AtkinsRéalis

Volume 3, Appendix 18.1 – Wind and microclimate calculations

Manchester City Council

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FORMER CENTRAL RETAIL PARK – THE PARK

AtkinsRéalis - Sensitive / Sensible

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1. Wind and Microclimate calculations

1.1 Single Wind Direction Scenario

1.1.1 Existing Scenario

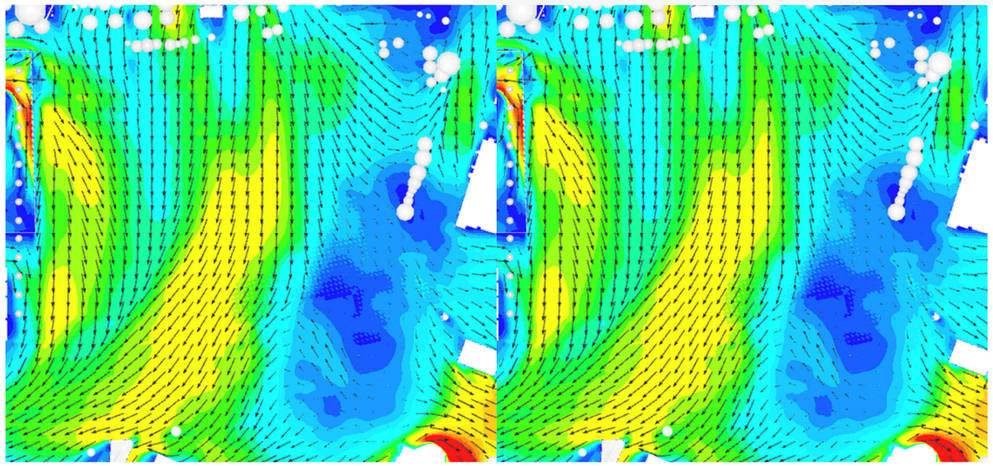


Figure 1-1– Existing Phase, wind speed contours for direction 0º (Left) and 22.5º (Right)

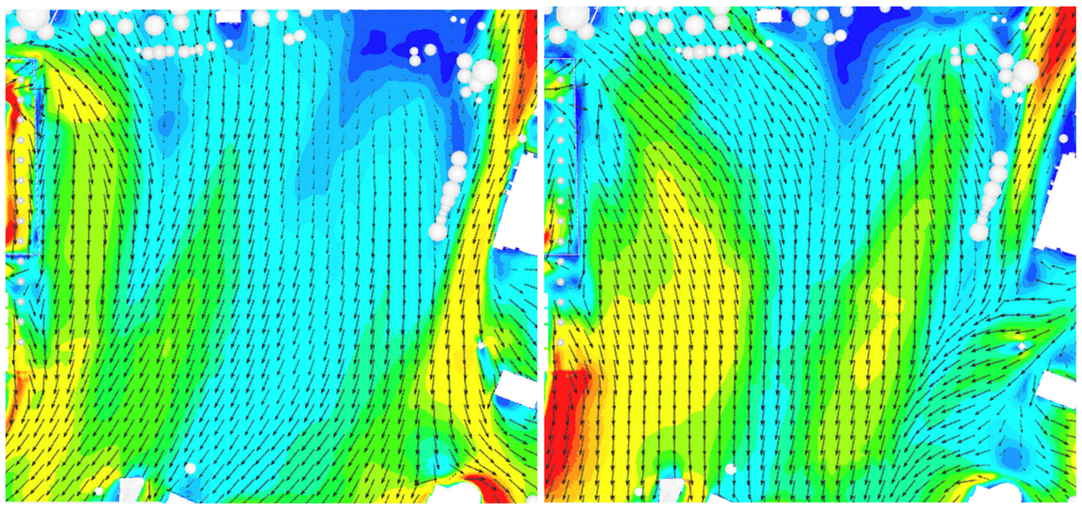


Figure 1-2 - Existing Phase, wind speed contours for direction 45º (Left) and 67.5º (Right)

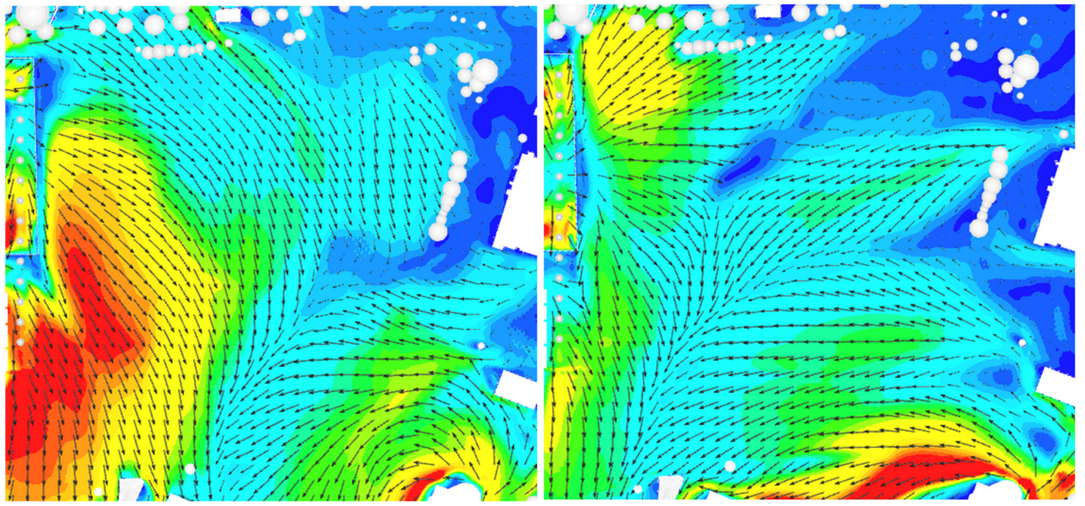


Figure 1-3 - Existing Phase, wind speed contours for direction 90º (Left) and 112.5º (Right)

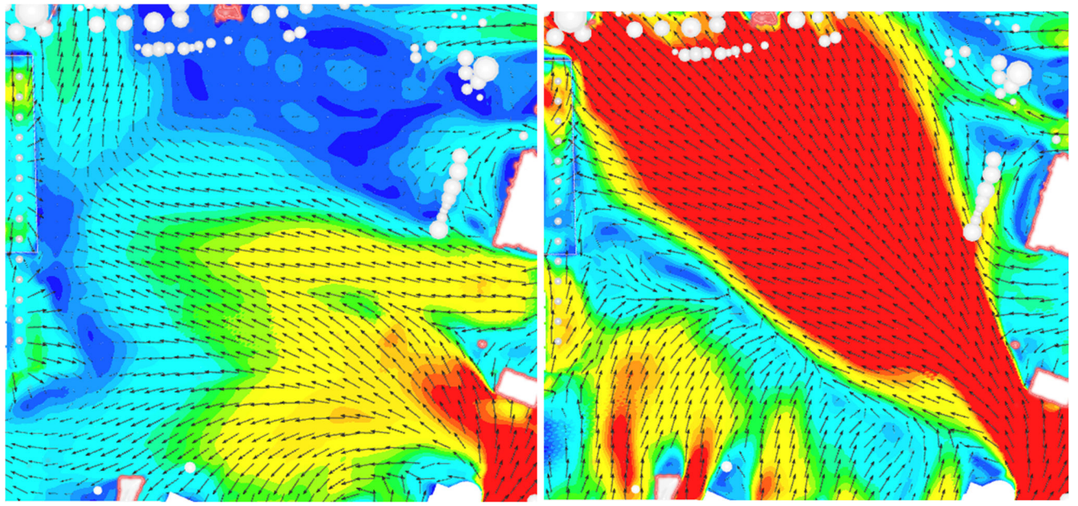


Figure 1-4 - Existing Phase, wind speed contours for direction 135º (Left) and 157.5º (Right)

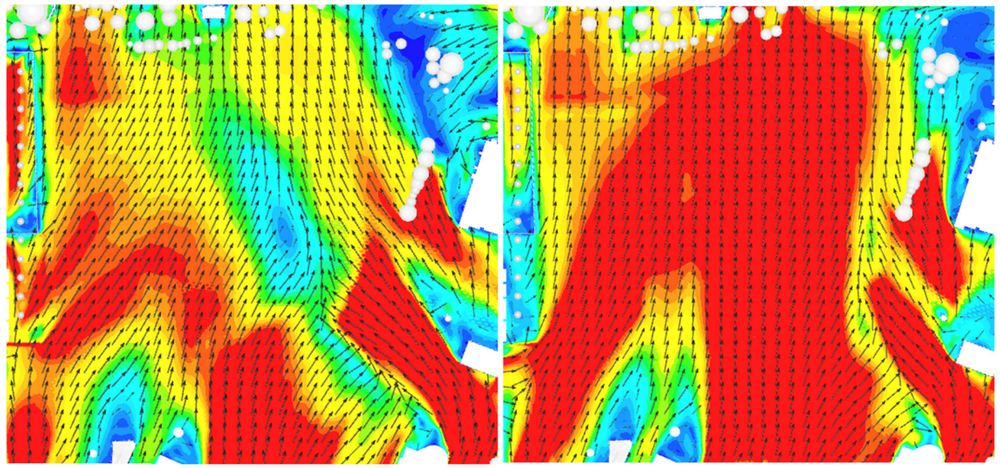


Figure 1-5 - Existing Phase, wind speed contours for direction 180º (Left) and 202.5º (Right)

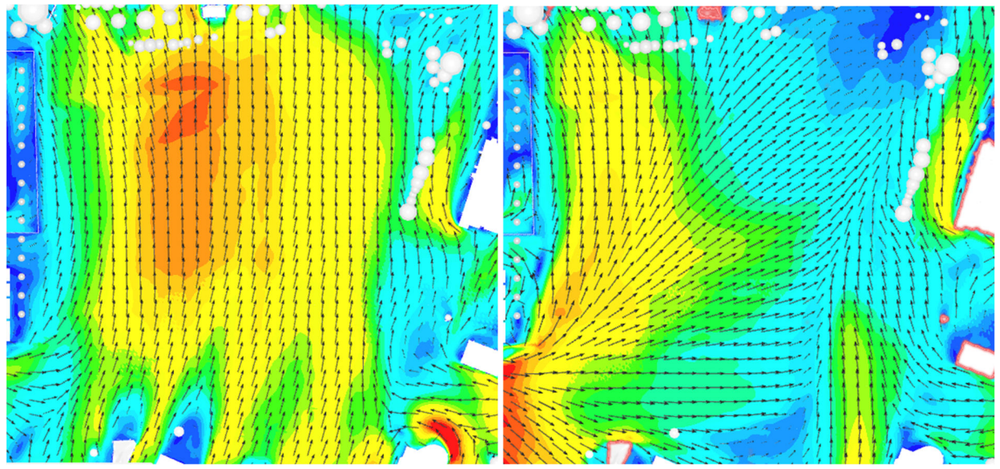


Figure 1-6 - Existing Phase, wind speed contours for direction 225º (Left) and 247.5º (Right)

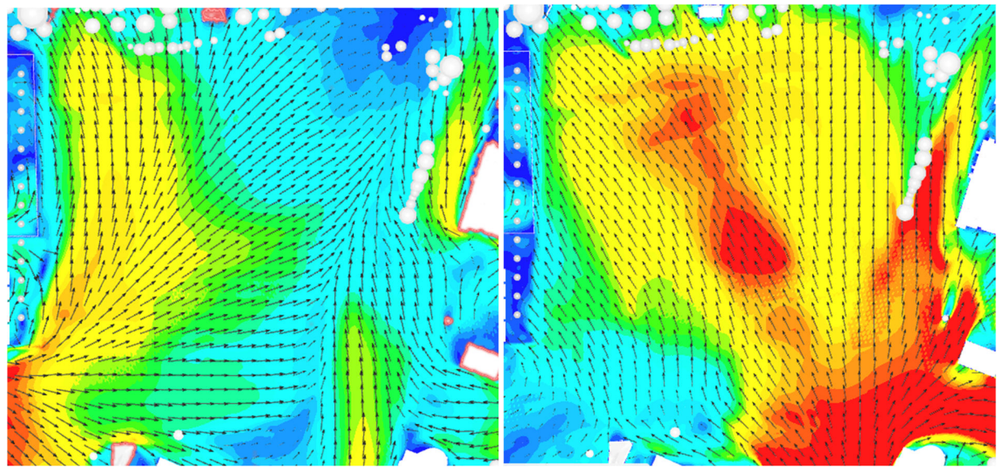


Figure 1-7 – Existing Phase, wind speed contours for direction 270º (Left) and 292.5º (Right)

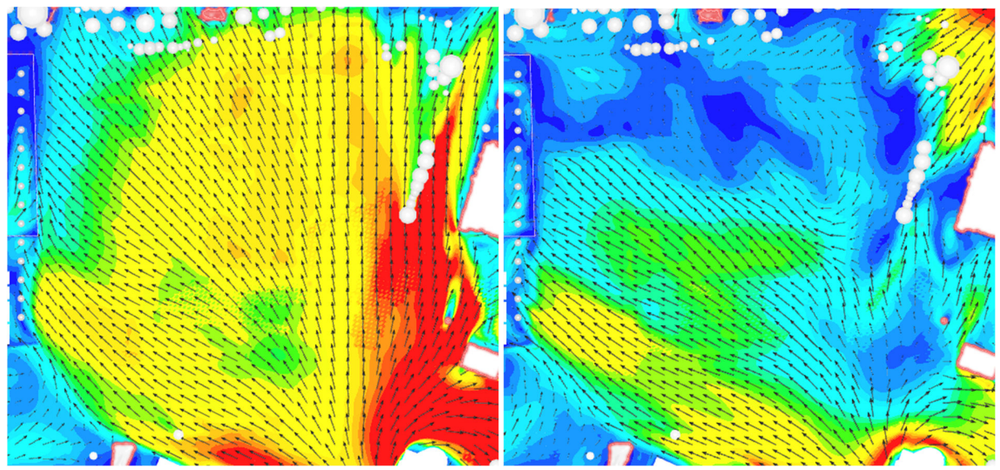


Figure 1-8 - Existing Phase, wind speed contours for direction 315º (Left) and 337.5º (Right)

1.1.2 Proposed Scenario

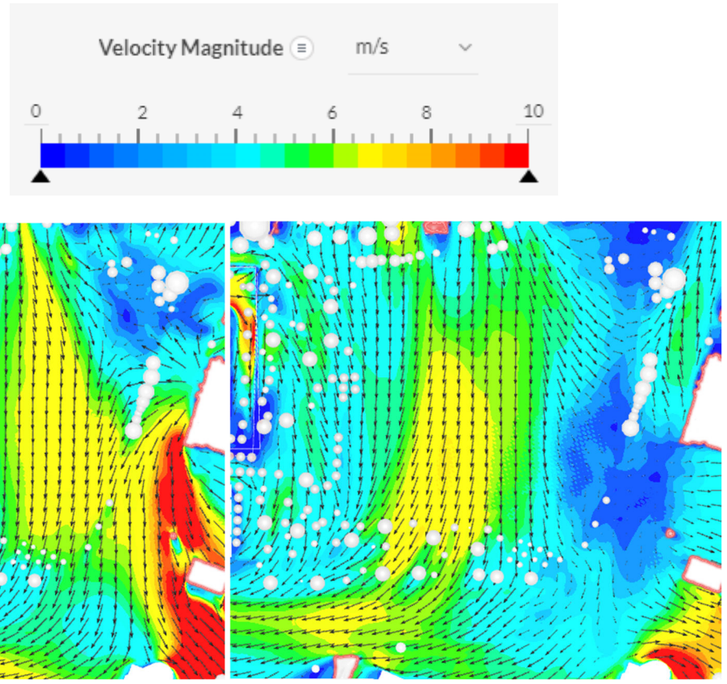


Figure 1-9 - Phase 1, wind speed contours for direction 0º (Left) and 22.5º (Right)

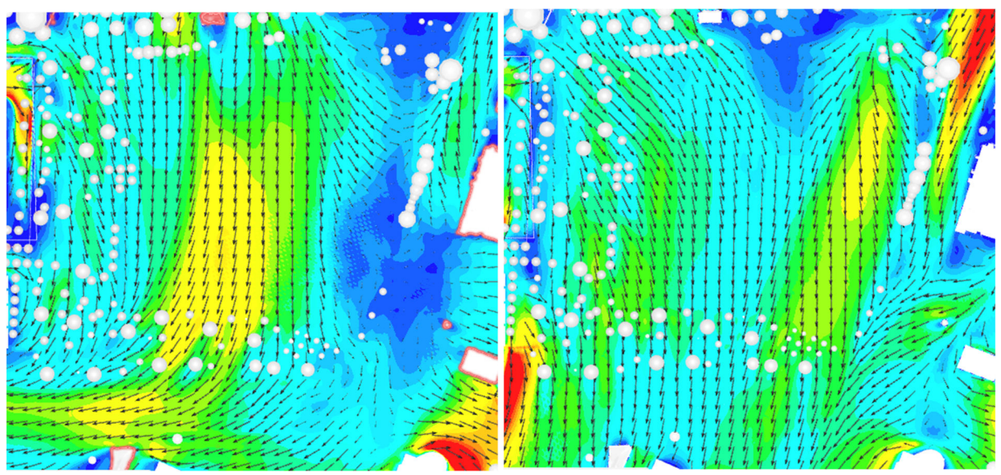


Figure 1-10 - Phase 1, wind speed contours for direction 45º (Left) and 67.5º (Right

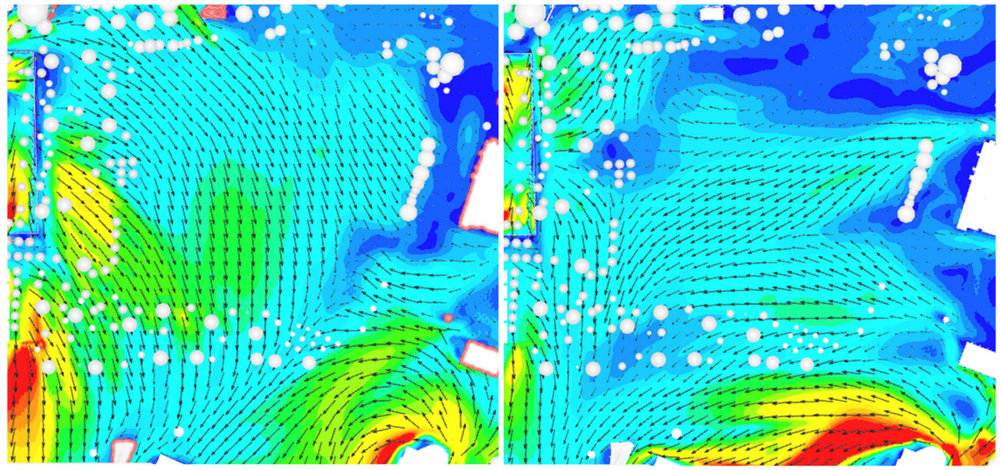


Figure 1-11 - Phase1, wind speed contours for direction 90º (Left) and 112.5º (Right)

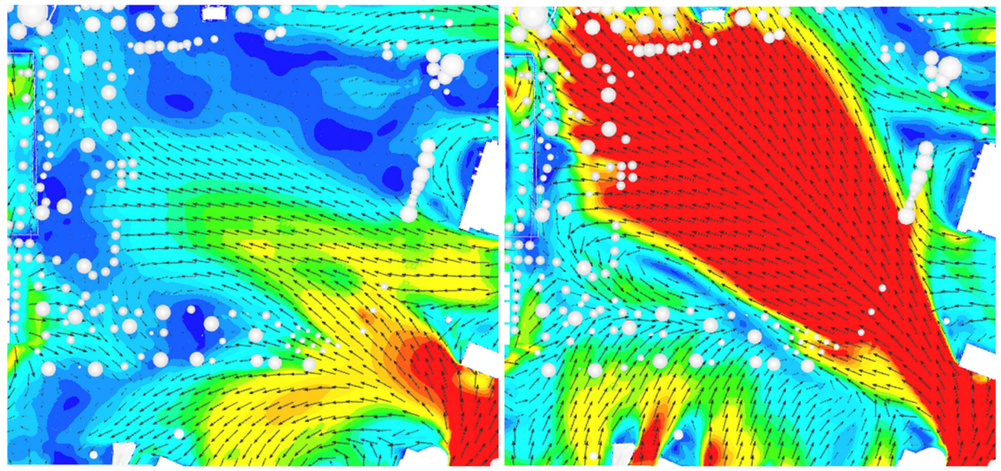


Figure 1-12 - Phase1, wind speed contours for direction 135º (Left) and 157.5º (Right)

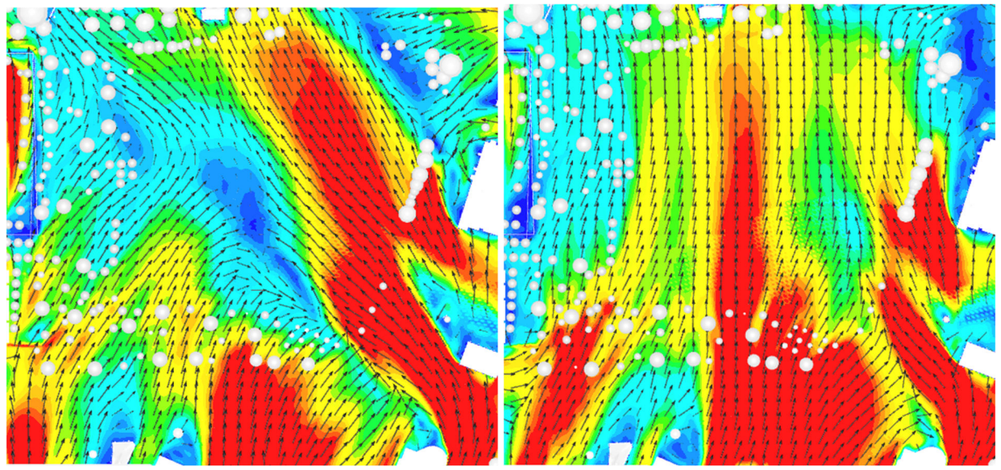


Figure 1-13 - Phase1, wind speed contours for direction 180º (Left) and 202.5º (Right)

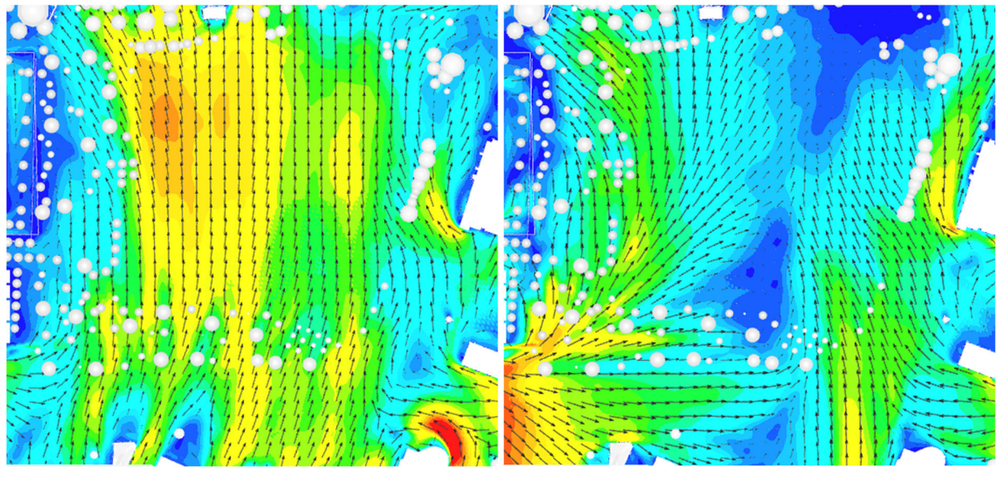


Figure 1-14 - Phase1, wind speed contours for direction 225º (Left) and 247.5º (Right)

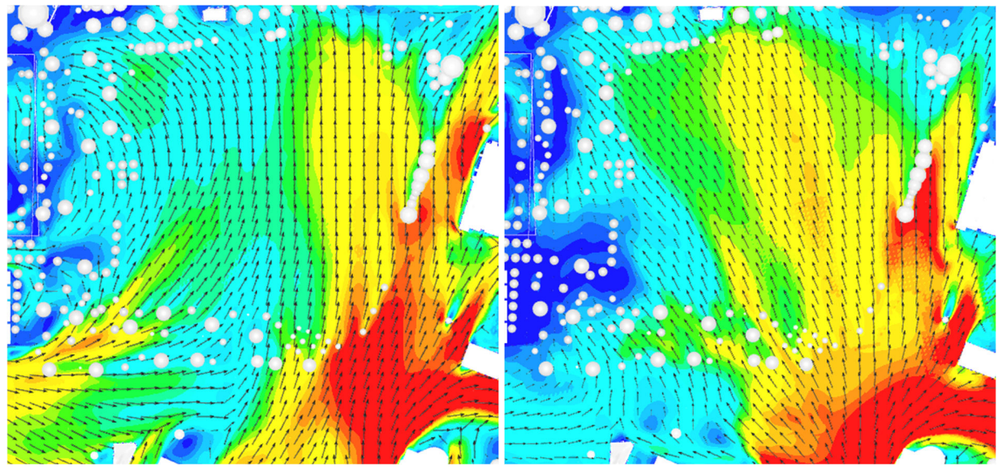


Figure 1-15 - Phase1, wind speed contours for direction 270º (Left) and 292.5º (Right)

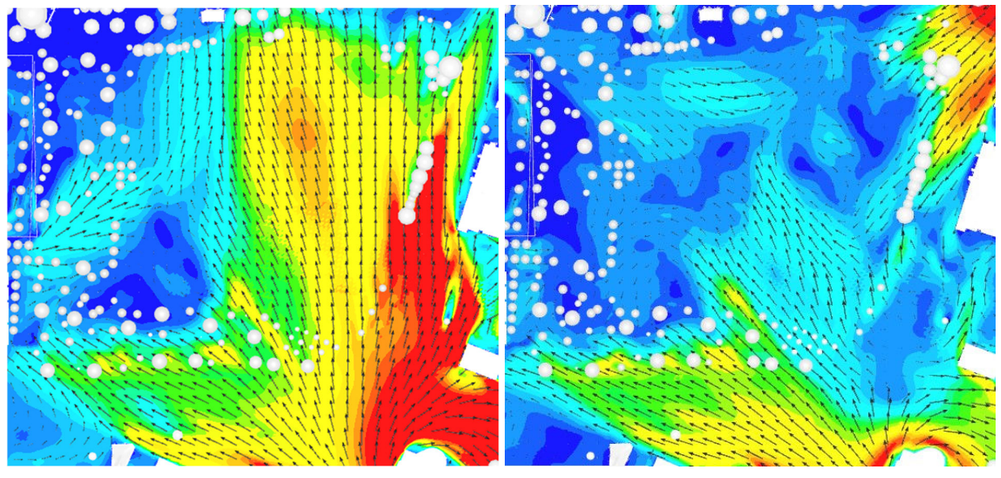


Figure 1-16 - Phase1, wind speed contours for direction 315º (Left) and 337.5º (Right)

1.2 CFD Inputs and Assumptions

1.2.1 Computational Domain, Mesh and Region of Interest

Computational Domain

The computational domain represents the wind tunnel in which the wind simulation is performed. A rectangular domain was used for the analysis and its dimensions are reported below

$$h = 155.4m$$

$$H, S, I = 3h = 240m$$

$$O = 9h = 600m$$

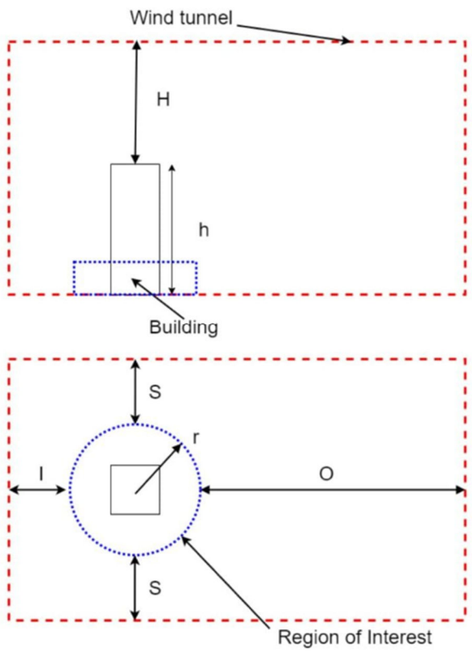


Figure 1-17 - Computational Domain dimensions

Therefore, the total wind tunnel dimensions are (L*W*H): 2130(m)*1680(m)*513(m)

Mesh

The mesh used by the software for the purpose of this assessment is based on the lattice-Boltzmann method (LBM), which consists of a cartesian background mesh composed only of cube elements that are not necessarily aligned with the geometry of the buildings or the terrain. To consider the exact geometry, a sub-grid model is generated and accounts for the interfaces between the geometry and the fluid domains. The surface areas identified for analysis are divided in a 0.78m grid, aligned to the human scale. The identified surfaces are prepared, and the analysis surface is offset to 1.5-meter height to assess pedestrian wind comfort.

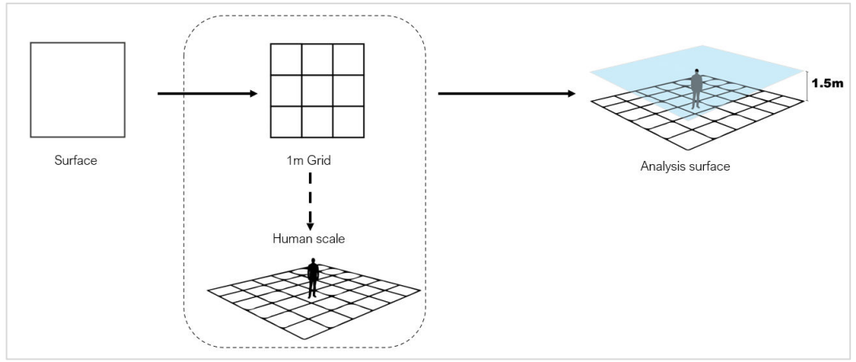


Figure 1-18 - Simulation grid generation

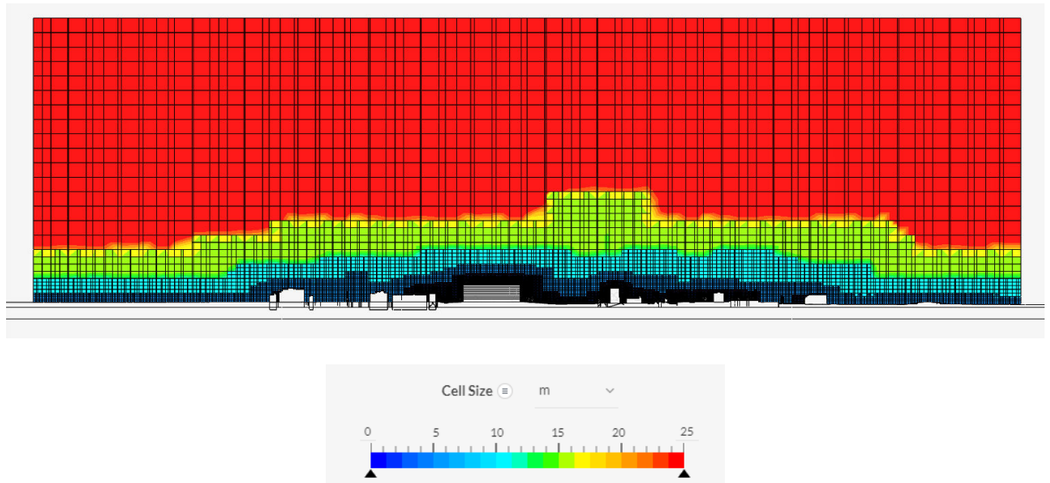


Figure 1-19 - Domain Mesh

Table 1-1 – Numbers of Meshing

Simulation Phase	Min Cell Size (m)	Max Cell Size (m)	Total Number of cells
Existing Phase	0.47	30	49 346 368
Proposed Scenario	0.47	30	49 102 208

Region of interest

The area of interest indicates the area or the domain around the proposed park or region over which the pedestrian comfort has been evaluated. This area is specified in the form of a disk, with a radius of 240m.

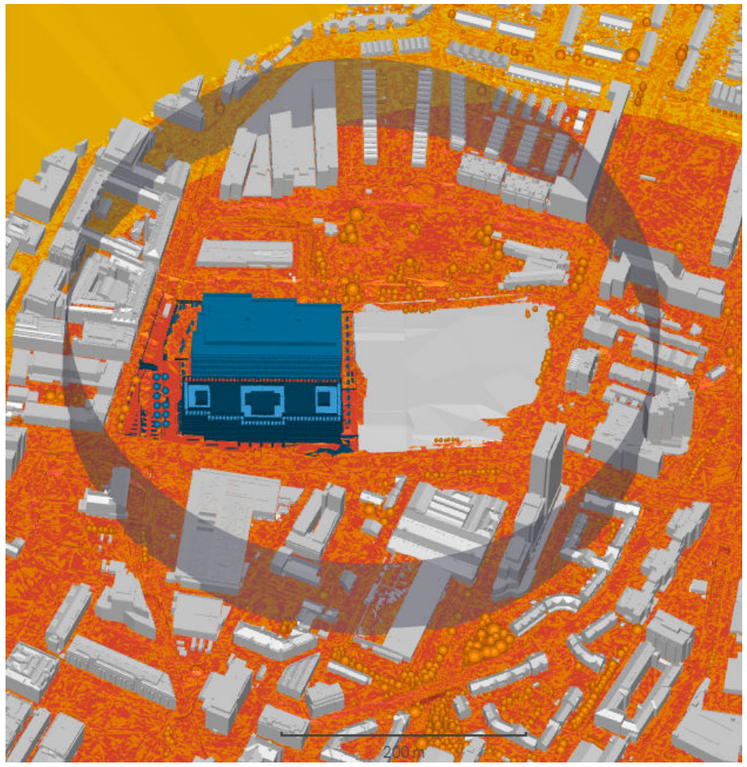


Figure 1-20 - Region of interest

The Ground height (z) defines the level at which the floor of the wind tunnel is placed, this has been assumed to be 0m as no significant difference in altitude is present on the site.

1.2.2 Boundary Conditions and Wind Profile

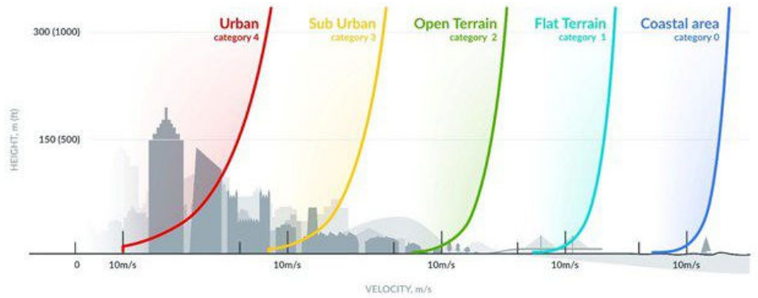
In wind analyses, the effect of wind over the model with respect to multiple wind directions is simulated simultaneously. Wind speed varies with respect to height, and this is called the Atmospheric Boundary Layer (or ABL). ABL depends on the height of the obstacles (buildings, trees, terrain, etc.). For the analysis, these conditions need to be defined, which indicate how a system interacts with the environment. These conditions are calculated using two main parameters:

- Wind exposure category
- Surface roughness

Wind exposures control how the wind speeds vary due to the presence of specific terrain characteristics. Different terrains cause different velocity gradient vertical to the ground commonly referred to as the atmospheric boundary layer (ABL).

A velocity profile and turbulence parameters have been specified at the domain inlet, considering the wind speed increase with increased distance from the ground.

No slip conditions have been used for the surfaces within the model to ensure the air velocity is zero at the contact with the solid boundary.



For the pedestrian comfort study, a reference velocity at 10 m height has been 10 m/s.

The boundary layer wind profile used for the simulation is based on the equation below

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

Suburban Category has been applied to all wind directions, this corresponds to a terrain category III and

Roughness length z_0= 0.3 as shown in the table below (CIBSE Guide A)

Table 2.21 Terrain categories and related parameters

Terrain category	Description	K_R	z_0 / m	z_{min} / m
I	Rough open sea; lake shore with at least 5 km fetch up-wind and smooth flat country without obstacles	0.17	0.01	2
II	Farm land with boundary hedges, occasional small farm structures, houses or trees	0.19	0.05	4
III	Suburban or industrial areas and permanent forests	0.22	0.3	8
IV	Urban areas in which at least 15% of surface is covered with buildings of average height exceeding 15 m	0.24	1	16

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