

## 12. Climatic Effects (Wind Microclimate)

### Introduction

- 12.1 This Chapter reports the outcome of the assessment of likely significant environmental effects arising from the Proposed Scheme in relation to the potential impact on the wind microclimate.
- 12.2 The Chapter describes the consultation that has been undertaken during the EIA, the scope of the assessment and assessment methodology, and a summary of the baseline information that has informed the assessment.
- 12.3 A number of effects have been avoided in advance of the assessment and where relevant these are clearly stated. The assessment reports on the likely significant environmental effects, the further mitigation measures required to prevent, reduce or offset any significant adverse effects, or further enhance beneficial effects. The conclusions are provided both in terms of the residual effects and whether these are considered significant.
- 12.4 This Chapter, and its associated figures and appendices, is intended to be read as part of the wider ES with particular reference to the introductory chapters of this ES (**Chapters 1 - 5**).
- 12.5 In addition, this Chapter should be read in conjunction with **Chapter 13 – Cumulative Effects Assessment**.

### Legislative Framework and Guidance

- 12.6 Several policy documents<sup>i,ii,iii</sup> and sets of guidance<sup>iv,v,vi</sup> have informed the assessment of effects within this Chapter, and are detailed further in **Appendix 12.1**.

### Scope of the Assessment

- 12.7 An EIA Scoping Report was submitted to LCC in January 2020, as presented as **Appendix 2.1**. This section provides confirmation on the scope of the assessment presented within this Chapter following submission of the EIA Scoping Report and receipt of the EIA Scoping Opinion (**Appendix 2.2**).

### Effects which are Not Significant

- 12.8 The following not significant effects were identified as part of the EIA Scoping Report and are not considered further in this Chapter. The effects and evidence to support this are represented and updated as below.

#### *Wind effects as a result of construction activities*

- 12.9 Any wind impacts associated with the construction phase will be temporary in nature and can be managed through appropriate mitigation, through the implementation of a Construction Environmental Management Plan (CEMP). This will include measures such as securing lightweight materials during temporary stockpiling. There are unlikely to be any adverse effects on nearby residential receptors during the construction phase and as such construction activities have not been considered within the EIA or reported in the ES.

### Likely Significant Effects

- 12.10 The following effects (**Table 12.1**) are considered significant and are reported within this Chapter:

**Table 12.1: Likely Significant Effects and Sensitive Receptors**

Likely Significant Effect	Receptor	Applicable Phase
Wind movement within the Stadium	Spectators inside the Stadium	Operation
Wind movement within the Stadium	Players using the pitch	Operation
Wind environment outside the Stadium	Pedestrians in the vicinity of the Stadium	Operation

### Extent of the Study Area

- 12.11 Wind conditions have been assessed at and surrounding the Site at up to 410 locations (refer to **Figures 12.46-12.49 in Appendix 12.2**); measurement locations covered pedestrian thoroughfares, entrances, bus stops, amenity areas and the stands/pitch of the Proposed Scheme

### Background Studies to Inform the ES

- 12.12 No background studies have been conducted in regard to wind microclimate, with the exception of those inherently included within the assessment methodology, as detailed below.

### Assessment Methodology

- 12.13 The wind environment around the Proposed Scheme has been assessed by means of wind tunnel testing. The wind microclimate assessment has been undertaken using physical wind tunnel modelling using RWDI's specialist boundary layer wind tunnel test facility.
- 12.14 Mean and peak wind speeds have been measured (for both the windiest season (normally winter) to show the worst case scenario, and summer season for amenity spaces (amenity spaces are assessed during the summer season as these areas are expected to be used most frequently during this period with an expectation of calmer conditions compared to other times of the year)). Tested locations were across the existing Site and at other surrounding buildings, paths, roads and areas of open spaces for 36 wind directions in 10° increments within a 360m radius of the Site which is considered a large enough scale to ensure all wind effects are captured. Details of the tunnel test methodology is presented in the section 'Wind Tunnel Test Methodology' of this ES Chapter.
- 12.15 The wind tunnel data have been combined with statistical meteorological data for the Liverpool Area, adjusted to the Site, to establish the likely magnitude and frequency of winds at each measured location.

### **Wind Tunnel Testing Methodology**

- 12.16 The methodology for quantifying the pedestrian level wind environment is outlined below within four steps:
- Step 1: The site's induced wind speeds are measured for the appropriate configuration(s) at the appropriate pedestrian level(s) in the wind tunnel;
  - Step 2: Standard meteorological data is adjusted to account for conditions at a subject site (for this assessment, meteorological data has been derived from the meteorological station of Liverpool John Lennon Airport);
  - Step 3: Data from Step 1 and Step 2 is combined to obtain the expected frequency and magnitude of wind speed for the appropriate configuration(s) and at the appropriate pedestrian level(s); and
  - Step 4: The results of Step 3 are compared with the Lawson Comfort Criteria (and where relevant, the change in the wind microclimate conditions between appropriate test configuration(s)) to 'grade / score' the conditions within and around the site.
- 12.17 To produce the results within the wind tunnel, a 1:300 scale model comprising the Site and the surrounding area (including relevant existing buildings and other topographical features) was constructed on a 2.4m diameter disc allowing for the surrounding area within a 360m radius of the centre of the Site of the Proposed Scheme to be modelled (the radius is determined based on the scale model and due to the physical constraints of the modelling in the wind tunnel). This radius is considered a large enough scale to ensure all likely wind effects are captured.
- 12.18 Wind is unsteady, or gusty, and this 'gustiness' or turbulence, varies depending upon the site. In order to model the likely effects of gustiness or turbulence (which depends on the geographical location), a combination of spires and floor roughness elements have been employed in the wind tunnel in order to create a 'boundary layer' that is representative of the suburban location of the Site. The detailed wind tunnel model around the Proposed Scheme is used to fine-tune the flow and create conditions similar to those expected at full scale.
- 12.19 Other developments outside the 360m radius of the Site would not individually be expected to modify the wind approaching the Site and as such have been included within the analysis of the surrounding terrain.
- 12.20 Wind speed measurements within and around the Site for the tested configurations were established using 'Irwin probes'. These sensors are able to measure the mean and gust wind speeds at a full-scale height of approximately 1.5 m above the surface upon which the probe is located.
- 12.21 The wind speed was measured at up to 410 locations under the configurations for all wind directions in equal increments (36 angles total), with 0° representing wind blowing from the north and 90° wind from the east and so on.

### **Model Configurations Assessed**

- 12.22 The assessment of the wind microclimate is based on the results from a series of tests of physical models within the wind tunnel to provide a detailed, quantitative assessment. The existing landscaping in the surroundings of the Site was included in order to provide an accurate representation of the environmental context and the wind microclimate across the Site; these landscaping features were retained for all tested configurations. The Proposed Scheme with existing and cumulative surrounding buildings was assessed with both the existing (Configurations 2 and 3) and proposed (Configurations 4 and 5) landscaping scheme in place. The proposed landscaping scheme included six 5m tall trees to the north of the Proposed Scheme along Anfield Road, eighteen 2m wide and 3m high 50% porous screens at 3m above ground level at the north-west corner of the Stadium, and an approximately 5m high 50% porous screen around the north-west entrances to the Proposed Scheme which leaves 2.5m of clearance from ground level (Figures **12.40- 12.43** of **Appendix 12.2**).
- 12.23 Configurations tested within the wind tunnel include:
- Configuration 1: Existing Site with Existing Surrounding Buildings and Existing Landscaping Scheme;
  - Configuration 2: Proposed Scheme with Existing Surrounding Buildings and Existing Landscaping Scheme;
  - Configuration 3: Proposed Scheme with Cumulative Surrounding Buildings and Existing Landscaping Scheme;
  - Configuration 4: Proposed Scheme with Existing Surrounding Buildings, Existing and Proposed Landscaping Scheme; and
  - Configuration 5: Proposed Scheme with Cumulative Surrounding Buildings, Existing and Proposed Landscaping Scheme.
- 12.24 Configuration 1 presents the baseline of the Site and is reported within the baseline section of this ES chapter.
- 12.25 Configuration 4 presents the Proposed Scheme, as applied for, and presents the likely effects on wind microclimate. Scenario 4 has therefore been included within this chapter.
- 12.26 Configuration 5 presents the Proposed Development alongside these cumulative schemes and is presented within **Chapter 13 Cumulative Effect Assessment**.
- 12.27 The remaining configurations show the testing undertaken to establish the need and benefit of mitigation in the form of proposed landscaping and are graphically presented in **Appendix 12.2** for narrative purposes only. A technical appendix has been provided in **Appendix 12.3 – Technical Report**.

### **Assessment Criteria: Lawson Comfort Criteria**

- 12.28 The assessment of the wind conditions requires a standard against which the measurements can be compared. The assessment of the wind tunnel results presented in this ES Chapter adopts the Lawson Comfort Criteria, which have been established for over 30 years.

- 12.29 The Lawson Criteria described in **Table 12.2** is presented to define the reaction of an average pedestrian to the wind. If the measured wind conditions exceed the threshold wind speed for more than 5 % of the time, then they are unacceptable for the stated pedestrian activity and the expectation is that there may be complaints of nuisance or people will not use the area for its intended purpose.
- 12.30 The Lawson Criteria set out four pedestrian activities (comfort categories) and reflect the fact that less active pursuits require more benign wind conditions. The four categories are: sitting, standing, strolling and walking, in ascending order of activity level, with a fifth category for conditions that are uncomfortable for all uses. In other words, the wind conditions in an area required for sitting need to be calmer than a location that people merely walk past.
- 12.31 The coloured key in **Table 12.2** corresponds to the presentation of wind tunnel test results.

**Table 12.2: Lawson Comfort Criteria**

Key	Comfort Category	Threshold	Description
●	Uncomfortable	>10 m/s	Winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended.
●	Walking	8-10 m/s	Relatively high speeds that can be tolerated if the objective is to walk, run or cycle without lingering.
●	Strolling	6-8 m/s	Moderate breezes that would be appropriate for strolling along a city/town centre street, plaza or park.
●	Standing	4-6 m/s	Gentle breezes suitable for main building entrances, pick-up/drop-off points and bus stops.
●	Sitting	0-4 m/s	Light breezes desired for outdoor restaurants and seating areas where one can read a paper or comfortably sit for long periods.

#### **Target Wind Conditions**

- 12.32 For a mixed-use urban environment, such as the Site and surrounding area, the desired wind microclimate for the Proposed Development would typically need to have areas suitable for sitting, standing/entrance use and strolling (**Table 12.2**).
- 12.33 The walking and uncomfortable classifications may be acceptable in isolated areas, but these classifications are also associated with occasional strong winds (which are described below) and so the aim has been to avoid conditions falling into these categories.

#### **Amenity Areas**

- 12.34 The target condition for seating in amenity areas is a wind microclimate that is suitable for sitting during the summer season. This is because these areas are more likely to be frequently used during the summer when pedestrians would expect to be able to sit comfortably. If an area is classified as suitable for sitting in the summer, the windier conditions that occur during the winter season usually mean that the area would be

classified as suitable for standing in the windiest season, unless additional shelter was provided.

#### ***Stands***

- 12.35 Wind conditions within the Stadium are desired to be suitable for a mix of sitting use to standing use during the windiest season. This is considered acceptable due to the more active purpose of the stands compared to a long-term seating area such as a café where sitting use wind conditions would be required.

#### ***Entrances***

- 12.36 Areas in proximity of building entrances, a wind environment suitable for standing or calmer is desired, as pedestrians will transition from the calm indoors to the windier outdoors throughout the year. The assessment for building entrances therefore focuses on the windiest season result.

#### ***Secondary Entrances***

- 12.37 Considered as entry points to a building which are not primary entrances and used for alternative purposes, like fire entrances or emergency exits, a wind environment for strolling or calmer is desired. The assessment focuses on the windiest season.

#### ***Bus Stops***

- 12.38 Wind conditions at bus stop locations are required to be suitable for standing use during the windiest season.

#### ***Thoroughfares***

- 12.39 A pedestrian thoroughfare should be suitable for strolling during the windiest season. The assessment for pedestrian thoroughfares therefore focuses on the windiest season result.
- 12.40 Localised occurrence of walking conditions may be acceptable in areas with limited footfall, or service areas, as long as the strong wind criteria (see section 'Strong Winds') is not exceeded.

#### ***Crossings***

- 12.41 Crossings should be suitable for walking during the windiest season.

#### ***Roadways***

- 12.42 The Lawson Criteria does not specify criteria for acceptable wind conditions for cyclists; however, the occurrence of winds exceeding the strong winds threshold (as described below) would be considered unsuitable for cyclists.

#### ***Strong Winds***

- 12.43 The Lawson Criteria also specifies a strong wind threshold when winds exceed 15m/s for more than 0.025% of the time (approximately 2.2 hours of the year) would have the potential to cause distress to pedestrians and cyclists. Exceedance of this threshold may indicate a need for remedial measures or a careful assessment of the expected use of that location; e.g. is it reasonable to expect older adults or young children to be present at the location on the windiest day of the year?
- 12.44 Wind Speeds that exceed 20m/s for more than 0.025% of the time (approximately 2.2 hours of the year) represent safety issue for all members of the population, which would require mitigation to provide an appropriate wind microclimate environment.

- 12.45 Strong winds are generally associated with areas which would be classified as acceptable for walking or conditions considered uncomfortable. In a mixed-use urban area, walking and uncomfortable conditions would not usually form part of the 'target' wind environment and would usually require mitigation due to pedestrian comfort considerations. This mitigation would also have the impact of reducing the frequency of, or even eliminate, any strong winds.

### ***Assumptions***

- 12.46 This assessment is based on worst-case conditions for each location whenever they happen to occur throughout the year, generally expected to be encountered during the winter season (December, January and February) in the UK. Additional consideration has been made for summer wind conditions due to the presence of ground floor public amenity space. This complies with the standard methodology set out by Lawson for wind-microclimate assessments.
- 12.47 It is expected that use of outdoor amenity spaces for sitting will be limited to the summer season. During the windier times of the year, it would be expected that these spaces would increase a criteria level to standing use.

### **Reporting of the Environmental Effect and Significance Criteria**

- 12.48 The assessment of likely significant environmental effects as a result of the Proposed Scheme has taken into account the construction and operational phases.
- 12.49 The duration of the effect has been assessed as either 'short-term', 'medium-term' or 'long-term'. Short-term is considered to be up to 1 year, medium-term is considered to be between 1 and 10 years and long-term is considered to be greater than 10 years.
- 12.50 The approach to the assessment of effects on wind microclimate follows a specialist methodology, which differs a little from that set out within **Chapter 2** and is explained in the section below.

### ***Determining Sensitivity of Receptor***

- 12.51 The sensitivity of receptors is related to the intended pedestrian usage at each location; there are no graded definitions for sensitivity, as the important consideration is whether the wind conditions experienced at a particular receptor location are suitable for the intended use (in terms of comfort and strong winds) at that particular location. All receptors are considered to be highly sensitive to the local wind microclimate conditions and are given an equal weighting.

### ***Determining Level of Effect***

- 12.52 Given that all receptors are considered to have an equal weighting in terms of sensitivity, the effect level is determined by the change in wind level from the baseline. The effect classification of the modelled wind microclimate is reported in **Table 12.3** below and discussed further below.

**Table 12.3: Effect Classification Criteria**

Modelled Wind Microclimate Criteria	Effect Classification
Wind Conditions are 3-steps calmer / windier than desired	Major

Modelled Wind Microclimate Criteria	Effect Classification
Wind Conditions are 2-steps calmer / windier than desired	Moderate
Wind Conditions are 1-step calmer / windier than desired	Minor
Wind Conditions are similar to those desired.	Negligible

- 12.53 The minor, moderate and major categories indicate the severity of the change in wind condition between the desired wind microclimate and the wind microclimate presented in the modelled results (i.e. the level of the effect experienced at a receptor). As an example, if the desired wind conditions at a location are required to be suitable for standing use, but the predicted wind conditions are suitable for strolling use, the difference between the desired and predicted wind condition is one category windier than desired. In this case, the scale of the effect would be identified as minor adverse.
- 12.54 The effect classification criteria must also account for comparison against the Baseline conditions and the predicted (modelled) wind conditions for the Proposed Scheme. Where predicted wind conditions are windier than the Baseline conditions, yet remain calmer than required, these would be identified as negligible (rather than minor beneficial). Additionally, if wind conditions remain suitable for the intended use, these would also be classified as negligible (i.e. if a thoroughfare location in the baseline condition has standing wind conditions but increase to a strolling condition when the Proposed Scheme is in situ, although windier than the baseline scenario, these wind conditions would remain suitable for the intended use and therefore represent a negligible effect.
- 12.55 An adverse effect implies that a location has a wind environment that is windier than the desired conditions and mitigation should therefore be considered. Where potential adverse effects are identified, consideration is provided in the mitigation section of this ES Chapter to discuss the remedial measures required to mitigate the potential impact and the resultant residual effects are then presented.
- 12.56 In light of the above, any adverse effect or residual adverse effect are considered to be 'Significant'. Any beneficial effects are considered to not be significant as they are calmer than the desired condition.
- 12.57 Effects once the Proposed Scheme is completed are direct, local and long-term (permanent) and irreversible.

## Baseline Conditions

### Meteorological Data

- 12.58 Meteorological data for Liverpool (Liverpool John Lennon Airport), shown in **Figure 12.1**, were used in this assessment as this is deemed to provide the best representation of the local wind microclimate for the Site area.
- 12.59 The meteorological data obtained for Liverpool indicates that the prevailing winds throughout the year are from the west (i.e. 225° to 315°). During the autumn and the winter seasons, winds are more frequent from the south-eastern quadrant, however, while winds from the west are less frequent during the winter, these tend to be the strongest throughout the year.



12.60 The meteorological data was corrected to reference wind speeds 10m above open flat level country terrain. The meteorological model was then adjusted to the Site conditions using the methodology implemented the ESDU methodology<sup>1</sup>. Adjustment factors (mean factors) were computed for wind directions from 0° through to 360°. The reference height in the wind tunnel was at the equivalent full-scale height of 120 metres. Table 12.5 within **Appendix 12.2** presents the mean factors for the Site. Mean factors for the north-westerly angles are higher than the rest which indicates that winds blow along more open terrains from this sector.

12.61 Liverpool is also noted to have a particularly windy environment with respect to other UK cities, therefore areas which experience building-induced wind acceleration will be expected to have relatively windy conditions.

#### **Configuration 1: Existing Site with Existing Surrounding Buildings and Existing Landscaping Scheme**

12.62 Wind conditions for Configuration 1 (baseline scenario) are presented in **Figures 12.2** and **12.3** respectively at ground level, and on the Main Stand podium and on the stands of the Stadium during the windiest season. **Figures 12.4** and **12.5** depict the wind conditions at ground level, podium level and on the stands during the summer season, while **Figures 12.6** and **12.7** report the strong winds exceedances throughout the year.

#### ***Pedestrian Comfort***

12.63 Within the baseline scenario, wind conditions range from suitable for sitting use to walking use during the windiest season; wind conditions during the summer season are generally one category calmer at and surrounding the Site.

#### ***Thoroughfares***

12.64 Wind conditions at all thoroughfare locations in the surrounding areas range from suitable for sitting use to walking use during the windiest season, as shown in **Figure 12.2**. Windiest areas are at the south-western and north-western corners of the Main Stand, with walking wind conditions at measurement locations 80, 81, 111, 112, 114, 118, 126, 127, 130-134, 348-352, 355, 356, 375 and 376.

12.65 Generally, one category calmer wind conditions occur during the summer season, ranging from suitable for sitting use to walking use (**Figure 12.4**); the windiest area would be the north-west corner of the Main Stand.

#### ***Crossings***

12.66 Crossings in the surrounding of the Site are represented by measurement locations 88, 259-262, and 265. All these locations have wind conditions suitable for standing use during the windiest season, as shown in **Figure 12.2**.

#### ***Entrances***

12.67 Entrances to the surrounding buildings are represented by measurement locations 59, 61, 256, 258, 361, and 364. All these entrances have wind conditions suitable for standing use or calmer during the windiest season in this configuration (**Figure 12.2**). Entrance to the Stadium (measurement locations 18-20, 22, 27, 30, 34-36, 38, 44-47, 68, 69, 71-74, 76, 77,

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<sup>1</sup> ESDU International, Computer program for wind speeds and turbulence properties; flat or hilly sites in terrain with roughness changes, ESDU 01008, 2001.

85, 86, 90, 91, 95, 99, 119, 135, 136, 138-140, 144, 169-172, 248-250, 268-270, 287, 289, 298, 304-306, 308, 310, 312, 315, and 317) would have wind conditions suitable for sitting use to strolling use during the windiest season, with strolling use wind conditions at entrance location 85 (**Figures 12.2 and 12.4**).

#### ***Bus Stops***

- 12.68 Bus stops in the surroundings of the Site are represented by measurement locations 29, 37, 56, 243, 255. All these locations have standing use or calmer wind conditions during the windiest season (**Figure 12.2**).

#### ***Pitch and Stands***

- 12.69 Wind conditions on the pitch during the windiest season range from suitable for sitting use to standing use, with sitting use wind conditions throughout during the summer season (**Figures 12.2 and 12.4**). A mix of sitting use to standing use wind conditions occur on the stands during the windiest season, with strolling to walking use wind conditions at the podium level concourse of the Main Stand (**Figure 12.3**). Generally, one category calmer conditions occur at both the podium of the Main Stand and within the stands during the summer season (**Figure 12.5**).
- 12.70 There is a mix of standing use to walking use wind conditions on the thoroughfares located at the podium level concourse of the Main Stand during the windiest season. Measurement location 307 would have walking wind conditions (**Figure 12.3**).

#### ***Ground Level Amenity Spaces***

- 12.71 Ground level amenity spaces within the surrounding of the Site are represented by measurement locations 26, 264, 266, 272, 273, 275, 277, 283, 285, 286, 292, and 295. All these locations have sitting use wind conditions during the summer season (**Figure 12.4**).
- 12.72 Measurement locations 148-150, 153-156, 195, 384-391, and 393-410 represent Stanley Park to the north of the Site. Wind conditions at these locations are suitable for standing use to strolling use during the summer season, with strolling use wind conditions at measurement locations 154, 399, and 408-410.

#### ***Strong Winds***

- 12.73 In the baseline scenario there are 40 instances of strong winds exceeding 15 m/s for more than 2.2 hours per year, namely at measurement locations 80, 112, 114, 118, 123, 124, 125, 126, 127, 130, 131, 132, 133, 134, 143, 145, 160, 161, 162, 163, 164, 165, 166, 167, 173, 174, 346, 347, 348, 349, 350, 351, 352, 353, 355, 356, 375, 376, 377, and 378. Strong winds at measurement location 134 also exceed the 20 m/s safety threshold for approximately 4.5 hours per year (**Figures 12.6 and 12.7**). The annual exceedance of strong winds can be found in Table 3 of **Appendix 12.3 – Technical Report**.

#### ***Future Baseline***

- 12.74 The evolution of the baseline condition (in the event that the Proposed Scheme does not come forward) has been considered using professional judgement informed by the results of the baseline scenario (Configuration 1) and the wind tunnel results undertaken as part of the cumulative effects assessment.

- 12.75 Wind conditions in the future baseline scenario would be largely consistent with those of Configuration 1, with slightly calmer wind conditions expected to the west of the stadium.

### **Sensitive Receptors**

- 12.76 The receptors considered in this wind assessment are people using external areas within the Proposed Scheme and within the surrounding area.
- 12.77 Equal sensitivity is assigned to receptors identified both within and around the Site because the assessment criteria and the categories for defining impact and significance for the wind assessment are based on whether the wind environment within the external areas of the Site is suitable for the intended use. In other words, the 'sensitivity' of an area, which is related to its use, is already accounted for in the assessment criteria.

### **Primary and Tertiary Mitigation Measures**

- 12.78 The following primary and tertiary mitigation which has been evaluated as part of the operational phase assessment is outlined below.
- 12.79 Configurations 4 and 5 (Configuration 5 reported within **Chapter 13 Cumulative Effects Assessment**) included the proposed landscaping scheme, namely:
- six approximately 5m high deciduous trees along Anfield Road;
  - eighteen 50% porous screens (2m wide by 3m high) located at 3m above the ground;
  - 5m high 50% porous screen around the north-west entrances to the Proposed Scheme (leaving 2.5m of clearance from ground level); and
  - 2m high 50% porous fence around the OB area.
- 12.80 All these wind mitigation measures are depicted in **Figures 12.40 - 12.43** of **Appendix 12.2**.

### **Assessment of Effects, Secondary Mitigation and Residual Effects**

#### **Configuration 4: Proposed Scheme with Existing Surrounding Buildings, Existing and Proposed Landscaping Scheme and Proposed Mitigation Measures**

- 12.81 Wind conditions for Configuration 4 are presented in **Figures 12.20** and **12.21** respectively at ground level, and on the Main Stand podium and on the stands of the Stadium during the windiest season. **Figures 12.22** and **12.23** depict the wind conditions at ground level, podium level and on the stands during the summer season, while **Figures 12.24** and **12.25** report the strong winds exceedances throughout the year.
- 12.82 Configuration 4 included the proposed landscaping scheme in addition to the existing landscaping in the surrounding of the Stadium; these features are shown in **12.40- 12.43** of **Appendix 12.2**.

#### ***Pedestrian Comfort***

- 12.83 In general, wind conditions in this configuration at and surrounding the Proposed Scheme would be significantly calmer than those in Configuration 1, especially around the north

corner of the Main Stand. Wind conditions would generally range from suitable for sitting use to walking use during the windiest season, with walking use wind conditions around the north corner and to the south of the Main Stand; wind conditions during the summer season would be generally one category calmer at and surrounding the Site. Further details of the wind conditions for Configuration 4 can be found within the below paragraphs.

#### ***Thoroughfares***

- 12.84 Wind conditions at all thoroughfare locations would range from suitable for sitting use to walking use during the windiest season, as shown in **Figure 12.20**. Instances of walking use wind conditions would remain at measurement locations 80, 112, 118, and 134 during the windiest season. Walking use wind conditions at these locations would be one category windier than required; however, these wind conditions are already existing in the baseline scenario (Configuration 1), therefore wind mitigation measures would not be required at any of these locations as this represents a **negligible** (Not Significant) effect.
- 12.85 Generally, one category calmer wind conditions occur during the summer season, ranging from suitable for sitting use to strolling use (**Figure 12.22**); the windiest areas would be the northern corner of the Main Stand and the north-west corner of the Proposed Scheme. These wind conditions would be acceptable during the summer season representing a **negligible** (Not Significant) effect, and wind mitigation measures would not be required at any thoroughfare location.

#### ***Crossings***

- 12.86 Wind conditions at all crossing locations 88, 259-262, and 265 would be suitable for standing use or calmer during the windiest season in this configuration representing a **moderate beneficial** (Not Significant) to **major beneficial** effect (Not Significant), as shown in **Figure 12.20**.

#### ***Entrances***

- 12.87 Entrances to the surrounding buildings (measurement locations 59, 61, 256, 258, 361, and 364) would have wind conditions suitable for standing use or calmer during the windiest season in this configuration (**Figure 12.20**). This represents a **negligible** (Not Significant) to **minor beneficial** (Not Significant) effect and mitigation would not be required at these locations.
- 12.88 Entrances to the Proposed Scheme and to the stadium represented by measurement locations 18-20, 22, 27, 30, 34-36, 38, 44-47, 68, 69, 71-74, 76, 77, 85, 86, 90, 91, 95, 99, 119, 135, 136, 138-140, 144, 164, 166-171, 173, 175, 176, 185-189, 209-211, 213, 214, 224-226, 232-234, 238, 248-250, 268-270, 287, 289, 298, 308, 310, 312, 315, and 317 would have wind conditions suitable for sitting use to strolling use during the windiest season, representing a **moderate beneficial** (Not Significant) to **minor adverse** (Significant) effect (**Figures 12.20 and 12.22**). Strolling use wind conditions would occur at entrance locations 85, 164, 173, 175, and 232. Strolling use wind conditions at the secondary entrance 85 would be acceptable, representing a **negligible** (Not Significant) effect. However, entrance locations 164, 173, 175, and 232 would have one category windier than required conditions representing a **minor adverse** (Significant) effect. Main entrances require standing use wind conditions during the windiest season, so that pedestrians can gradually step from the calmer environment inside the Stadium to the outdoor climate. Therefore, entrance locations 164, 173, 175, and 232 would require localised wind mitigation measure to provide a suitable wind environment at these locations

### ***Bus Stops***

- 12.89 Wind conditions at all the bus stops in the surrounding of the Site (measurement locations 29, 37, 56, 243, 255) would remain consistent with those in Configuration 1, suitable for standing use or calmer wind conditions during the windiest season (**Figure 12.20**). This represents a **negligible** (Not Significant) to **minor beneficial** (Not Significant) effect, and no mitigation would be required at any of these locations.

### ***Pitch and Stands***

- 12.90 Wind conditions on the pitch during the windiest season would be largely consistent with those of Configuration 1 with calmer wind conditions to the north, ranging from suitable for sitting use to standing use (**Figure 12.20**). This represents a **minor beneficial** (Not Significant) to **negligible** (Not Significant) effect, and no wind mitigation would be required.
- 12.91 Wind conditions on the pitch during the summer season would be suitable for sitting use representing a **minor beneficial** (Not Significant) effect (**Figure 12.22**).
- 12.92 Wind conditions on the stands would remain largely consistent with those of Configuration 1 during the windiest season, ranging from suitable for sitting use to standing use during the windiest season. This represents a **minor beneficial** (Not Significant) to **negligible** (Not Significant) effect (**Figure 12.21**).
- 12.93 Wind conditions at podium level of the Main Stand would be largely consistent with those of Configuration 1, ranging from suitable for standing use to strolling use during the windiest season, representing a **minor beneficial** (Not Significant) to **negligible** (Not Significant). Wind mitigation measures would not be required at any location at podium level of the Main Stand.
- 12.94 Generally, one category calmer conditions occur at both the podium of the Main Stand and within the stands during the summer season (**Figure 12.23**).

### ***Ground Level Amenity Spaces***

- 12.95 Ground level amenity spaces within the surroundings (measurement locations 26, 264, 266, 272, 273, 275, 277, 283, 285, 286, 292, and 295) would have sitting use wind conditions during the summer season (**Figure 12.22**), representing a **negligible** (Not Significant) effect.
- 12.96 Wind conditions at Stanley Park to the north represented by measurement locations 148-150, 153-156, 195, 384-391, and 393-410, would remain suitable for standing use to strolling use during the summer season (**Figure 12.22**). Strolling use wind conditions would occur at measurement locations 404, and 408-410; however, these wind conditions are already existing in the baseline scenario and would not be made worse with the inclusion of the Proposed Scheme in this configuration, therefore this represents a **negligible** (Not Significant).

### ***Strong Winds***

- 12.97 With the proposed landscaping scheme in place the extent of the strong winds would be substantially reduced along Anfield Road and in Stanley Park, with 13 instances of strong winds exceeding 15 m/s for more than 2.2 hours per year at measurement locations 80, 112, 118, 133, 134, 164, 173, 177, 345, 347, 350, 355, and 356 (**Figures 12.24 and 12.25**). The annual exceedance of strong winds can be found in Table 3 of **Appendix 12.3 – Technical Report**.

12.98 Wind mitigation measures would be required at measurement locations 164, 173, 177, 345, and 347 as wind conditions would be made worse compared to Configuration 1 (in terms of hours of exceedance) with the inclusion of the Proposed Scheme or the intended use has changed (measurement locations 164 and 173 were thoroughfares in Configuration 1, while in Configuration 4 represent entrances). Strong winds at measurement location 80 would have a frequency largely consistent with the baseline scenario (Configuration 1), therefore wind conditions at this location would remain consistent with the existing scenario. Strong winds at all the other locations represent a safety concern, and wind mitigation is highly recommended at these locations.

#### **Secondary Mitigation and Residual Effects**

12.99 Wind mitigation measures have been tested in both the context of the existing and cumulative schemes (respectively Configurations 4 and 5; Configuration 5 is reported in **Chapter 13 Cumulative Effects Assessment**) and included:

- six approximately 5m high deciduous trees along Anfield Road;
- eighteen 50% porous screens (2m wide by 3m high) located at 3m above the ground;
- 5m high 50% porous screen around the north-west entrances to the Proposed Scheme (leaving 2.5m of clearance from ground level); and
- 2m high 50% porous fence around the OB area.

12.100 All these wind mitigation measures are depicted in **12.40- 12.43 of Appendix 12.2** and are considered to be primary mitigation.

12.101 Wind conditions with all these features in place would generally improve at and surrounding the Proposed Scheme in both the context of the existing and cumulative schemes (Configurations 4 and 5); however, further wind mitigation will be required at a few windier than required locations, namely:

- Entrance locations 164, 173, 175, and 232; and
- Strong winds at measurement locations 164, 173, 177, 345, and 347.

12.102 Wind mitigation measures are required at these locations and surrounding the Proposed Scheme to provide a safe and comfortable wind environment. Architectural options will be considered and presented to LCC ahead of installation. It is anticipated that these will continue to accord with the principles set out under primary mitigation.

12.103 In the absence of secondary mitigation measures, effects would remain as stated.

#### **Limitation and Assumptions**

12.104 To ensure transparency within the EIA process, the following limitations and assumptions have been identified:

- It is assumed that there will be restricted access (i.e. not accessible to the general public) across the Site during the demolition and construction works, and therefore

windier conditions will be tolerable as the area is not for typical pedestrian use where the tolerable wind speed threshold would be lower.

## Summary

12.105 Wind tunnel results for Configuration 1 (Existing Site with Existing Surrounding Buildings and Existing Landscaping Scheme) showed wind conditions ranging from suitable for sitting use to walking use during the windiest season, with the windiest area around the northern corner of the Main Stand. Several instances of strong winds would occur in the baseline scenario at the western corner of the Main Stand and to the north of the Stadium along Anfield Road and within Stanley Park.

12.106 The inclusion of the proposed landscaping scheme tested in Configurations 4 and 5 would improve wind conditions at and surrounding the Proposed Scheme, and the extent of the strong winds would be substantially reduced along Anfield Road and within Stanley Park. However, further wind mitigation measures would be required at the following measurement locations:

- Entrance locations 164, 173, 175, and 232; and
- Strong winds at measurement locations 164, 173, 177, 345, and 347.

12.107 Additional wind tunnel tested will be required to develop and verify an effective wind mitigation strategy at these locations.

12.108 **Table 12.4** provides a summary of the effects, receptors, residual effects and a conclusion as to whether the effect is significant or not significant.

Effect	Receptor	Residual Effect	Is the Effect Significant
Operational Phase			
Thoroughfares locations with walking use wind conditions during the windiest season (Configuration 4)	80, 112, 118, and 134	Negligible	NO
Thoroughfares locations with strolling to sitting use wind conditions during the windiest season (Configuration 4)	All other thoroughfare receptors	Negligible to moderate beneficial	NO
Crossings locations with standing use to sitting use wind conditions during the windiest season (Configuration 4)	88, 259-262, and 265	Minor beneficial to major beneficial	NO
Entrances to the Proposed Scheme and to the Stadium with strolling use wind conditions or calmer during the	85	Negligible	NO

Effect	Receptor	Residual Effect	Is the Effect Significant
windiest season (Configuration 4)			
Entrances to the Proposed Scheme and to the stadium with strolling use wind conditions or calmer during the windiest season (Configuration 4)	164, 173, 175, and 232	Minor adverse	YES
Entrances to the Proposed Scheme and to the Stadium with standing use wind conditions or calmer during the windiest season (Configuration 4)	18-20, 22, 27, 30, 34-36, 38, 44-47, 68, 69, 71-74, 76, 77, 90, 91, 95, 99, 119, 135, 136, 138-140, 144, 166-171, 176, 185-189, 209-211, 213, 214, 224-226, 233, 234, 238, 248-250, 268-270, 287, 289, 298, 308, 310, 312, 315, and 317	Negligible to minor beneficial	NO
Bus stops with standing use wind conditions or calmer during the windiest season (Configuration 4)	29, 37, 56, 243, 255	Negligible to minor beneficial	NO
Pitch and Stands with standing use wind conditions or calmer during the windiest season (Configuration 4)	1-15, and 319-339	Negligible to minor beneficial	NO
Ground level amenity spaces with sitting use wind conditions or calmer during the summer season (Configuration 4)	26, 264, 266, 272, 273, 275, 277, 283, 285, 286, 292, and 295	Negligible	NO
Stanley Park with wind conditions strolling to standing use wind conditions during the summer season (Configuration 4)	148-150, 153-156, 195, 384-391, and 393-410	Negligible	NO
Strong Winds (Configuration 4)	164, 173, 177, 345, and 347	Major Adverse	YES



## References

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<sup>i</sup> National Planning Policy Framework, 2019

<sup>ii</sup> Liverpool Local Plan, 2018

<sup>iii</sup> World Heritage Site SPD, 2009

<sup>iv</sup> Guidance on tall buildings, English Heritage and the Commission for Architecture and the Built Environment, 2007

<sup>v</sup> National Planning Practice Guidance (NPPG), 2019

<sup>vi</sup> Tall Buildings, Historic England Advice Note 4, 2015