



Manchester Goods Yard

Wind Microclimate

July 2021

Prepared For:

Manchester Quays Limited
Suite 1, Bonded Warehouse
18 Lower Byrom Street
Manchester M3 4AP

Contents

Executive Summary.....	1
1. Introduction	2
2. Methodology and Criteria.....	3
2.1. Guidelines.....	3
2.2. Assessment Methodology	3
3. Assessment	7
3.1. Wind Climate.....	7
3.2. Mitigation Development	7
3.3. Proposed Minor Amendments.....	10
3.4. Residual Effects of Development with Existing Surrounds	10
3.5. Residual Effects of Development with Future Surrounds.....	13
3.6. Roof Terraces	14
4. Conclusions	15
Appendix A – Wind Tunnel Testing and Results	16
Wind Tunnel.....	16
Instrumentation	16
Wind Tunnel Model	17
Wind Climate Statistics	17
Pedestrian Level Wind Environment Results.....	17

Executive Summary

The current report provides details of the wind mitigation measures developed for the combined effects of Manchester Goods Yard (MGY), Union T1 and No.1 Grape Street, which share a common public realm, in accordance with the requirements of the amended planning condition no. 23. Proposed minor amendments to the currently consented design for MGY are also reviewed.

The wind mitigation measures for the plot were developed and their effectiveness verified through several phases of wind tunnel testing, initially as part of the 2019 ES for the Union T1 development and then to support the revised planning application for the Union T2 development in January 2021. These later tests also considered amendments to the public realm around Union T1 and MGY resulting from the revised highways layout for Water Street. Details of the wind mitigation measures developed are provided in Section 3.2 of this report.

With the mitigation features implemented, pedestrian level wind conditions in and around the site rate as safe for all users.

In terms of pedestrian comfort, wind conditions within the site are considered suitable for pedestrian access to, and passage through or past, the developments.

Conditions at the main entrances are expected to be suitable for pedestrian ingress / egress. A secondary entrance to a commercial unit is marginally windy but likely tolerable for pedestrian ingress / egress during winter. The detailed design of No.1 Grape Street will also need to purposely locate the commercial entrances, away from the western corners.

Within the surrounding area, conditions are expected to be considered generally suitable to no worse than tolerable for associated uses.

With the completion of the St Johns masterplan and the introduction of consented future surrounding developments, the Union T1, MGY and No.1 Grape Street site is significantly sheltered from the most frequent strong winds from the west-south-west and west. Consequently, several of the mitigation measures detailed in Section 3.2 can be removed in the final scenario.

MGY's operators will implement a management strategy to preclude the use of the Level 08 terraces during storms. This is considered an appropriate form of mitigation with regards to occupant safety. The MGY operators are also satisfied that the roof-terrace level conditions, given the office occupants and likely infrequent usage of the spaces, are acceptable for associated recreational activities.

The proposed amendments are not expected to have any material effect on wind conditions, in terms of suitability for pedestrian and occupant uses. No further mitigation measures associated with the Manchester Goods Yard development are therefore considered to be required.

1. Introduction

Urban Microclimate Ltd. has been commissioned by Allied London, on behalf of Manchester Quays Limited, to assess the likely effects of the proposed minor amendments to the Manchester Goods Yard (MGY) development (approved under planning reference 127790/NMC/2020) on the pedestrian level wind microclimate in and around the site. The current report further confirms the wind mitigation measures in accordance with amended Condition 23 introduced for the previous planning consent (reference 123047/NMC/2019).

The amended condition 23 states:

“Within 6 months of commencement of any phase of development (other than enabling works comprising demolition, piling and construction of the sub structure), full details of all wind mitigation measures for that phase, if required, must be submitted to, and approved in writing by the City Council, as local planning authority. All such measures shall be fully incorporated within the relevant phase of the development in accordance with the approved details.”

The MGY development forms part of the St Johns masterplan in Manchester. The associated phase / plot is located in the central area of the masterplan and consists of the following buildings, with a shared public realm:

- Union T1;
- Manchester Goods Yard; and
- No.1 Grape Street

The wind mitigation measures for the plot were initially developed as part of the 2019 ES for the Union T1 development (on behalf of Vita Group), which represents the dominant structure within the plot, and were also presented in a Manchester Goods Yard Wind Microclimate report dated December 2019.

Subsequent to this, wind tunnel tests were carried out in January 2021 (also on behalf of Vita Group), to support the revised planning application for the Union T2 development (to the west of the plot). These tests also considered amendments to the public realm around Union T1 and MGY resulting from the revised highways layout for Water Street, which has been discussed and agreed in principle with the local planning authority and is therefore currently considered to be the most up-to-date and anticipated final layout for the area.

The current report is primarily based on the later tests, but also considers the 2019 tests for areas unaffected by the amendments to the public realm and therefore not tested in 2021, such as the east elevation of MGY.

2. Methodology and Criteria

2.1. Guidelines

The assessment of environmental wind flows also lies outside the scope of BS EN 1991-1-4:2005, the current European Standard for wind actions on structures, which focuses on wind loading issues.

The impact of environmental wind on pedestrian spaces and the consequent suitability of these spaces for planned usage are described by and compared against the industry standard Lawson criteria, which are recognised by Local Authorities as a suitable benchmark for wind assessments.

2.2. Assessment Methodology

The assessment combines the following elements to determine the probability of local wind speeds exceeding thresholds that relate to pedestrian safety and to comfort levels perceived during standard pedestrian activities, based on the Lawson criteria for pedestrian comfort and safety:

- Measured pedestrian level wind speeds at key areas in and around the site, from model-scale boundary layer wind tunnel testing; with
- Long-term wind frequency statistics transposed from the nearest suitable weather centre to apply directly at the site.

Wind Tunnel Tests

Details of the wind tunnel testing are provided at Appendix A. The tests were conducted in RWDI Anemos Ltd's boundary layer wind tunnel facility, where an atmospheric boundary layer representative of that at the site was simulated. The wind tunnel model was constructed at a scale of 1:300 and covers a full-scale extent of 360 m from the approximate centre of the St Johns masterplan (up to and beyond the extent of potential significant effects of the development).

The wind tunnel model was constructed by RWDI for testing the proposed Union T1 and Union T2 developments. As such, the Union T1 model was constructed based on a 3D model provided by the design team, whilst the models of Manchester Good Yard and No.1 Grape Street were based on information sourced from the local authority planning portal for planning application reference 121511/FO/2018 (the latest consent at the time of the model construction).

The subsequent non-material amendments (application references 123047/NMC/2019 and 127790/NMC/2020) revised the upper floors and roof terraces, slightly reduced the building heights and distance between blocks and re-aligned the canopies. These minor amendments are not expected to materially affect the conclusions of the assessment.

The remaining existing / consented surrounding area was constructed based on survey information provided for previous tests and new or future buildings were based on planning application information sourced from the local authority planning portals (as at the time of the model construction).

Proposed semi-mature and existing surrounding trees were modelled in winter, or bare, format.

To inform the testing, an initial experience-based assessment was carried out to identify areas of potential accelerated winds in and around the site, and to identify the potential extent of likely significant wind effects within the surrounding area. Existing and proposed pedestrian activities were also reviewed to identify areas of increased sensitivity to wind effects, such as recreational areas and building entrances. Wind speed measurements at these key pedestrian level locations were then made using probes capable of measuring fluctuating pressure differences that are calibrated against wind speed. A system of probes running simultaneously were used to obtain results from 126 pedestrian level locations. In accordance with best practice, measurements were taken for a full range of wind directions in increments of 22.5°. To fully meet the requirements of the Lawson criteria, recordings were taken for a sufficient length of time to determine the mean and gust wind speeds.

Wind tunnel tests were carried out for the following configurations:

- Development with existing surrounds (as the baseline for Union T2); and
- Development with consented future surrounds.

Committed surrounding developments were reviewed using publicly available information and professional experience to determine their relevance to the wind assessment. Buildings currently under construction or committed to completion prior to the development were included within the baseline, in their completed form. This included the following schemes:

- Union T1 (ref 125655/FO/2019)
- Manchester Goods Yard and No.1 Grape Street (ref 121511/FO/2018)
- St Johns Place Zone 2, Globe and Simpson (ref 121721/FO/2018)
- Old Granada Studios (ref 118040/FO/2017)
- The Factory (ref 119890/VO/2018)
- Salford Central Zone B (ref 16/68199/REM)
- Salford Central Zone C (ref 19/73721/REM)

Subsequent minor amendments to Globe and Simpson (ref 125222/JO/2019) and Old Granada Studios (ref 127612/FO/2020) are not expected to materially affect the conclusions of the assessment.

The future committed developments considered within the cumulative effects assessment comprised the following surrounding schemes:

- Union T2 (current application)

- St Johns Place Zones 1, 3 & 4 (ref 109660/FO/2015/C1)
- Middlewood Locks (ref 14/65457/OUTEIA)
- Middlewood Locks (ref 14/65793/OUT)
- Salford Central (ref 16/68325/OUT)
- Trinity Islands (ref 115107/FO/2017)

Further committed developments in the area lie beyond the extent of the wind tunnel model and are considered too distant to have any potential significant cumulative effects.

Wind Climate Data

Long-term wind frequency statistics from Manchester Airport, for the period 2001 to 2015, were corrected to apply directly at the site, taking account of differences in upwind terrain and altitude between the weather centre and the site based on the widely accepted Deaves and Harris log law wind model of the atmospheric boundary layer and BS EN 1991-14:2005. This is considered suitable to provide a statistically robust climate model for the site.

Historical wind statistics are used as standard practice due, in part, to lack of certainty in potential future changes in wind patterns, though any changes are expected to be minor.

Assessment Criteria

Details of the Lawson criteria for pedestrian comfort are presented in Table 2.1 and are based on the exceedance of threshold wind speeds, considering mean-hourly and gust-equivalent-mean values, occurring less than 5% of the time. The thresholds represent upper bounds of acceptability for a range of common activities. The value of 5% has been established as giving a reasonable allowance for extreme and relatively infrequent winds that are acceptable within each category.

Table 2.1: Lawson Criteria for Pedestrian Comfort

Threshold Mean-hourly Wind Speed Exceeded < 5% of the Time	Comfort Rating / Activity		Qualifying Comments
4m/s	C4	Long-term Sitting	Reading a newspaper and eating and drinking.
6m/s	C3	Standing or short-term Sitting	Appropriate for bus stops, window shopping and building entrances.
8m/s	C2	Walking and Strolling	General areas of walking and sightseeing.
10m/s	C1	Business walking	Local areas around tall buildings where people are not likely to linger.

Details of the Lawson criteria for pedestrian safety, or distress, are presented in Table 2.2 and are based on the exceedance of the threshold wind speeds, considering mean-hourly and gust-equivalent-mean values, occurring once per annum. These thresholds represent wind speeds with the potential to destabilise the less able or more susceptible members of the public (including elderly, cyclists and children) and able-bodied users.

Table 2.2: Lawson Criteria for Pedestrian Safety or Distress

Threshold mean-hourly wind speed exceeded once a year	Safety Rating		Qualifying Comments
15 m/s	S2	Unsuitable for general public	Less able and cyclists find conditions physically difficult.
20 m/s	S1	Unsuitable for able-bodied	Able-bodied persons find conditions difficult. Physically impossible to remain standing during gusts.

The pedestrian level wind environment assessment is summarised in terms of suitability for various activities, based on the Lawson criteria described above. The assessment takes full account of seasonal variations in wind conditions and pedestrian activities. Thus conditions for recreational activities focus on summer, but also consider spring and autumn.

Recreational activities do not consider winter comfort ratings as it is anticipated that users would not demand suitable conditions 95% of the time in winter but would instead be satisfied to use the amenity spaces on occasions when conditions, including precipitation and temperature, permit. Conditions for pedestrian thoroughfare, access or waiting (for example at bus stops) consider all seasons, with winter being predominantly the critical season due to generally higher wind speeds in the winter months.

The activities considered, and their relation to the comfort criteria detailed above, are shown in Table 2.3. The table is ordered in terms of decreasing sensitivity to wind speeds. Conditions considered suitable for the more sensitive activities would also be suitable for the subsequent, less sensitive, uses.

Table 2.3: Suitability Assessment

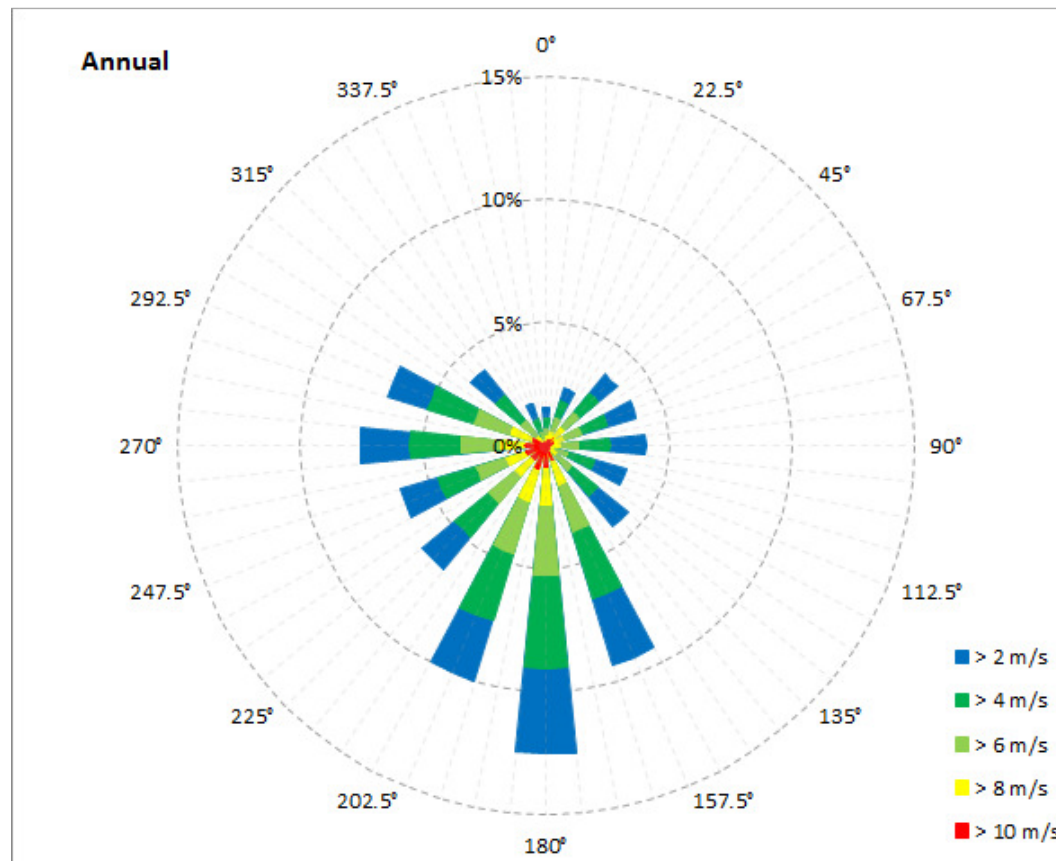
Suitability		Target Lawson comfort and safety criteria for specified seasons
Outdoor seating	For long periods of sitting, such as for an outdoor café or picnic area.	'Long-term sitting' (C4) in at least summer.
Entrances, waiting areas	For pedestrian ingress/egress at entrances, or short periods of sitting or standing such as at a bus stop, taxi rank, meeting point, window shopping, etc.	'Standing or short-term sitting' (C3) in all seasons.
General leisure (excluding seating areas)	For leisure uses excluding long periods of outdoor sitting, such as active leisure, general park spaces, children's play area, etc.	'Standing or short-term sitting' (C3) from spring to autumn.
Thoroughfare	For pedestrian access to, and passage through, the Site and surrounding area.	'Business walking' / 'Walking or strolling' (C1/C2) in all seasons - 'Walking or strolling' (C2) desired but 'Business walking' (C1) may be acceptable in some areas.
Unsuitable	Unsuitable for all activities.	Exceeds comfort criterion for 'Business walking' (C1) or safety criteria (S1/S2).

3. Assessment

3.1. Wind Climate

The wind climate expected at the site is summarised in Figure 3.1 in terms of the annual wind speed and direction probability distributions at a reference height of 100 m above local ground level. Seasonal wind speed and direction probability distributions are presented in Appendix A.

Figure 3.1: Wind Climate at Site (at reference height of 100 m)



Based on the wind climate statistics, winds from the southerly quadrant are prevalent. Light to moderate winds from the south and south-south-east are most common, whilst stronger winds more frequently blow from the south-south-west. Winds from the west-south-west and west also occur frequently, and extreme wind speeds (relevant to pedestrian safety) are most likely to blow from this direction. Northerly winds are generally light and rare, though cold north-easterly winds are common during spring. Wind speeds are generally higher during winter and lower during summer.

3.2. Mitigation Development

As indicated in Section 1, wind mitigation measures within the shared public realm were developed to account for the combined effects of MGY, Union T1 and No.1 Grape Street. In particular, the Union T1 development represents a substantial structure but presents a

narrow façade to prevailing southerly winds and is partially sheltered at lower levels from these winds. However, the developments are exposed to, and present a relatively wide obstruction to, the most frequent extreme winds from the west-south-west and west. Downdraughts from the westerly elevation of the Union T1 building are expected to reach pedestrian level before channelling along the façade and around the northwest and, to a lesser extent, the southwest corners of the building. The pedestrian level winds accelerating around the northwest corner of the Union T1 building are subsequently channelled along Water Street and around the northwest corner of the MGY building.

The landscaping within the Union T1 site and the shared public realm was developed during a series of interactive workshops to allow the developments to respond to the potential wind effects discussed above and the proposed pedestrian and occupant activities.

Resulting landscaping features implemented include:

- 6 – 8 m high trees, of a deciduous species with substantial retained solidity in winter (i.e. significant canopies with numerous branches):
 - across the public realm between Water Street and Union T1;
 - to the north of Union T1; and
 - along the south side of Union T1.
- ~1 m high shrub planting across the area around the northwest corner of MGY;
- Array of five ~50% porous screens, ~2.4 m high by ~1.8 m wide, amongst the trees in the space between the access roads to the north of Union T1;
- Two ~50% porous screens, ~2.4 m high by ~1.8 m wide, around the northwest corner of Union T1;
- Two ~50% porous screens, ~2.4 m high by ~1.8 m wide, around the northeast corner of Union T1;
- Two ~50% porous screens, ~2.4 m high by ~1.8 m wide, extending out from the southwest corner of Union T1; and
- Two ~50% porous screens, ~2.4 m high by ~1.5 m wide, on the east side of Water Street, to the west of Union T1.

Trees were also included along the east side of MGY and on the west and south sides of No.1 Grape Street, in line with the public realm landscaping plan.

The above features, as modelled, are illustrated in Figure 3.2.

Figure 3.2: Wind Mitigation and Landscaping

3.3. Proposed Minor Amendments

The proposed minor amendments to MGY comprise the following:

- Addition of a roof element above the previously proposed courtyard space on the roof level (L09) of the development;
- Closing off of the ground (and mezzanine) floor passageways through the development; and
- Internal layout changes at ground level.

The additional roof element is pitched and is set well back from the eaves on each elevation. As such, the additional roof element is not expected to have any significant effect on pedestrian level winds.

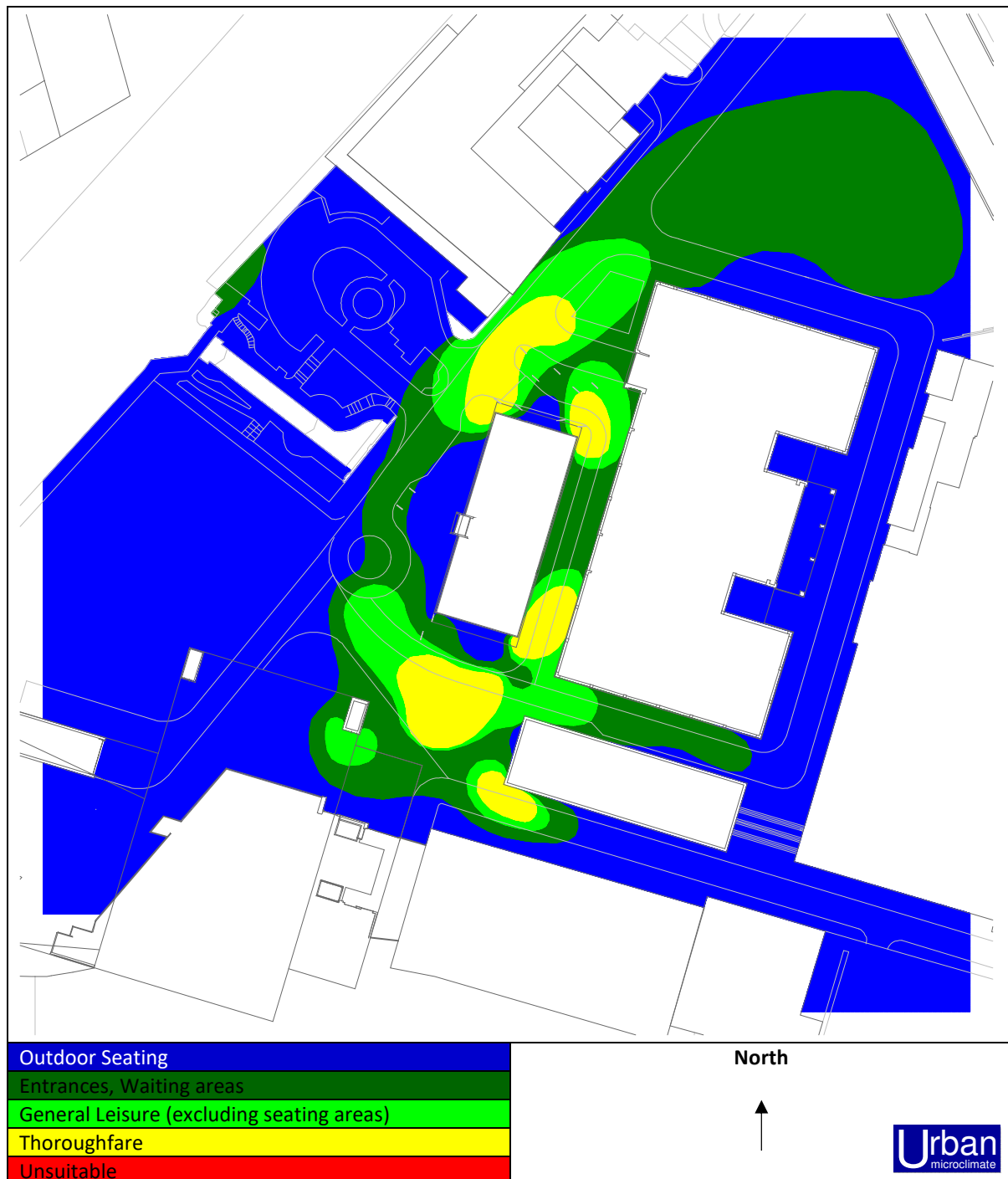
The closing of the passages does slightly reduce the permeability of the MGY development to the most frequent strong winds from the west-south-west and west. This may very slightly increase the back-pressure, enhancing conditions around the northwest corner of Union T1 but this effect is unlikely to be significant. Of greater significance is the potential exacerbation of channelling of these winds around the northwest corner of MGY and along the passage between MGY and No.1 Grape Street. However, sensitivity checks of the wind tunnel test results in these areas suggest that the expected scale of potential increases in wind speeds would not alter the assessed comfort and safety ratings.

The internal layout changes do not affect the main entrance locations and therefore have no effect on the suitability of the pedestrian level wind conditions.

On the basis of the above, the mitigation measures outlined in Section 3.2 are expected to remain effective and the following assessment of resulting residual conditions are considered to remain valid.

3.4. Residual Effects of Development with Existing Surrounds

The pedestrian level wind environment in and around the site resulting from the above effects and accounting for the landscaping features, as tested, is presented in terms of the Lawson comfort and safety criteria in Appendix A. Conditions are further summarised graphically in terms of likely suitability for pedestrian activities (based on the seasonal targets outlined in Table 2.3) in Figure 3.3, taking account of the proposed minor amendments. This presentation also applies expert judgement to extrapolate from the key-point measurements in order to indicatively cover the site and surrounding area.

Figure 3.3: Indicative Suitability Assessment (accounting for minor amendments)

Pedestrian Safety

With the mitigation features (described above) implemented, pedestrian level wind conditions in and around the site rate as safe for all users.

Pedestrian Comfort

In terms of pedestrian comfort, with respect to wind force, wind conditions within the plot are suitable for at least leisurely strolling and are thus considered suitable for pedestrian access to, and passage through or past, the developments.

The main entrances to each of the buildings are located away from areas of potential accelerated winds. As a result, conditions at the main entrances are expected to be suitable for pedestrian ingress / egress. A secondary entrance to the commercial unit at the southwest corner of MGY, facing the southeast corner of Union T1, has potential to be marginally windy for comfortable pedestrian ingress / egress during winter but is likely to be tolerable for such uses. The detailed design of No.1 Grape Street will also need to purposely locate the commercial entrances, away from the western corners.

The open space around the southwest corner of Union T1 has suitable conditions for recreational activities including short periods of sitting, at least from spring to autumn. Suitable conditions for long periods of sitting in summer, such as for an outdoor café, are limited to areas close to the west and south frontages.

Within the surrounding area, conditions remain suitable for at least leisurely strolling along thoroughfares, and entrances to surrounding buildings are expected to enjoy suitable conditions for pedestrian ingress / egress. The bus stop on Water Street, near the entrance to the Marriott Hotel, is also expected to retain suitable conditions for awaiting a bus.

The Marriott Hotel's outdoor seating areas both enjoy suitable conditions for long periods of outdoor sitting, such as for an outdoor café, during at least summer and spring.

Most of Festival Square (on the north side of and beneath The Factory) enjoys suitable conditions for recreational uses including at least short periods of sitting, with much of the space further suitable for long periods of outdoor sitting during at least summer. The northern area, towards to the southwest corner of Union T1, and around the north-eastern core have suitable conditions for leisurely strolling but are marginally windy for sedentary activities during winter. The eastern area is marginally windy for sedentary activities during spring, though the north-easterly winds causing this are typically cold and would limit sedentary activities anyway. Given the extent of areas affected, the overall conditions across the square are expected to be at least tolerable for associated recreational uses.

The open space at St Johns Place has suitable conditions for recreational activities including at least short periods of sitting and conditions are expected to be considered acceptable for associated temporary uses.

Overall, conditions are expected to be considered generally suitable to no worse than tolerable for associated uses and no further mitigation measures, associated with the Manchester Goods Yard development, are considered to be required.

3.5. Residual Effects of Development with Future Surrounds

With the completion of the St Johns masterplan and the introduction of consented future surrounding developments, the Union T1, MGY and No.1 Grape Street site is significantly sheltered from the most frequent strong winds from the west-south-west and west. Consequently, the following mitigation measures can be removed in the final site conditions:

- Array of five ~50% porous screens, ~2.4 m high by ~1.8 m wide, amongst the trees in the space between the access roads to the north of Union T1;
- Two ~50% porous screens, ~2.4 m high by ~1.8 m wide, around the northwest corner of Union T1;
- Two ~50% porous screens, ~2.4 m high by ~1.8 m wide, around the northeast corner of Union T1; and
- Two ~50% porous screens, ~2.4 m high by ~1.8 m wide, extending out from the southwest corner of Union T1.

The resulting pedestrian level wind conditions in and around the site, following the further introduction of consented future surrounding developments and removal of the above listed screens, are presented in terms of the Lawson comfort and safety criteria in Appendix A.

There are a number of wind effects, in terms of both pedestrian comfort and pedestrian safety, around the St Johns Place tower. However, the accelerated winds are dictated by downdraughts from St Johns Place tower and are not considered a combined effect of the development with this future scheme. The design of the St Johns Place tower is also expected to significantly change and appropriate mitigation will be developed as part of the detailed design process, in line with the planning condition attached to the outline consent for the tower.

Otherwise, pedestrian level wind conditions in and around site rate as safe for all users.

In terms of pedestrian comfort, with respect to wind force, wind conditions within the plot remain suitable for at least leisurely strolling and are thus considered suitable for pedestrian access to, and passage through or past, the developments.

The main entrances to each of the buildings retain suitable conditions for pedestrian ingress / egress. The commercial unit entrances at the southwest corner of MGY and western part of No.1 Grape Street, discussed above for the existing surround context, are enhanced and are also expected to enjoy suitable conditions for pedestrian ingress / egress.

The open space around the southwest corner of Union T1 retains suitable conditions for recreational activities including at least short periods of sitting and the extent of area with amenable conditions for long periods of sitting in summer, such as for an outdoor café, in summer are extended.

Within the surrounding area, the open space on the south side of the Union T2 development is susceptible to some downdraughts from Union T2 but, given the open nature of this space, resulting conditions are expected to be considered tolerable for proposed activities. Otherwise, conditions away from the St Johns Place tower (discussed above) are generally enhanced, relative to the existing surrounding context discussed above, and are expected to be generally suitable for proposed activities.

No further mitigation measures associated with the Manchester Goods Yard development are therefore considered to be required.

3.6. Roof Terraces

The MGY roof terraces were not re-assessed as part of the 2021 wind tunnel tests. The proposed roof element removes the previous outdoor courtyard at Level 09 and is not expected to significantly impact on conditions across the perimeter terraces at Level 08.

Based on the 2019 wind tunnel tests (as presented in the MGY Wind Microclimate report, December 2019), conditions have potential to rate as unsuitable, in terms of occupant safety, for the general public on the western perimeter terrace at Level 08. To address this, the building operators will implement a management strategy to preclude the use of the Level 08 terraces during storms. This is considered an appropriate form of mitigation with regards to occupant safety.

In terms of occupant comfort, conditions on the west side of the perimeter terrace have potential to be too windy for sedentary activities. Otherwise, conditions within the perimeter roof terraces are expected to be suitable for recreational activities including at least short periods of sitting or standing, such as for viewing, though suitable conditions for longer periods of outdoor sitting during summer are expected to be limited to areas of the perimeter terraces located away from the northwest and southwest areas, and potentially away from the building corners. The building's operators are satisfied that these conditions, given the office occupants and likely infrequent usage of the spaces, are acceptable for envisaged uses and no further mitigation is proposed.

4. Conclusions

The current report provides details of the wind mitigation measures developed for the combined effects of Manchester Goods Yard, Union T1 and No.1 Grape Street, which share a common public realm, in accordance with the requirements of the amended planning condition no. 23. Proposed minor amendments to the currently consented design are also reviewed.

The proposed amendments are not expected to have any material effect on wind conditions, in terms of suitability for pedestrian and occupant uses.

With the mitigation features (as described in Section 3.2) implemented, pedestrian level wind conditions in and around the site rate as safe for all users.

In terms of pedestrian comfort, wind conditions within the site are considered suitable for pedestrian access to, and passage through or past, the developments.

Conditions at the main entrances are expected to be suitable for pedestrian ingress / egress. A secondary entrance to a commercial unit is marginally windy but likely tolerable for pedestrian ingress / egress during winter. The detailed design of No.1 Grape Street will also need to purposely locate the commercial entrances, away from the western corners.

Within the surrounding area, conditions are expected to be considered generally suitable to no worse than tolerable for associated uses.

With the completion of the St Johns masterplan and the introduction of consented future surrounding developments, the Union T1, MGY and No.1 Grape Street site is significantly sheltered from the most frequent strong winds from the west-south-west and west. Consequently, several of the mitigation measures detailed in Section 3.2 can be removed in the final scenario.

MGY's operators will implement a management strategy to preclude the use of the Level 08 terraces during storms. This is considered an appropriate form of mitigation with regards to occupant safety. The MGY operators are also satisfied that the roof-terrace level conditions, given the office occupants and likely infrequent usage of the spaces, are acceptable for associated recreational activities.

No further mitigation measures associated with the Manchester Good Yard development are considered to be required.

Appendix A – Wind Tunnel Testing and Results

Wind Tunnel

The wind tunnel tests were carried out in RWDI Anemos Ltd's boundary layer wind tunnel facility, in Milton Keynes. This tunnel has an open working section with an effective width of 3.0 m.

An atmospheric boundary layer, representative of the conditions at the site, was simulated using an arrangement of roughness elements distributed over the floor of the wind tunnel and a turbulence grid at the entrance to the test section.

The boundary layer simulation was calibrated against the variation in mean wind speed and the intensity and scale of the turbulence with height above ground level appropriate to the site, based on profiles derived using the widely accepted Deaves and Harris log law wind model and a detailed terrain analysis for the area surrounding the site. This method yields a good approximation of the mean flow and turbulence characteristics and fully meets the requirements of clause NA2.2 'Guidance on design assisted by testing and measurements' from the UK National Annex to BS EN 1991-1-4:2005.

Figure A.1 presents the variation of mean wind speed, longitudinal turbulence intensity and gust wind speed used in the tests. The wind speed profiles are normalised by the mean wind speed at a reference height of 100 m.

Instrumentation

Measurements of pedestrian level wind speed were made using instruments known as Irwin probes. These are standard devices for such measurements. The probes consist of a small tube with a pit at its base. The pressure difference between the top of the tube and the pit is calibrated against wind speed. The top of the tube is set at an equivalent full-scale height of 1.5 m to measure wind speeds at pedestrian height. The sampling rate, combined with the wind tunnel running speed and the linear scale of the model, were appropriate to the model scale simulation used.

People subjected to fluctuating or gusty wind conditions will react to either the mean wind strength or to the maximum gust that occurs. For this reason, both the mean and maximum gust speeds were determined for each measurement location. The gust speed was then converted to a gust-equivalent-mean value based on a factor of $1 / 1.85$.

Measurements were made for a full range of wind directions in 22.5° increments. The wind tunnel measurements were recorded as non-dimensional wind speed ratios relative to the wind tunnel reference wind speed.

Wind Tunnel Model

The wind tunnel model was constructed by RWDI for testing the Union T1 and Union T2 developments. As such, the Union T1 and Union T2 models were constructed based on 3D models provided by the design team. The models of Manchester Good Yard and No.1 Grape Street were based on information sourced from the local authority planning portal at the time of the model construction, in 2019. The remaining existing / consented surrounding area was constructed based on survey information provided for previous tests and new or future buildings were based on planning application information sourced from the local authority planning portals. The linear scale of the model is 1:300. The model was constructed on a circular baseboard of diameter 2.4 m, centred around the site's centre.

Proposed semi-mature and existing surrounding trees were modelled in winter, or bare, format.

Figure A.2 illustrates the models for the development in the context of existing surrounding conditions and the development with consented future surrounding developments.

Wind Climate Statistics

The wind climate, based on statistics from Manchester Airport for the period 2001 to 2015 transposed to apply to the site, is summarised in Figure A.3 in terms of the seasonal wind speed and direction probability distributions at a reference height of 100 m. The factors applied to correct the statistics from open-country terrain to reference height at the site are also presented.

Pedestrian Level Wind Environment Results

The measured wind speed ratios from the wind tunnel tests are combined with the wind statistics applicable to the site to assess the pedestrian level wind environment based on the Lawson criteria for pedestrian comfort and safety. The resulting annual and seasonal ratings for each measurement location are summarised in Figures A.4 for the following scenarios:

- Development with existing surrounds
- Development with consented future surrounds

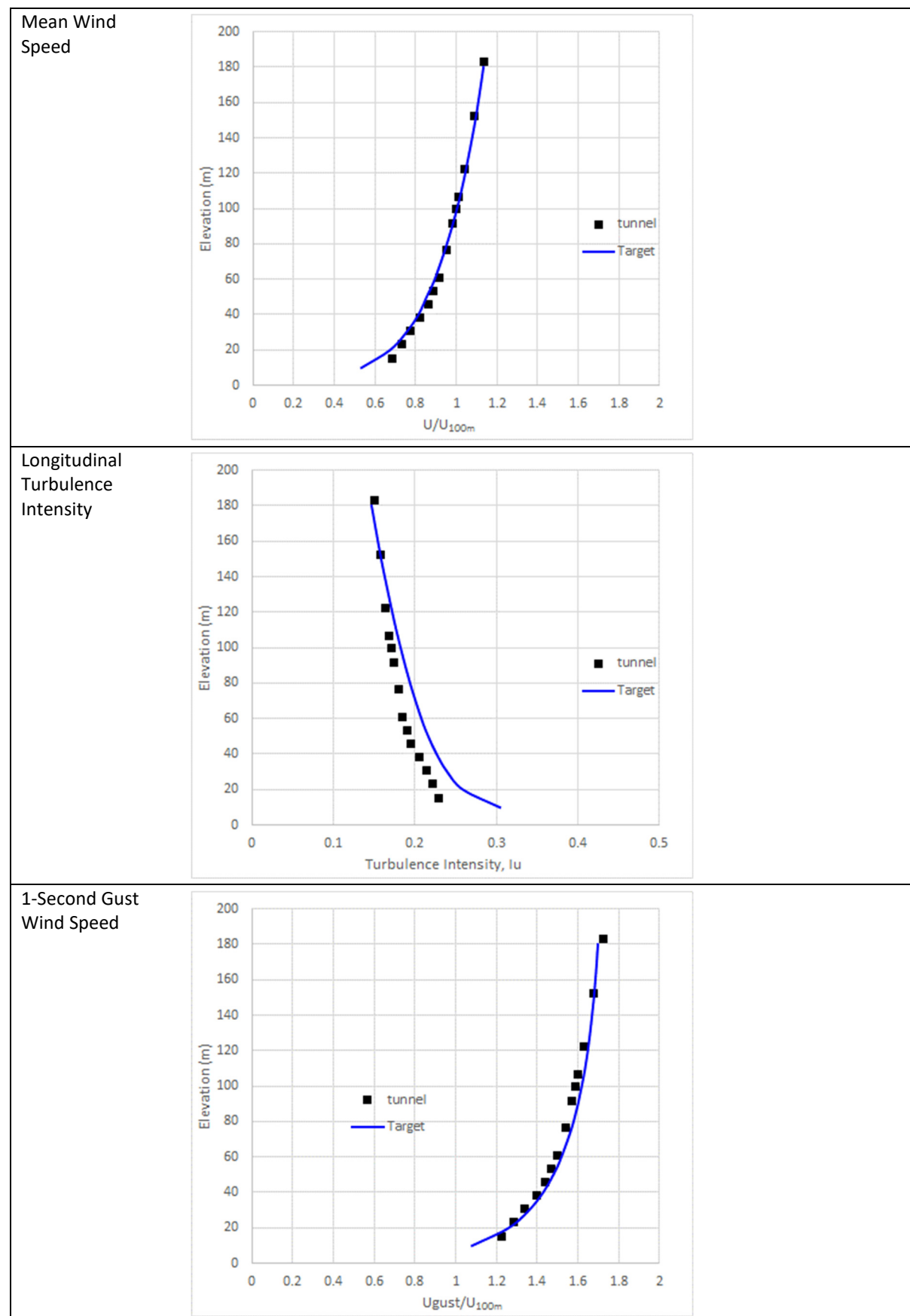
Figure A.1: Wind Tunnel Boundary Layer Simulation

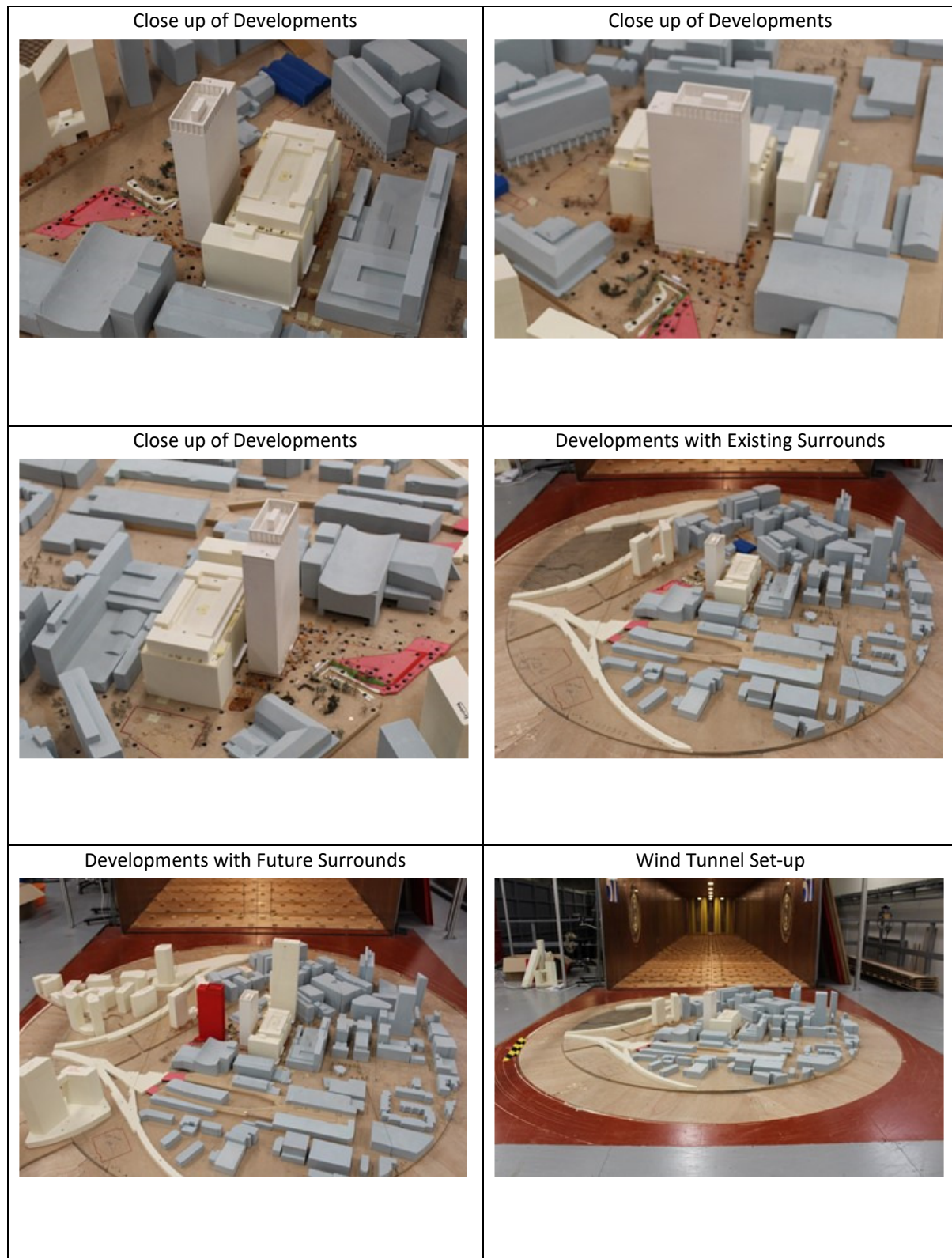
Figure A.2: Wind Tunnel Models

Figure A.3a: Wind Speed Correction Factors, Open Country to Ref. Height (100m) at Site

Direction	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°
Factor	1.30	1.28	1.27	1.26	1.26	1.27	1.28	1.28
Direction	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°
Factor	1.28	1.27	1.29	1.31	1.31	1.31	1.31	1.31

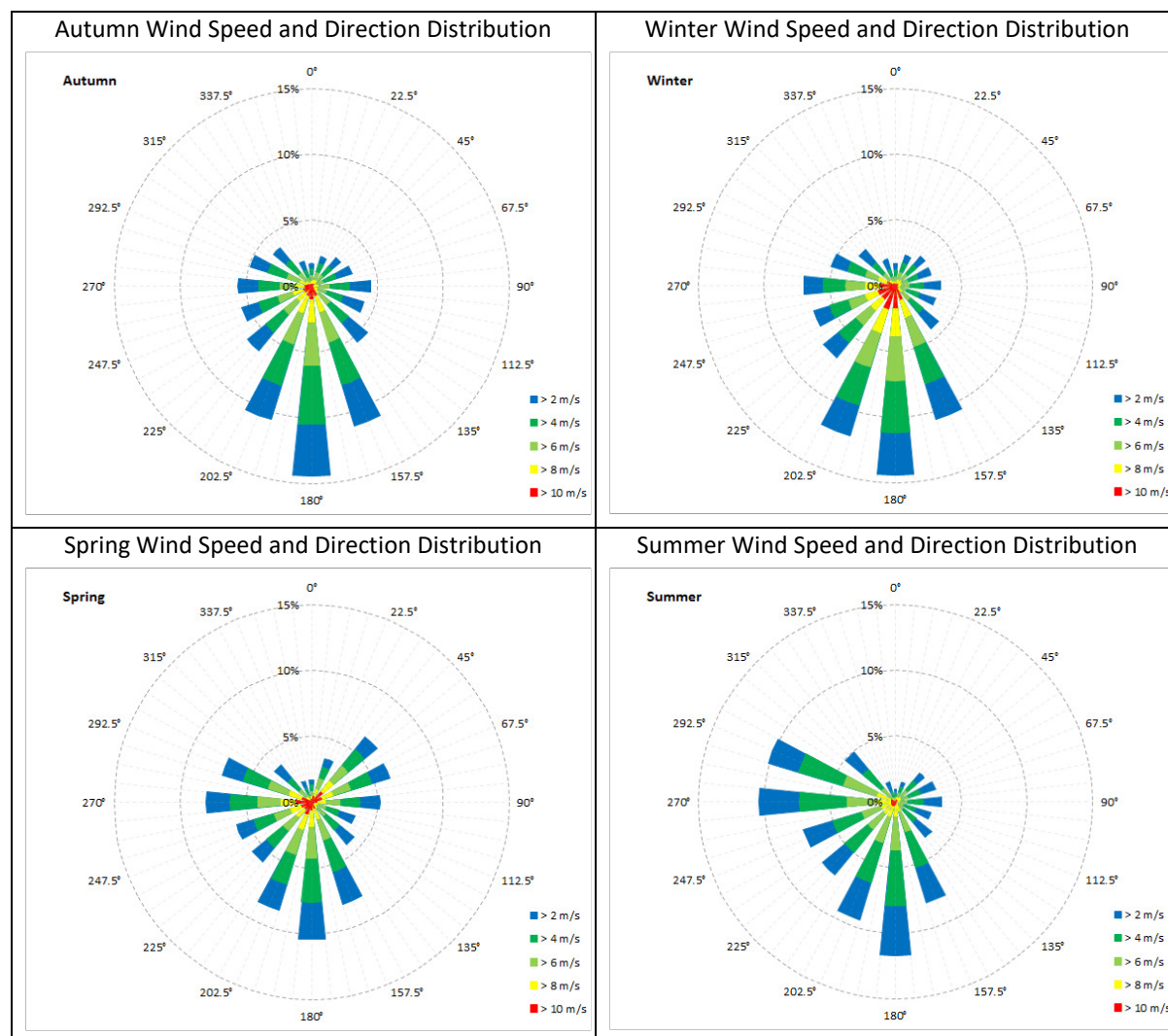
Figure A.3b: Wind Climate at Site (at reference height of 100m)

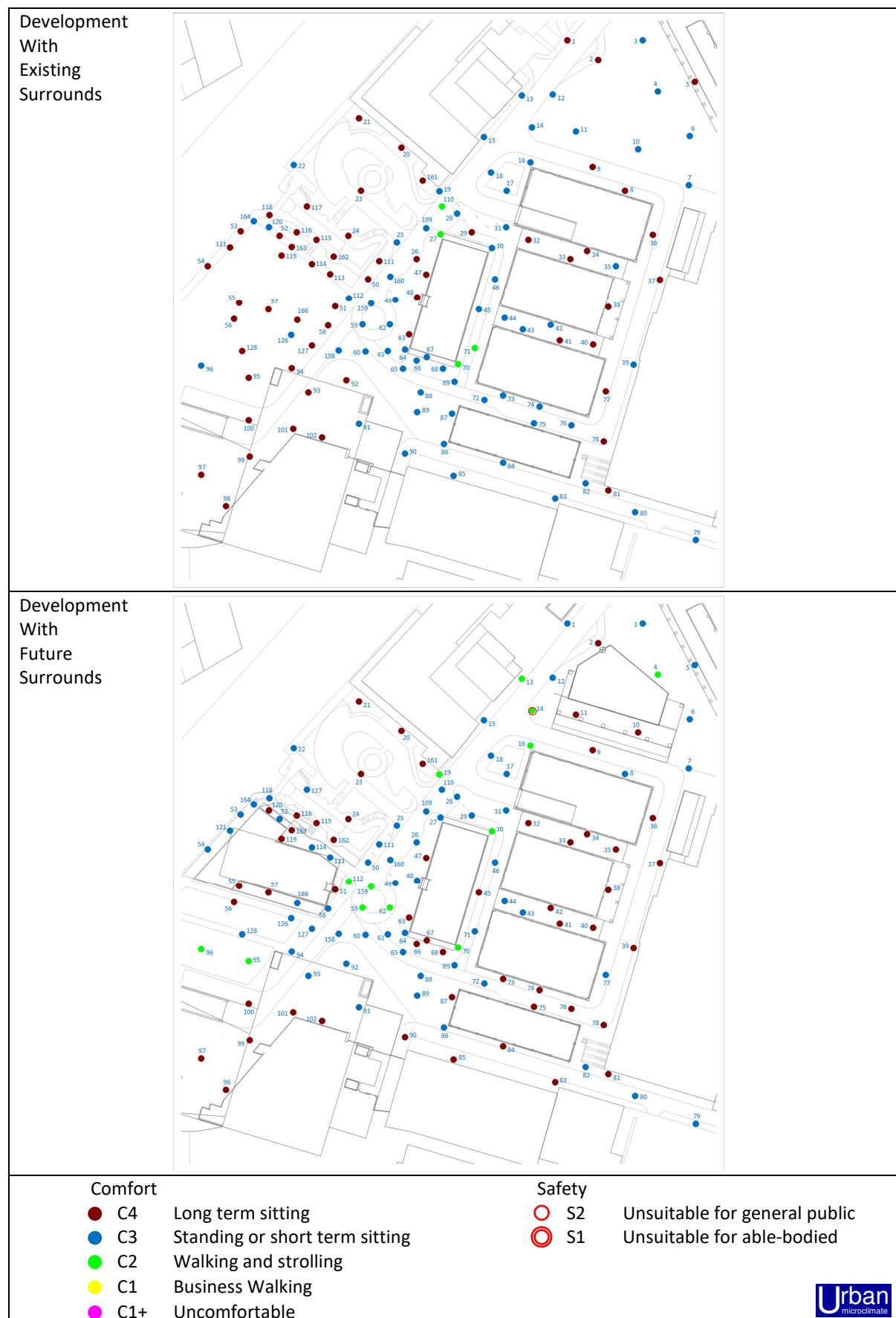
Figure A.4a: Wind Environment – Annual Comfort and Safety Ratings

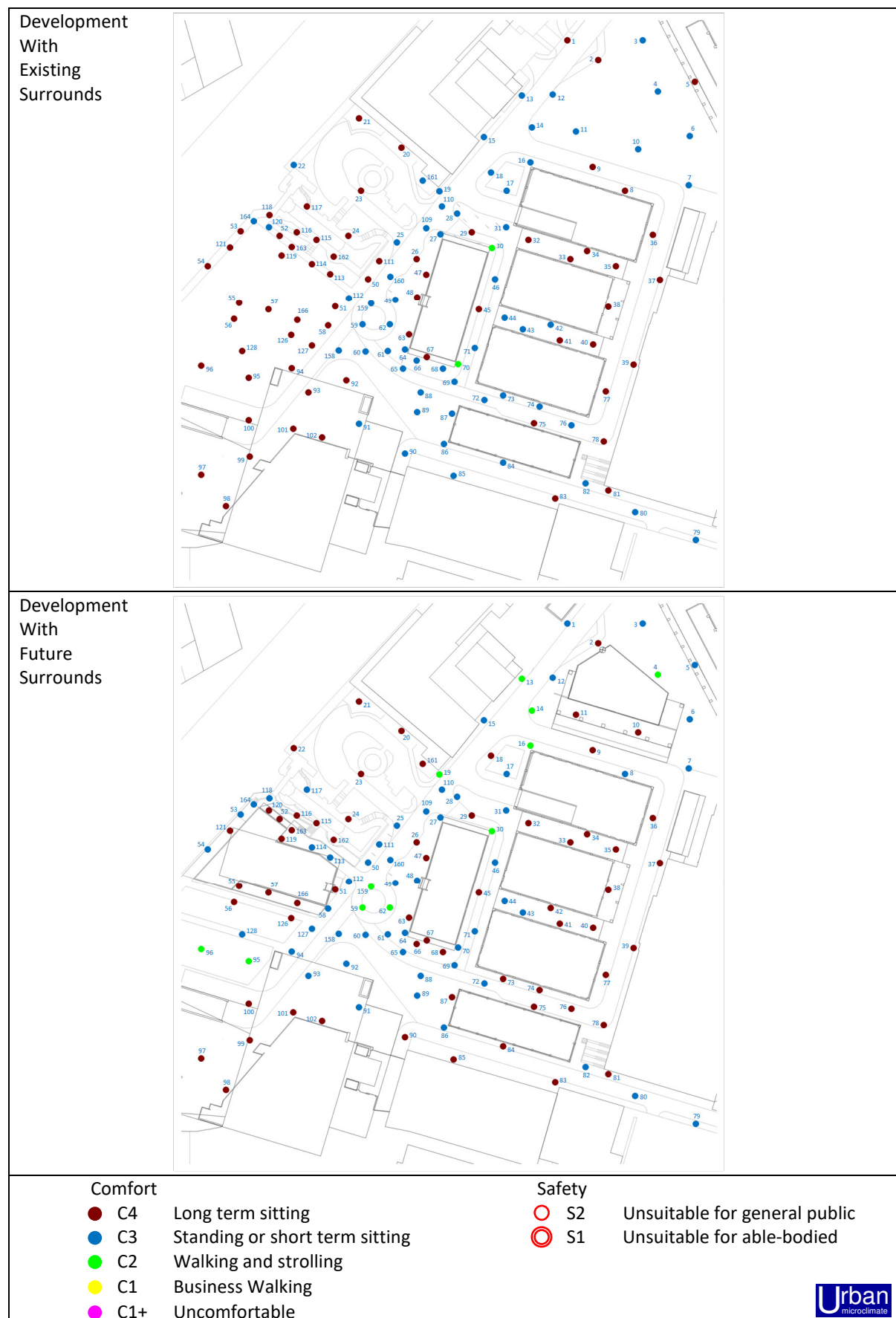
Figure A.4b: Wind Environment – Autumn Comfort and Safety Ratings

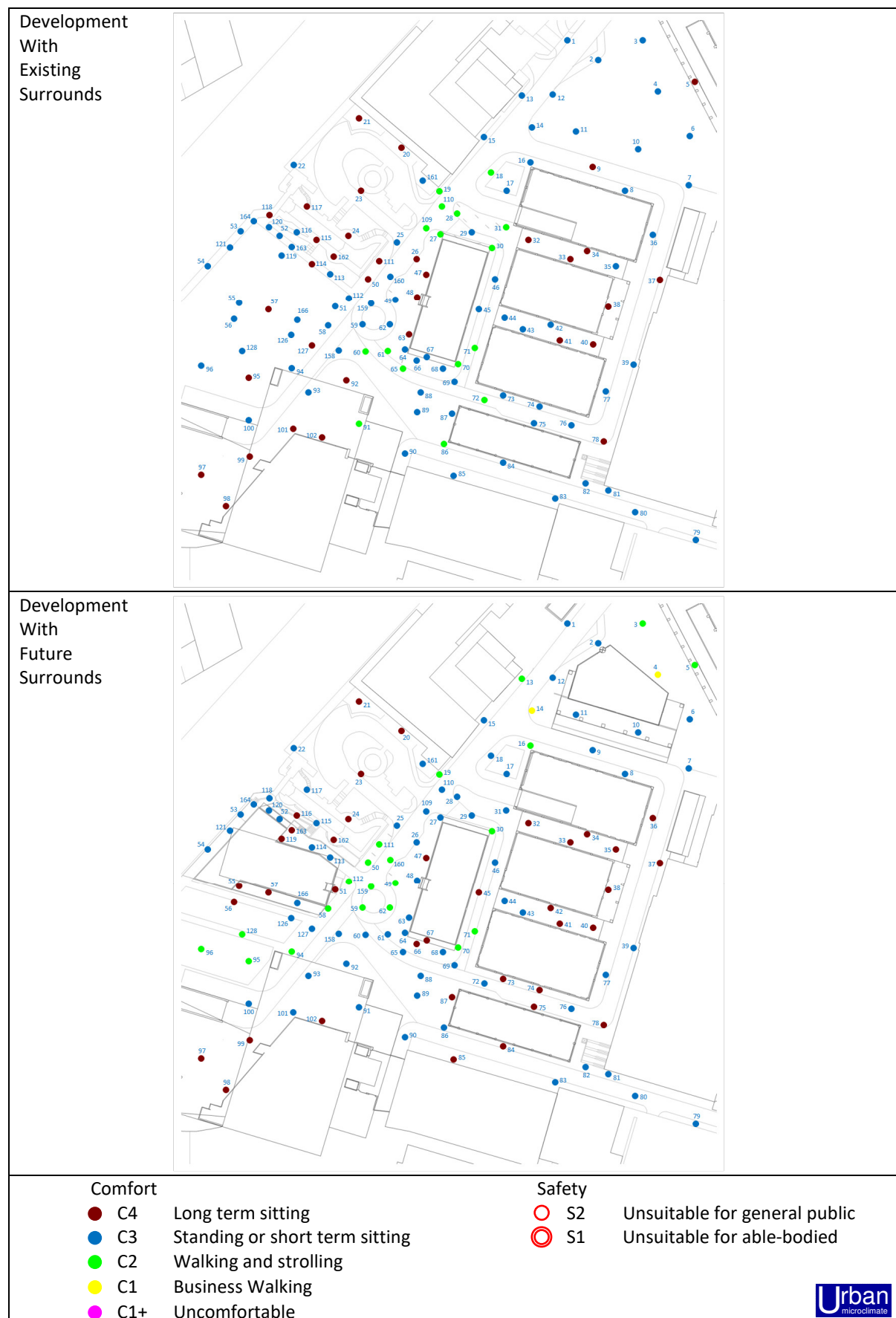
Figure A.4c: Wind Environment – Winter Comfort and Safety Ratings

Figure A.4d: Wind Environment – Spring Comfort and Safety Ratings

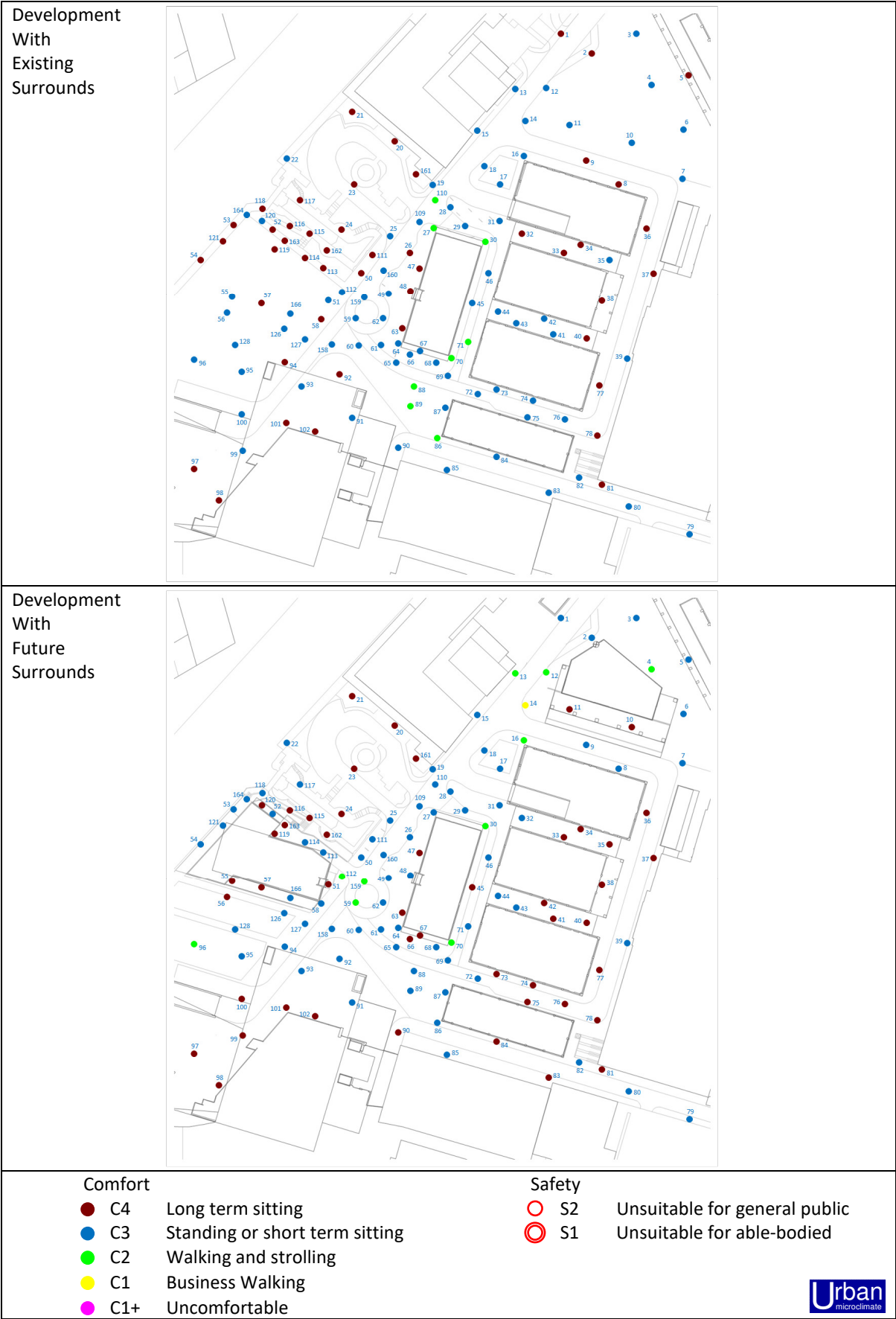
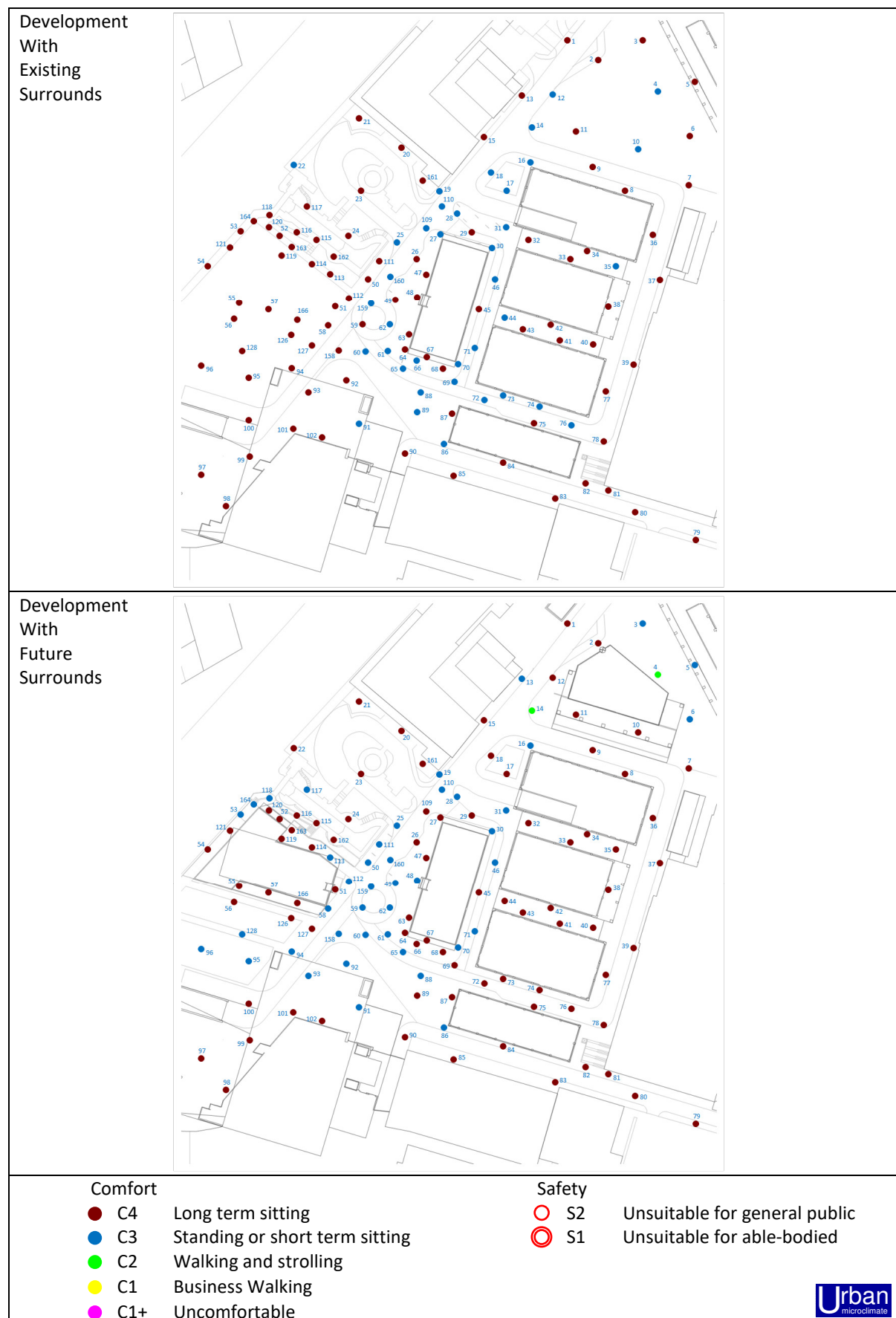


Figure A.4e: Wind Environment – Summer Comfort and Safety Ratings

Urban Microclimate Limited

16 Torrington Gardens, Perivale, Middlesex UB6 7EN

Tel 0799 097 2510

Registered in England and Wales No. 9286534