Appendix 13.1

Computational Fluid Dynamics 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 123 and 159 million cells.

Buildings within 500m 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 an empirical relationship between the gust and mean ratios recorded at over 13,000 data points from wind tunnel tests. This method is found to give a significant correlation improvement over the more traditional methods based on the CFD turbulent kinetic energy field.

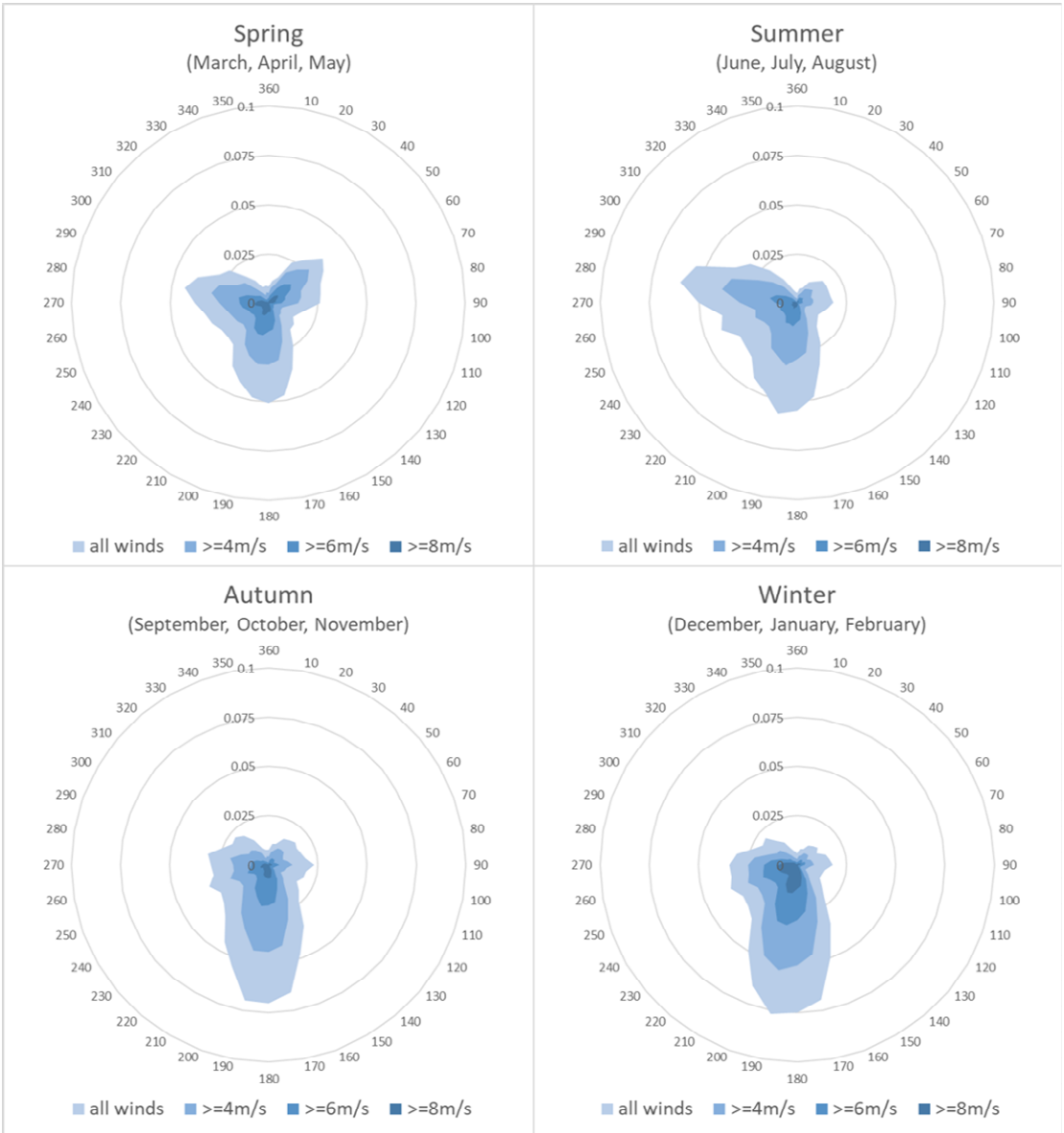
Wind Climate Methodology

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

The directions tested were 0°,30°,60°,90°,120°,150°,170°,180°,190°,200°,210°,220°, 240°, 260°, 270°, 280°, 300°, 330°.

30 years of weather data for Manchester International Airport was used for this study. Seasonal wind roses for this data are shown in *Figure 1*.

Figure 1 Seasonal Wind Roses for Manchester International Airport



Target wind profiles for the site, from each wind direction, were generated using sectoral analysis of the terrain surrounding the site with ESDU 2010 Item01008 'Computer program for wind speeds and turbulent properties: flat or hilly sites in terrain with roughness changes'. The target wind profile, compared to the wind speeds measured from the CFD are shown in *Figure 2.*

Figure 2 Wind Profile (Velocity) for Central Manchester

