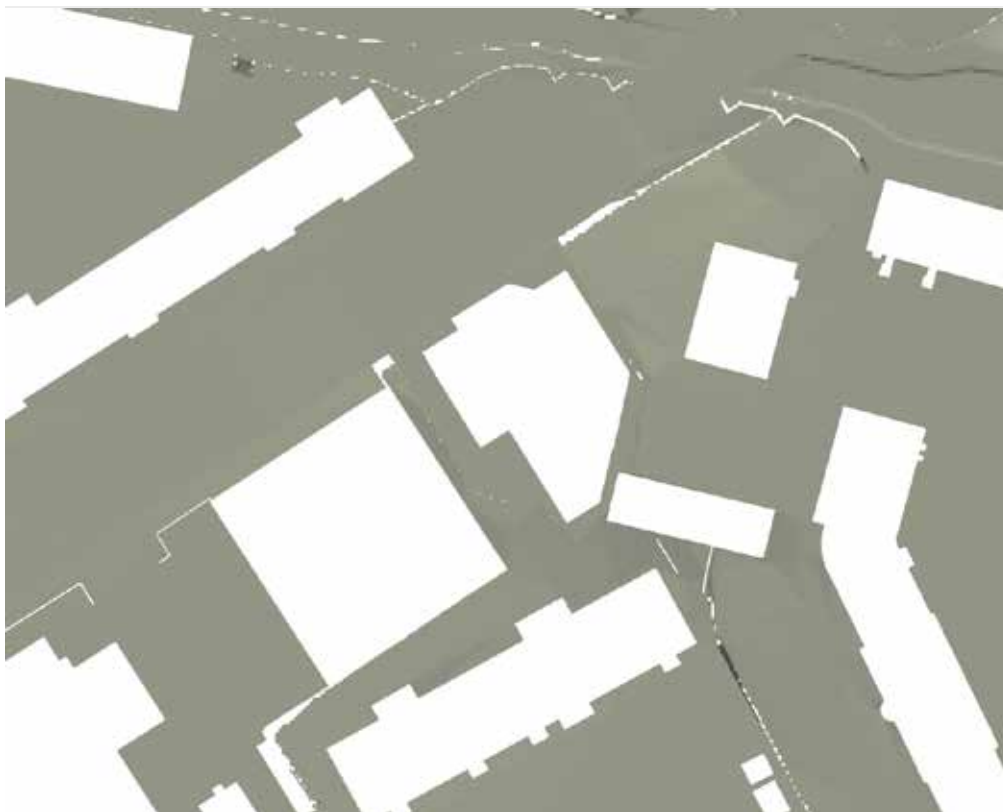


Fig. 15: Annual Safety, Proposal with Cumulative Surrounds

KEY	SAFETY CATEGORY
	No Safety Exceedance
	S15 (Distress)
	S20 (Safety)

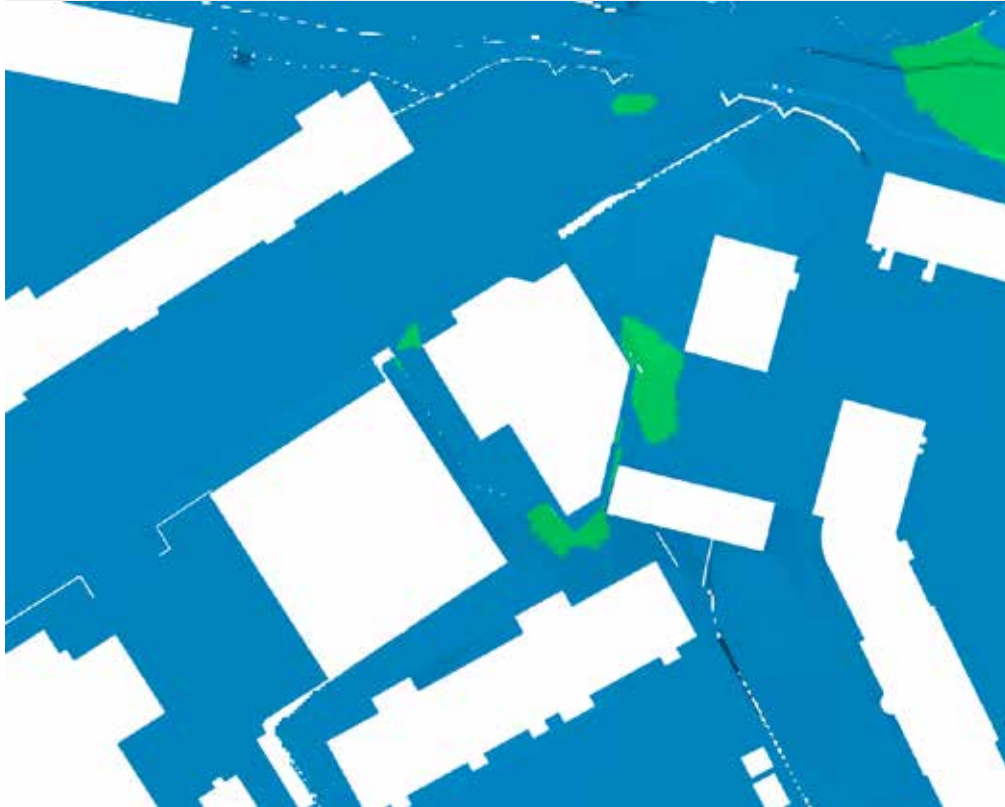


Fig. 16: Winter Comfort, Proposal with Cumulative Surrounds

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

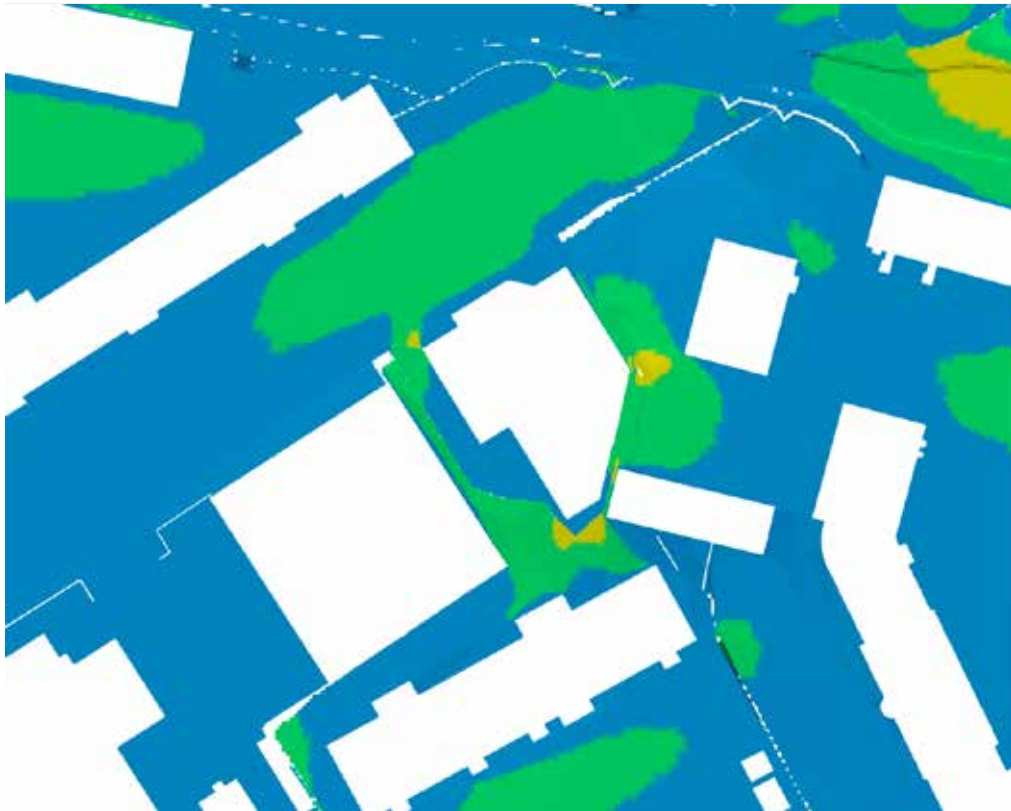


Fig. 17: Summer Comfort, Proposal with Cumulative Surrounds

KEY	COMFORT CATEGORY
	Sitting
	Standing
	Walking (leisure)
	Walking (business)
	Uncomfortable

4 CONCLUSIONS

Wind microclimate conditions for the proposed redevelopment of Piccadilly Wharf were assessed using high resolution CFD.

There are no wind safety or distress exceedances at ground level anywhere in the site of surrounding area.

There are no significant wind safety or distress exceedances on any of the building terraces for the proposed development.

All ground level comfort conditions are suitable for their intended use.

The level 1 north, level 2 and level 13 north terraces are suitable for any intended use.

The level 1 south, level 12, level 13 south and roof terraces are suitable for occasional use, such as break out terraces, but may require local mitigation measures such as baffles or planting if they are to be used as long term dwell spaces.

APPENDIX 01 DETAILED METHODOLOGY

CFD METHODOLOGY

The CFD was performed using OpenFOAM.

Meshed using a hybrid mesh of hexahedral, polyhedral, tetrahedral and prismatic elements:

- On site building edge length: 0.05m – 0.25m
- Surrounding context edge length: 0.25m – 1m

Prismatic cells were used in the boundary layer region, with 4 layers of cells growing with an expansion ratio of 1.15 and aspect ratios between 0.1 and 0.4.

The total mesh size was between 108 and 115 million cells. Mesh detail is shown in Figure 18 and Figure 19.

Buildings within 300m of the site were included.

The domain was 5000mx5000m, with a blockage ratio of 0.5%

The blockage ratio uses a “test section” of 600mx200m (within which detail is captured).

Run using the SST turbulence model with high Re wall functions to ensure mesh suitability.

The simulations were steady state and isothermal.

2nd order discretisation schemes were used.

Convergence was measured as the residuals of the continuity, x-velocity, y-velocity, z-velocity, k and omega equations all falling by at least 2 orders of magnitude, and by measured static pressure on the site buildings varying by less than 1% over the final 100 iterations.

The wind speed is corrected into a “gust-equivalent” mean. The gust-equivalent mean is calculated using mean velocity and turbulent kinetic energy to calculate the velocity fluctuations and hence peak gust velocity, which is divided by 1.85 to be equivalent to the mean and appropriate to the comfort and safety calculations.

WIND CLIMATE METHODOLOGY

The simulations were performed from 18 wind directions, spaced such that no single direction contributed more than 10% of the annual winds.

The directions simulated were 0°, 30°, 90°, 90°, 120°, 150°, 170°, 180°, 190°, 200°, 210°, 220°, 240°, 260°, 270°, 280°, 300°, 330°.

30 years of wind data was obtained for Manchester International Airport, seasonal wind roses for this data are shown in Figure 20.

Target wind profiles for the site, from each wind direction, were generated using sectoral analysis of the terrain surrounding the site and the local weather stations with ESDU 2010 Item 01008 ‘Computer program for wind speeds and turbulent properties: flat or hilly sites in terrain with roughness changes’. The target wind profiles, compared to the wind speeds measured from the CFD model are shown in Figure 21.

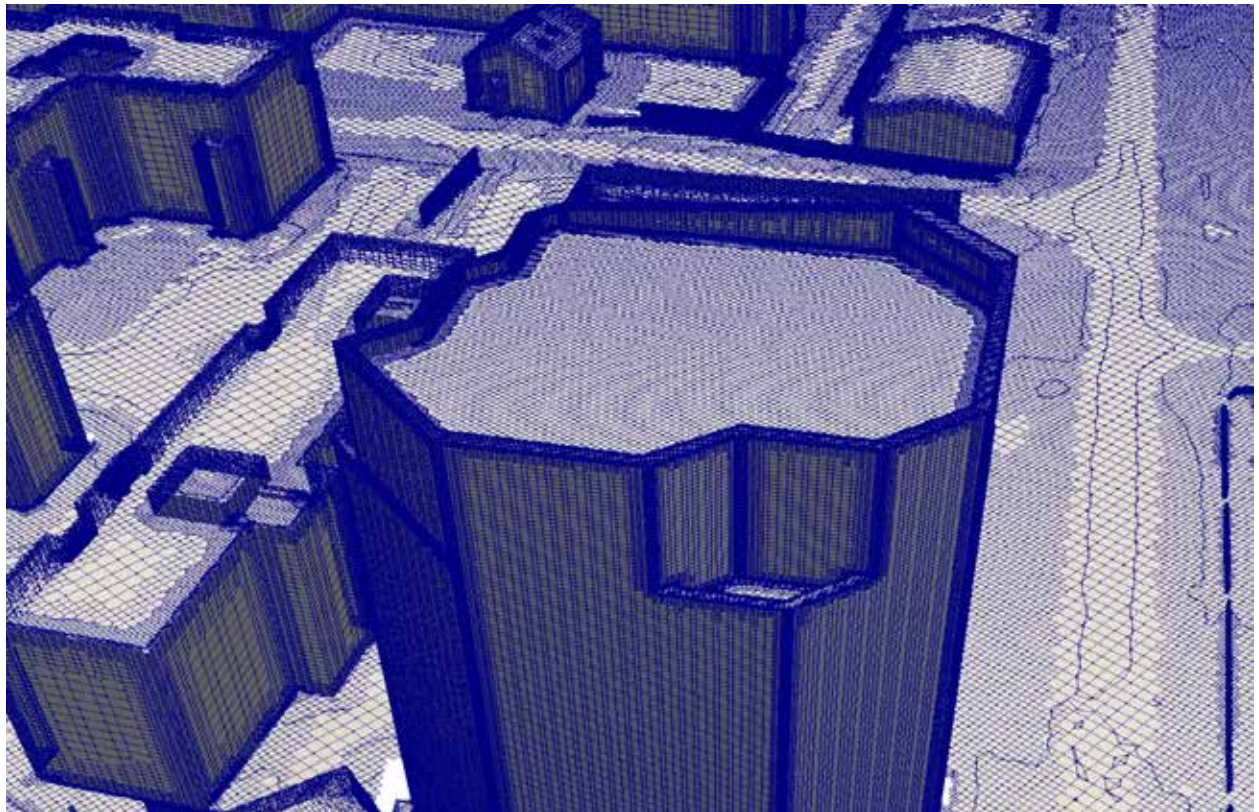


Fig. 18: Mesh Detail on Site Buildings

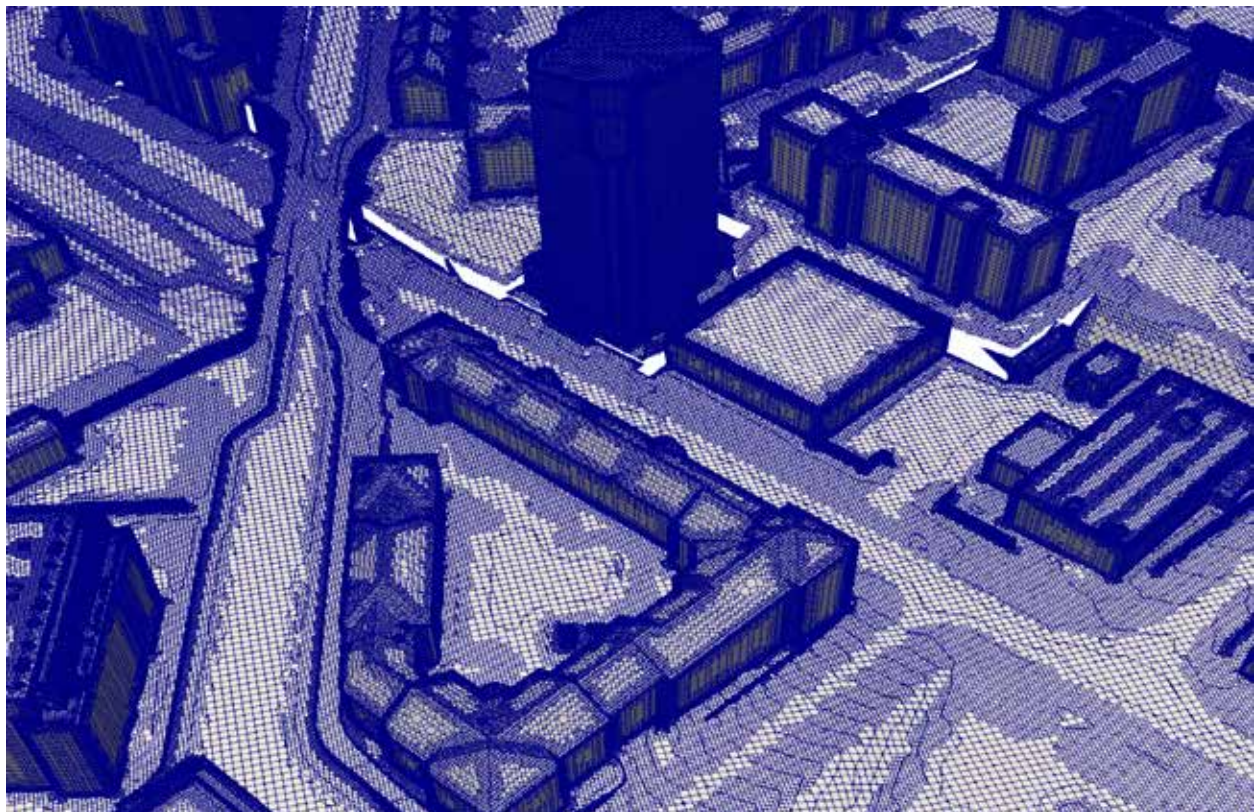


Fig. 19: Mesh Detail on Surrounds

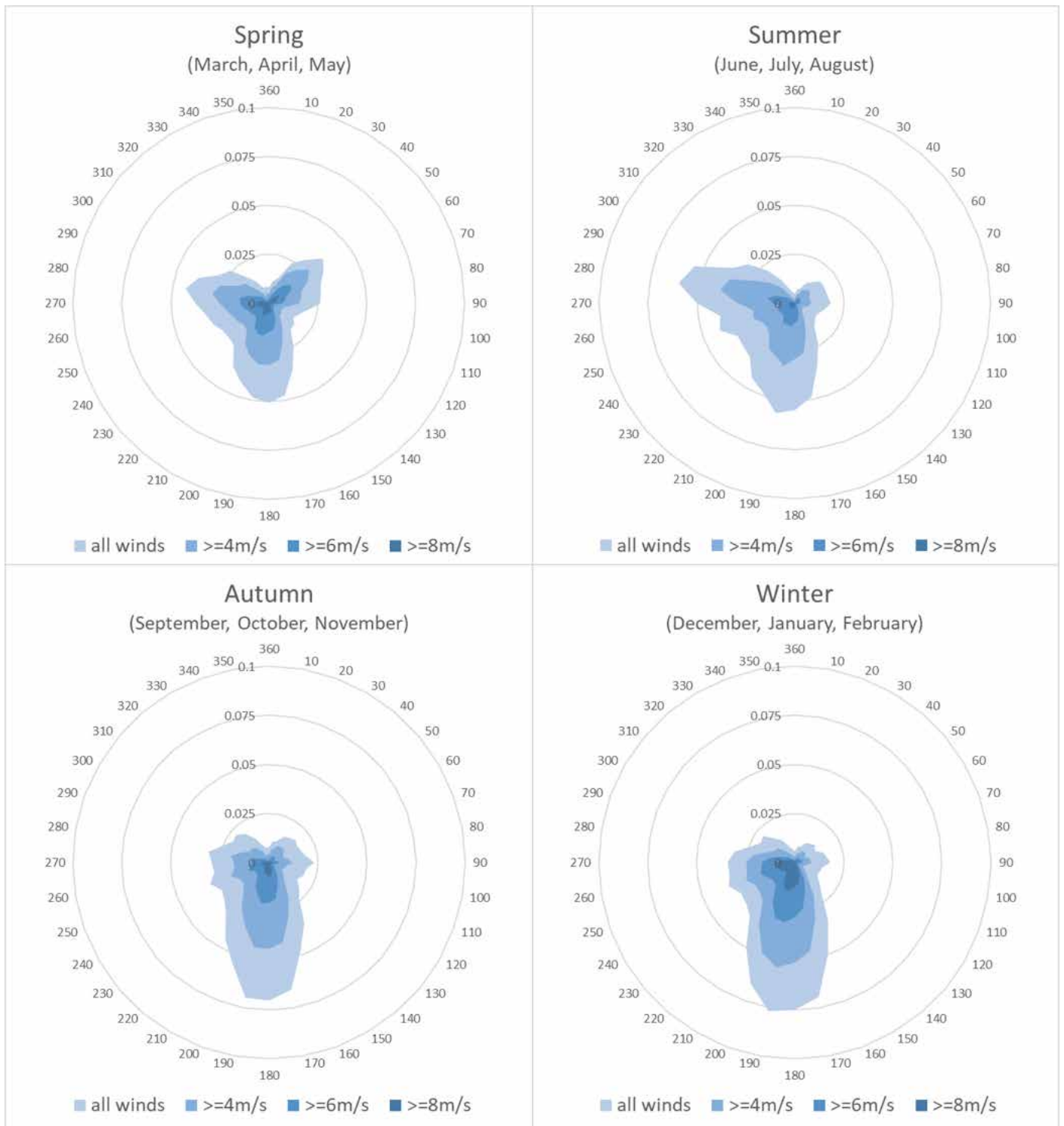


Fig. 20: Seasonal Wind Roses for Manchester International Airport

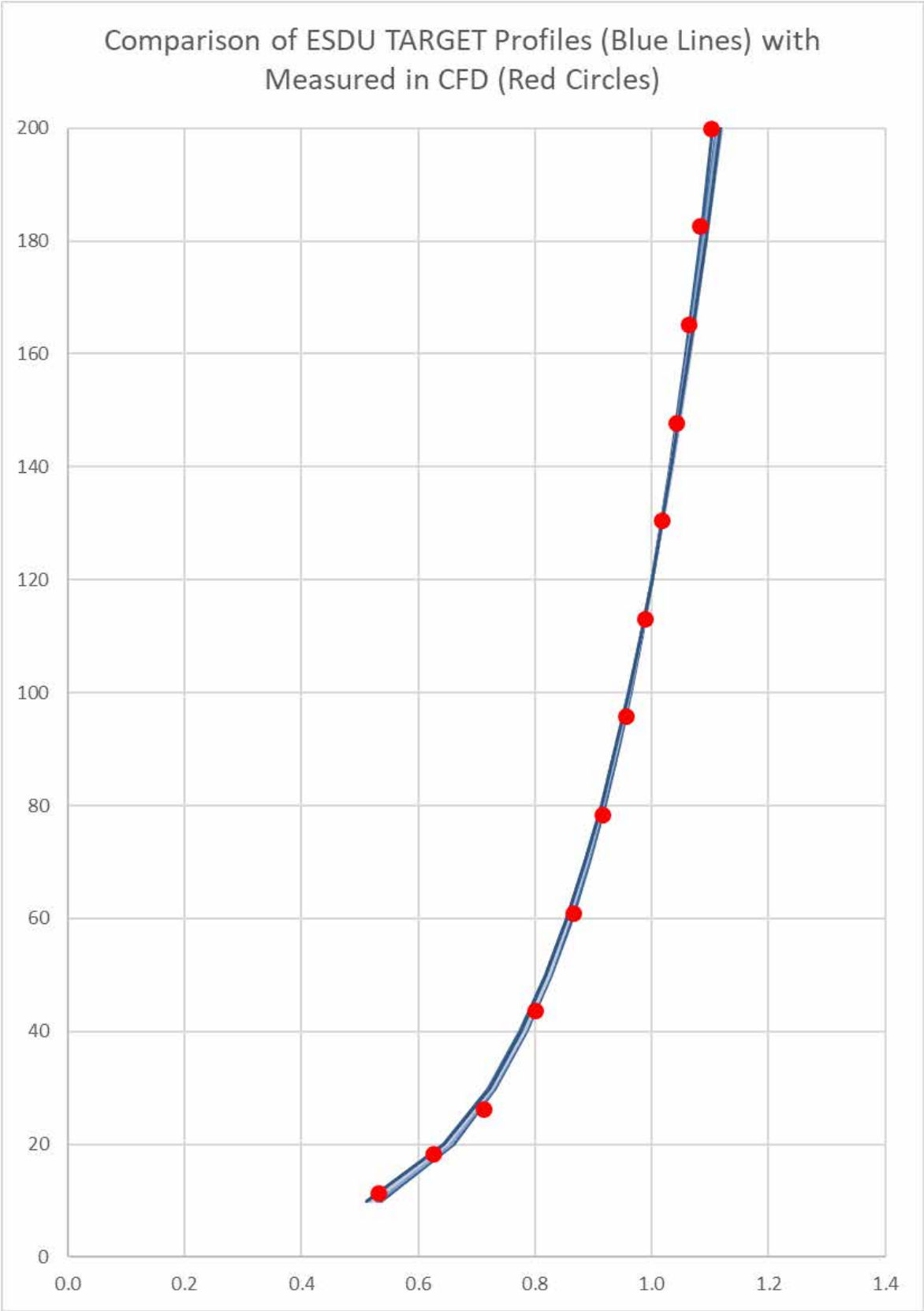


Fig. 21: Wind Profile for Piccadilly Wharf



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