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ENVIRONMENTAL
SOLUTIONS

14897

Cairn Homes Citywest

Pedestrian Comfort CFD Analysis

Report P3

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1 Development Description

The proposed development will consist of the construction of 421 no. residential units within 9 no. blocks ranging in height from 1 – 13 storeys, retail/commercial/office units, residential amenity space, and open spaces along with all associated site development works and services provisions to facilitate the development including parking, bin storage, substations, landscaping and all services. A full description is provided in the statutory notices and in Chapter 3 of the EIAR.



Figure 1: Site Layout

2 Executive Summary

Steady state CFD simulations were performed to study the impact of wind movement on pedestrian comfort at the proposed Cooldown Commons Phase 3 development by Cairn Homes Properties Ltd in Citywest, Dublin.

For the analysis, 8 steady state CFD simulations were performed, one each for the 8 main wind directions – N, NE, E, SE, S, SW, W and NW. The wind speed was set to the annual average wind speed for Dublin. The wind was assumed to have the characteristics associated with wind flowing through a city centre.

The results obtained from these simulations were extrapolated along the annual weather data for Dublin to obtain the most probable local air speed for each hour of the year. Statistical analysis was performed on this dataset to check compliance against the Lawson’s Pedestrian Comfort criterion.

The following table provides values for Lawson’s Pedestrian Comfort Assessment criteria for various activities.

Category	Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time (m/s)
C1	Business Walking	10
C2	Leisurely Walking	8
C3	Standing	6
C4	Sitting	4

The following table provides values for Lawson’s Pedestrian Safety Assessment criteria.

Category	Pedestrian Type	Threshold mean hourly wind speed not to be exceeded more than once per annum (m/s)
S1	Typical Pedestrian	20
S2	Sensitive Pedestrian	15

2.1 Sitting and Standing Comfort (C4 and C3)

The Lawson's sitting comfort criteria states that the local air speed at designated locations should not exceed 4m/s for more than 5% of the year. The Lawson's standing comfort criteria states that the local air speed at designated locations should not exceed 6m/s for more than 5% of the year.

The results of the annual analysis for sitting and standing criterion are observed in the top left hand and top right hand corner of images in [section 7.1](#) respectively.

Excellent compliance was observed for the amenity space outside retail unit to the west of Block E1, seen marked in [Figure 29](#). Excellent compliance was also observed for the seating area in the courtyard surrounded by blocks D2, D3 and D4, seen marked in [Figure 32](#).

Rest of the public realm shows acceptable compliance, when the sitting criterion results are combined with the standing criterion results. It should be noted that many of the locations in yellow and orange bands are above the threshold of the sitting comfort criterion of 4m/s for more than 5% of the year. However, when we observe the results of standing comfort criteria, where the threshold air speed is 6 m/s, we see that those locations are effectively compliant. So even when the air speed exceeds 4 m/s, it is also unlikely to exceed 6 m/s.

Also, the results can be noted as excellent overall in context of the Dublin weather. The median wind speed for Dublin is around 5m/s. Therefore, for 50% of the year, the wind speed is greater than 5m/s. Even in such conditions, most of the site shows wind speeds less than 6 m/s for more than 95% of the year, and less than 4m/s for more than 80% of the year.

Another context that needs to be considered is that many of the areas noted here are parks, and Active Recreation Zones, the occupants are likely to be engaged in exercise type activities. The air speed levels observed are hence well within acceptable limits for such activities.

2.2 Walking Comfort (C1 and C2)

The Lawson's Leisure Walking comfort criteria states that the local air speed at designated locations should not exceed 8m/s for more than 5% of the duration analysed. The Lawson's Business Walking comfort criteria stipulates that the local air speed at designated locations should not exceed 10m/s for more than 5% of the duration analysed.

The results of the annual analysis for walking criteria are observed in the bottom images in [section 7.1](#). The site generally shows excellent compliance with the Lawson's Leisure and Business Walking Comfort Criteria.

2.3 Safety (S1 and S2)

The Lawson's Normal Pedestrian safety criteria stipulates that the local air speed at designated locations should not exceed 20m/s for more than 0.01% of the duration analysed. The Lawson's Sensitive Pedestrian safety criteria stipulates that the local air speed at designated locations should not exceed 15m/s for more than 0.01% of the duration analysed.

The results of the annual analysis for walking criteria are observed in the bottom images in [section 7.2](#). The site shows excellent compliance with both of the safety criteria – normal and sensitive pedestrians. The Sensitive pedestrian safety criterion applies to the vulnerable people like OAP and children.

3 Weather Data

The analysis is based on the ‘DublinIWEC.epw’ weather file. The variation of wind speed recorded in the weather file is shown in figure 1 below. Figure 2 shows the wind direction variation and Figure 3 shows the wind rose.

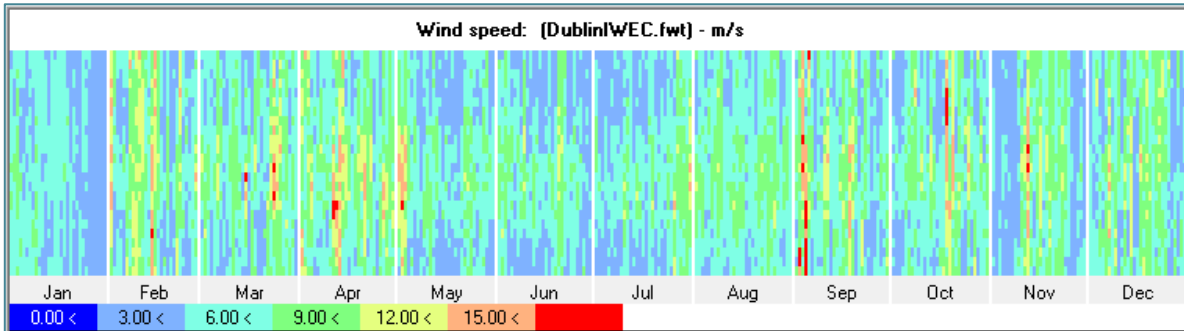


Figure 2: Wind speed variation as per DublinIWEC.epw

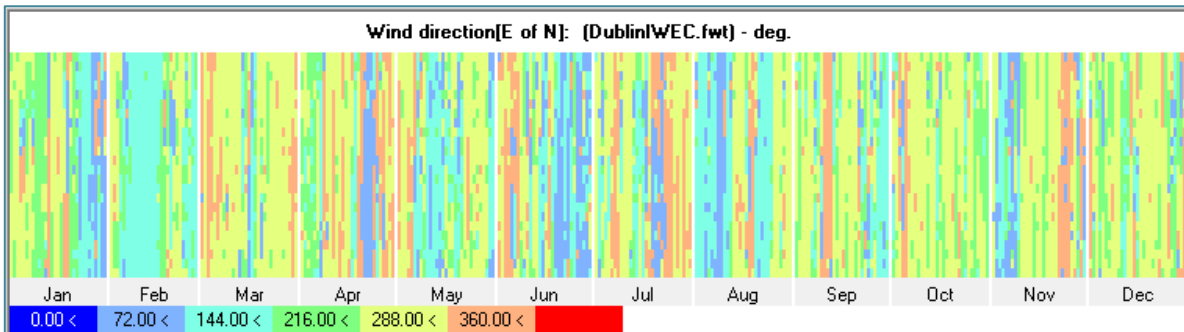


Figure 3: Wind direction variation as per DublinIWEC.epw

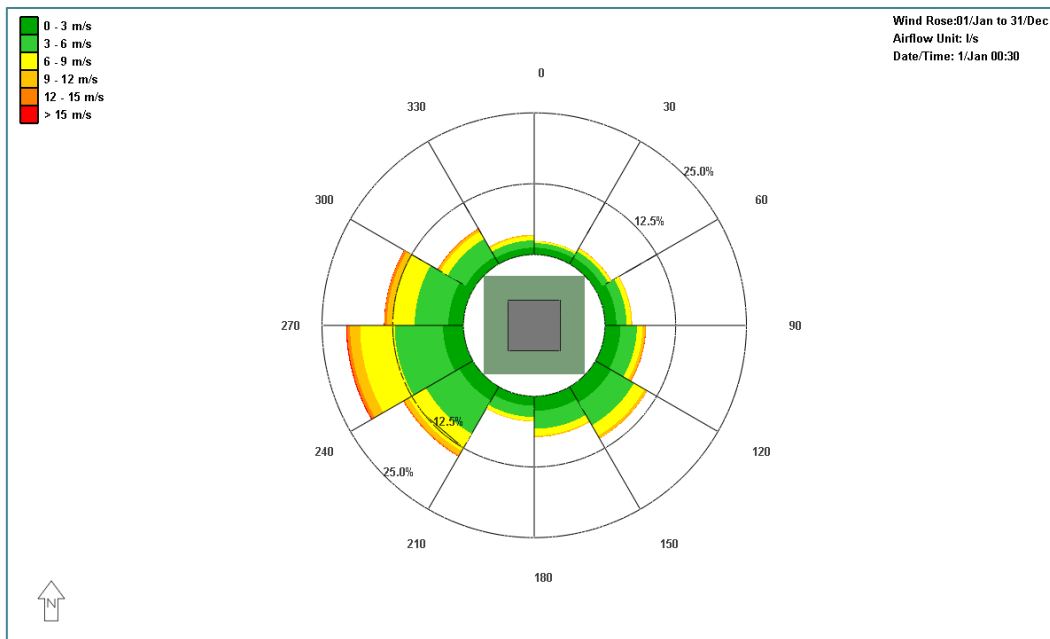


Figure 4: Wind rose as per DublinIWEC.epw

Based on this, the mean wind speed recorded was 5m/s with a westerly prevailing direction.

4 Wind Boundary Layer

In an atmospheric boundary layer, wind speed increases with height due to the influence of surface roughness (i.e. the presence of buildings, trees, roads etc. on the ground), see Figure 4.

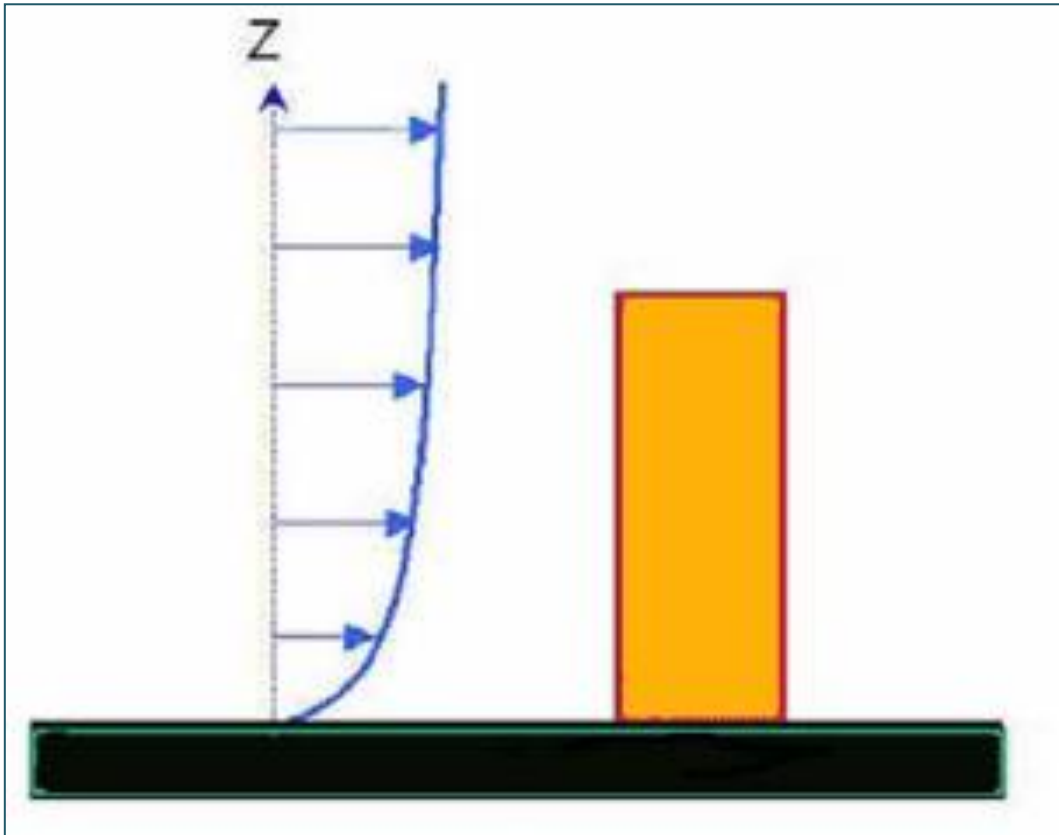


Figure 5: Typical velocity profile of an atmospheric boundary layer

In the current CFD modelling, the velocity profile was generated according to the parameterised ASHRAE methodology described below. This allows for different wind profiles across various terrain types: Open country; urban; and city centre.

The wind speed U_H at height H above the ground is given by:

$$U_H = U_{met} \left(\frac{\delta_{met}}{H_{met}} \right)^{a_{met}} \left(\frac{H}{\delta} \right)^a \dots \dots \dots (Eq. 1)$$

Where,

- a = Exponent in power law wind speed profile for local building terrain
- δ = fully developed strong wind atmospheric boundary layer thickness (m)
- a_{met} = Exponent for the meteorological station
- δ_{met} = Atmospheric boundary thickness at the meteorological station (m)
- H_{met} = Height at which meteorological wind speed was measured (m)
- U_{met} = Hourly meteorological wind speed, measured at height H_{met} (m/s)

The parameters for different types of terrain are given as in table 1.

Table 1: Atmospheric boundary layer parameters

Terrain Category	Description	a	δ
1	Large city centres 50% of buildings above 21m over a distance of at least 2000m upwind.	0.33	460
2	Urban, suburban, wooded areas.	0.22	370
3	Open, with scattered objects generally less than 10m high.	0.14	270
4	Flat, unobstructed areas exposed to wind flowing over a large water body (no more than 500m inland).	0.10	210

For the current project, we used the atmospheric boundary layer corresponding to the terrain category 1 i.e. large city centres type of site. The met data was taken on category 3 terrain at a height of 10m. Figure 5 below shows the shape of the wind boundary profile.

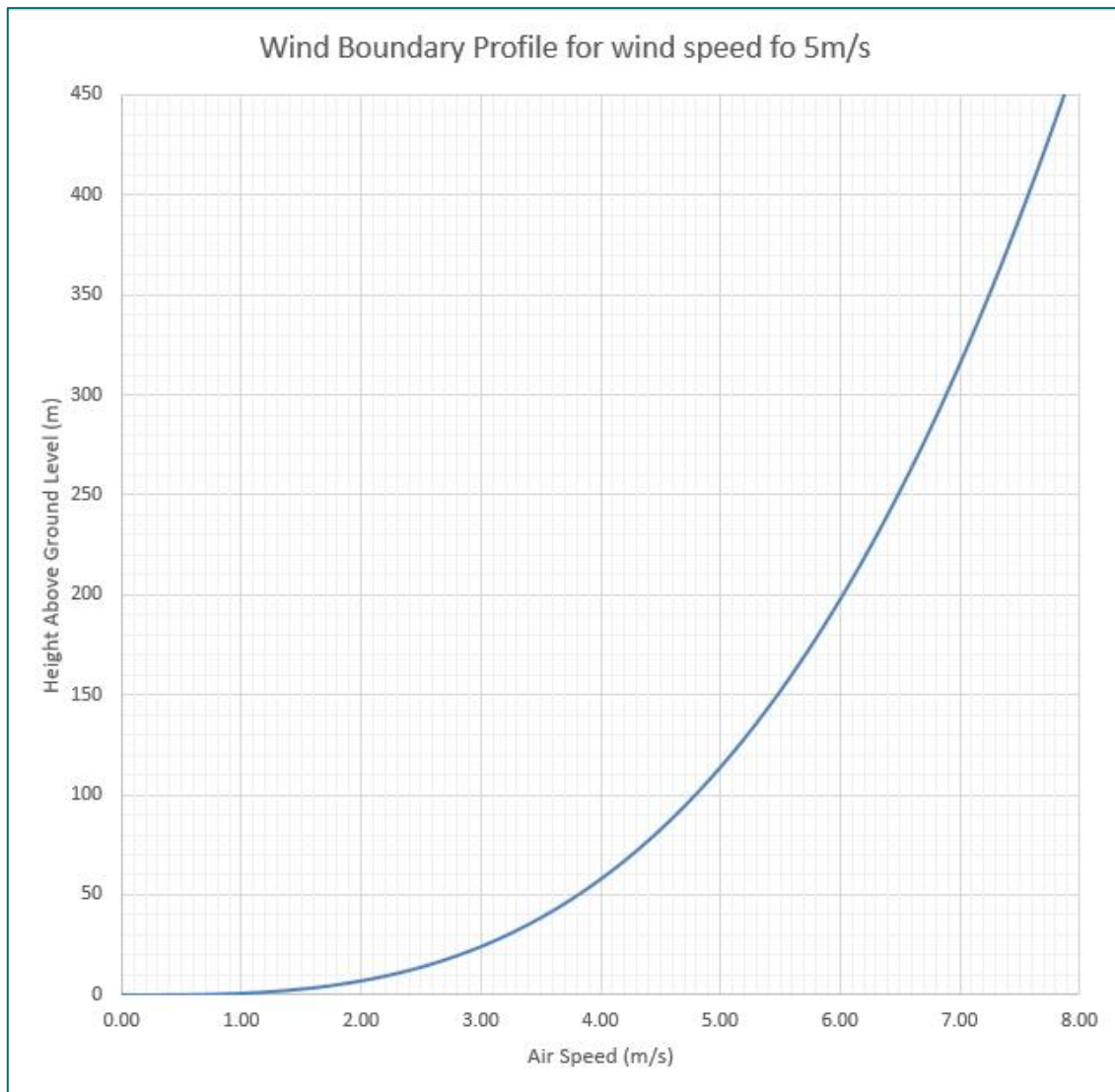


Figure 6: Wind boundary profile for the CFD simulations using annual average wind speed

5 Methodology for Pedestrian Comfort Calculation

The methodology for the analysis was as follows:

- 1) The annual mean wind speed was determined from the 'casement_AMY_2018.epw' weather file.
- 2) 8 steady state CFD simulations were performed corresponding to the 8 directions – SW, W, NW, N, NE, E, SE and S respectively.
- 3) The local air speed at various designated locations around the site was recorded for each of the simulations.
- 4) This value was compared to the meteorological wind speed used and the magnification factor at that location for the corresponding wind direction was determined.
- 5) The magnification factor was used to determine the air speed at the designated locations for the various recorded values of the wind speed and direction in the weather file, thus generating the local air speeds at designated locations for a year.
- 6) These recorded values were compared to the Lawson Pedestrian Comfort/Safety Criteria.

5.1 Lawson Pedestrian Comfort/Safety Criteria

The Lawson Criteria¹ was used as a reference to assess the wind effects. It is the most widely used reference for assessment of pedestrian comfort. It considers the air speed at the location as well as the frequency of the occurrence of this air speed. It consists of two assessment criteria:

1. The first criteria assess whether the air movement will be comfortable for the pedestrian for different types of activities.
2. The second criteria assess the feeling of safety or distress by the pedestrian at higher air speeds.

Following table gives the values for the Lawson's pedestrian comfort assessment criteria for various activities.

Category	Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time (m/s)
C1	Business Walking	10
C2	Leisurely Walking	8
C3	Standing	6
C4	Sitting	4

Following table gives the values for Lawson's Pedestrian Safety Assessment criteria.

Category	Pedestrian Type	Threshold mean hourly wind speed not to be exceeded more than once per annum ² (m/s)
S1	Typical Pedestrian	20
S2	Sensitive Pedestrian	15

¹T. V. Lawson (2001) *Building Aerodynamics*, Imperial College Press, London.

²Once per annum means the safety threshold is not be exceeded 0.01% of the year.

6 CFD Model

The CFD model was created based on the CAD drawings provided.

6.1 Model Geometry

Figures 6 to 23 show the geometry as modelled.



Figure 7: Plan view of the site

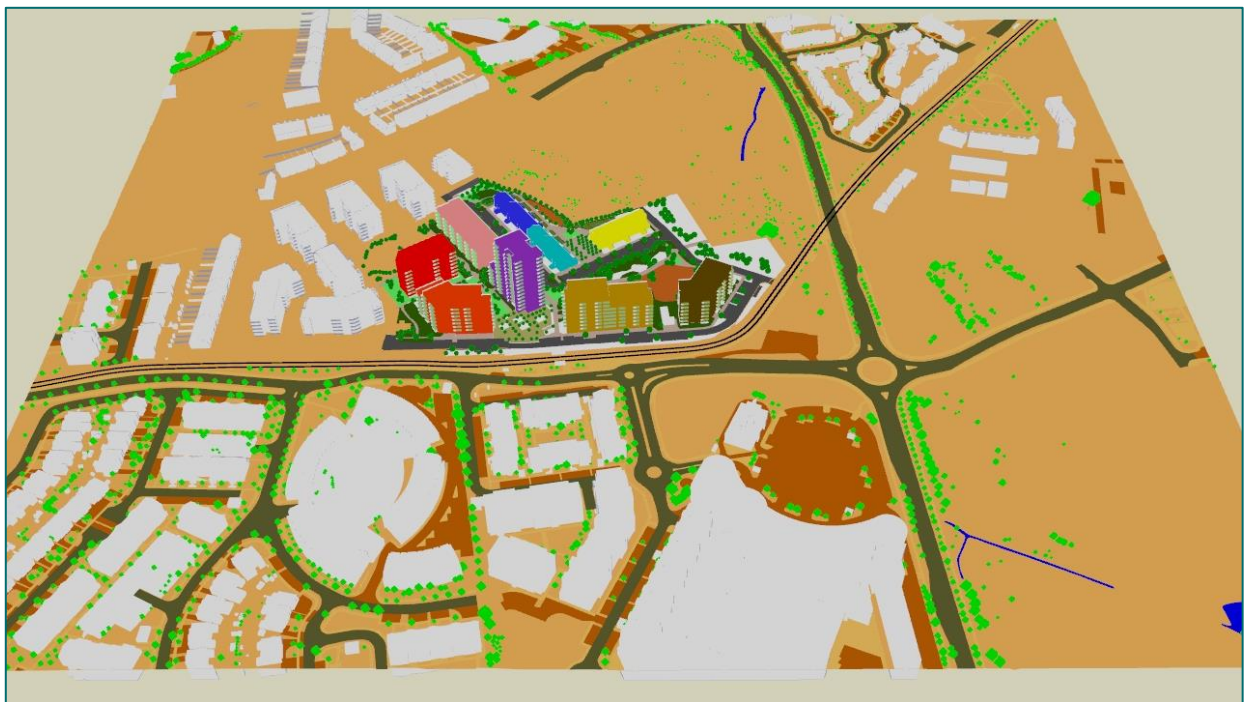


Figure 8: View of the site from the south

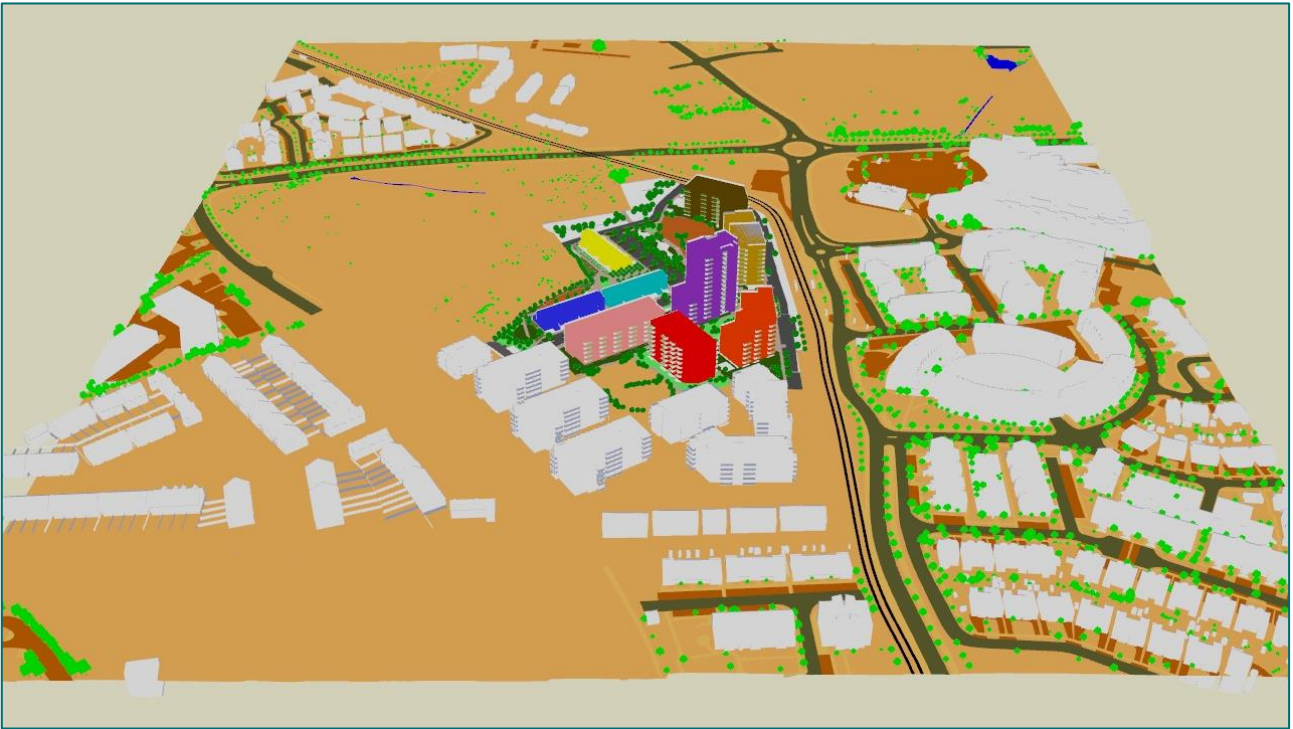


Figure 9: View of the site from the west

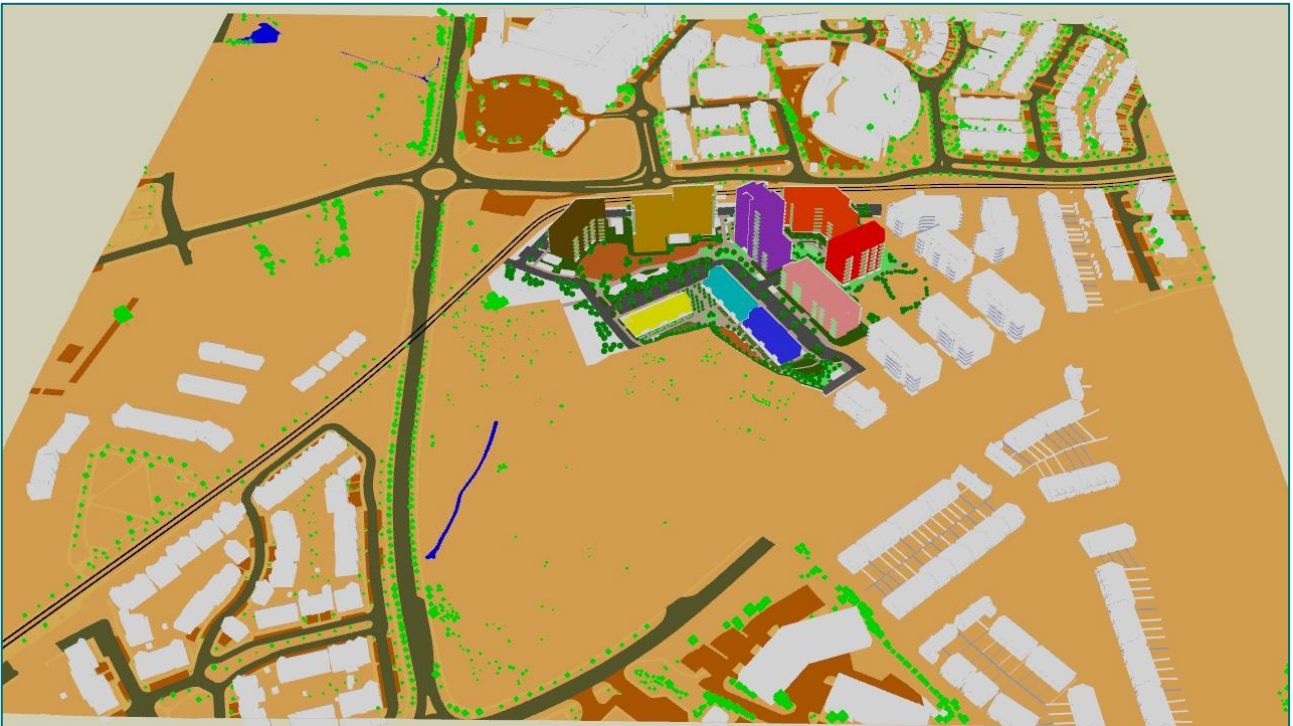


Figure 10: View of the site from the north

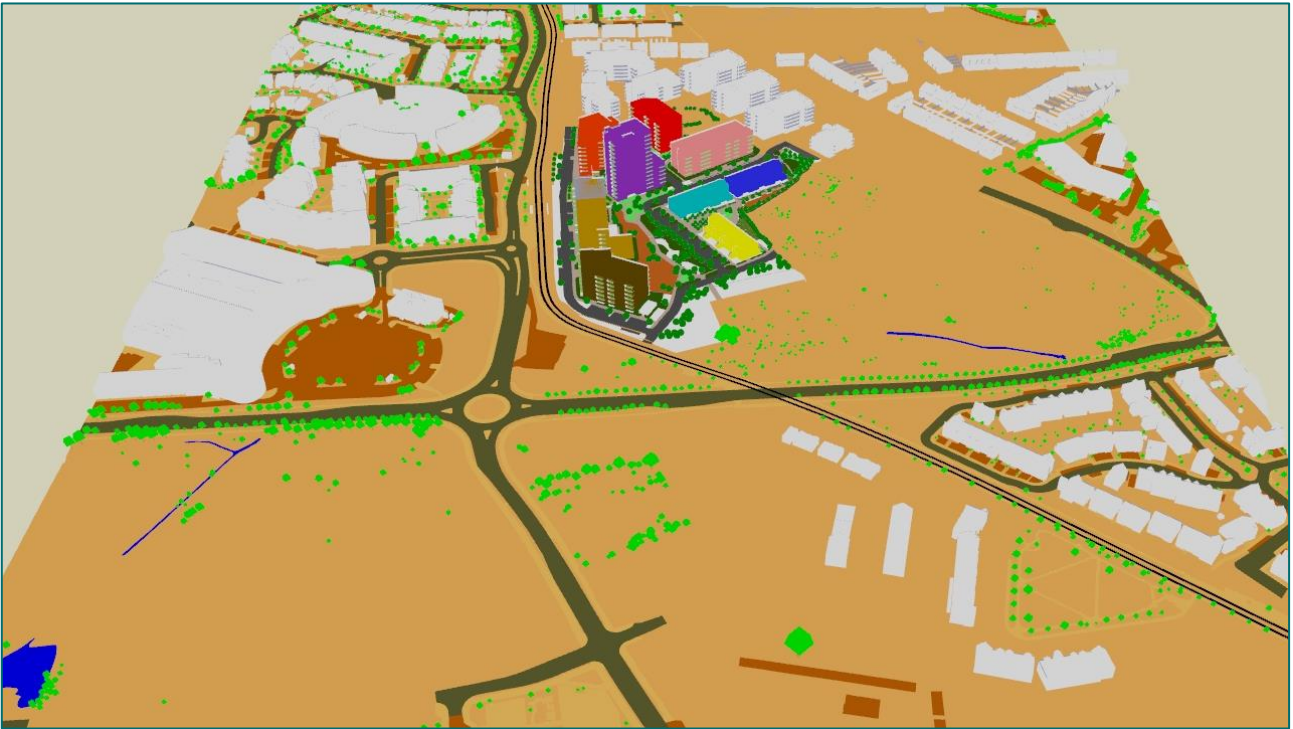


Figure 11: View of the site from the east

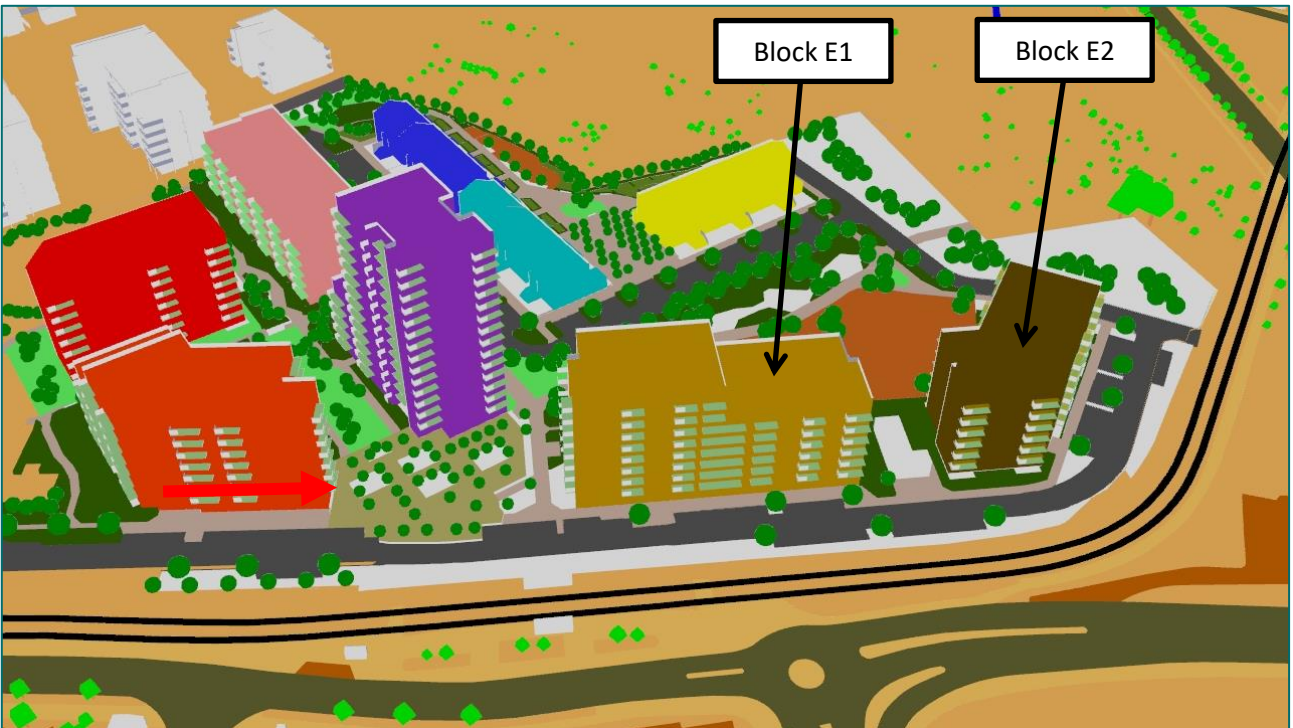


Figure 12: Closer view of Cairn Homes Citywest plot from south

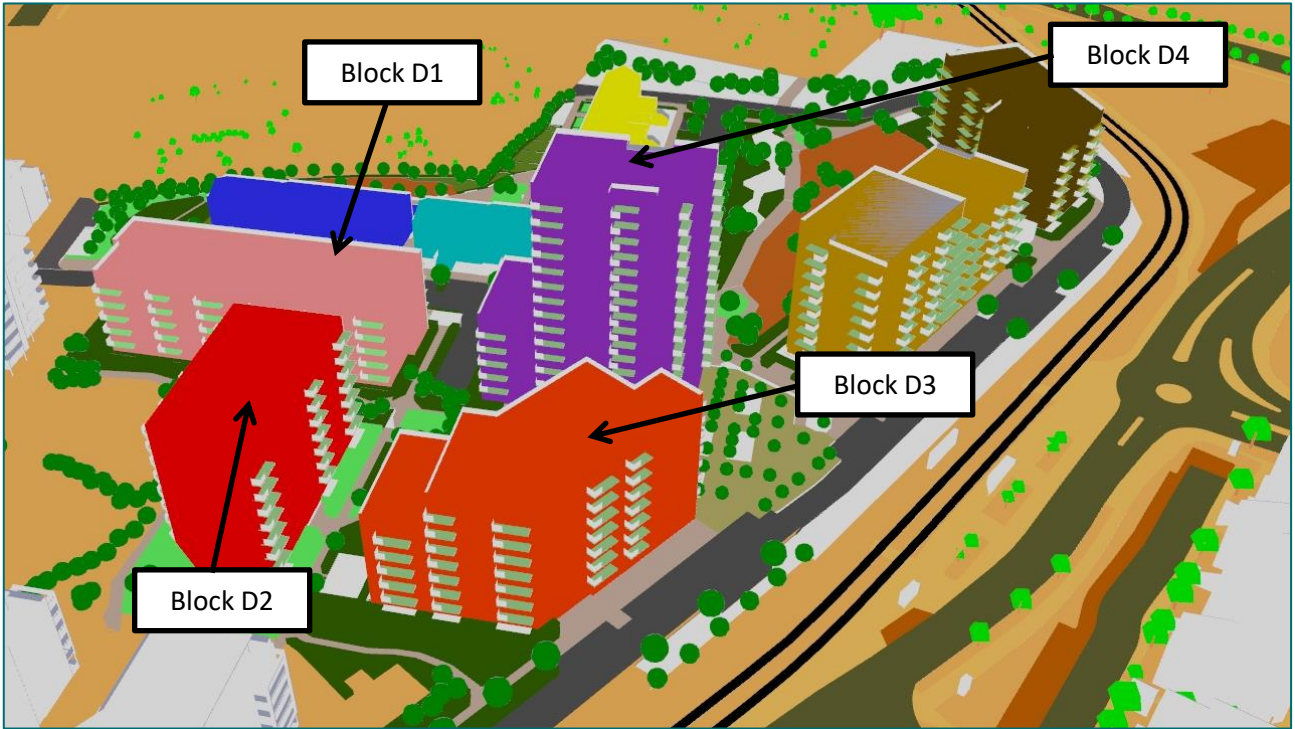


Figure 13: Closer view of Cairn Homes Citywest plot from southwest

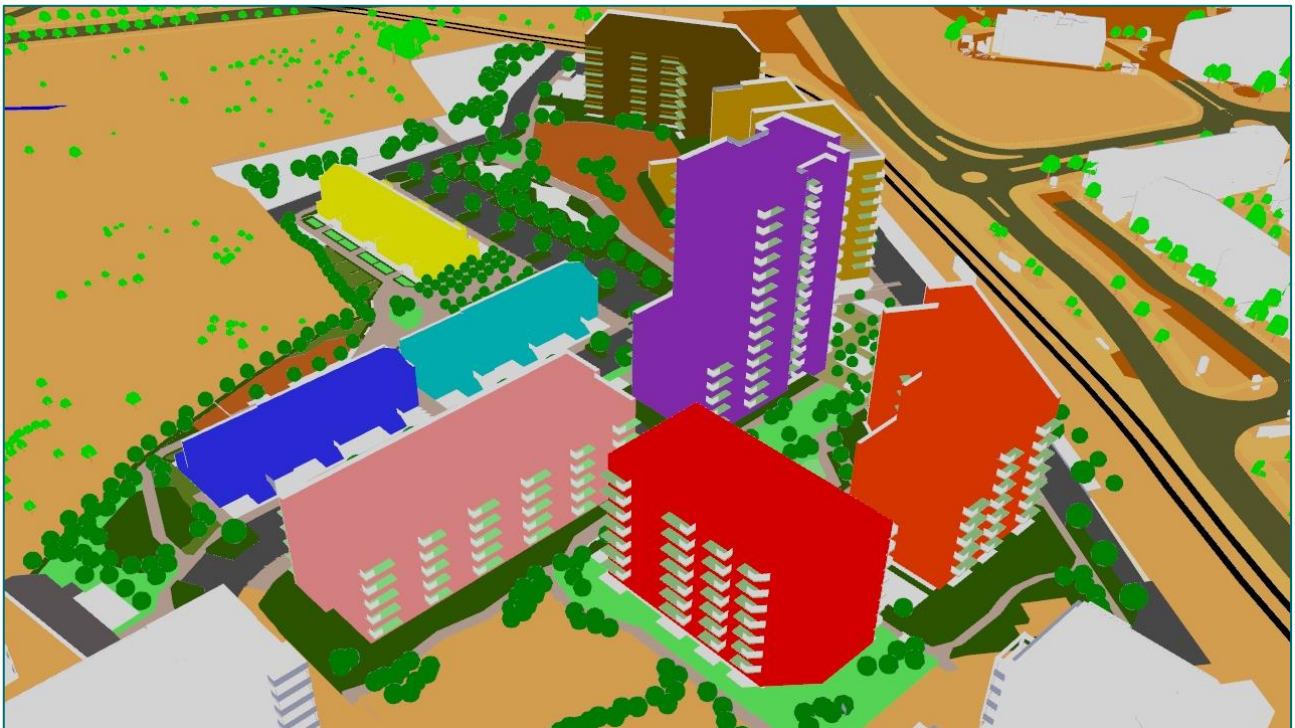


Figure 14: Closer view of Cairn Homes Citywest plot from west

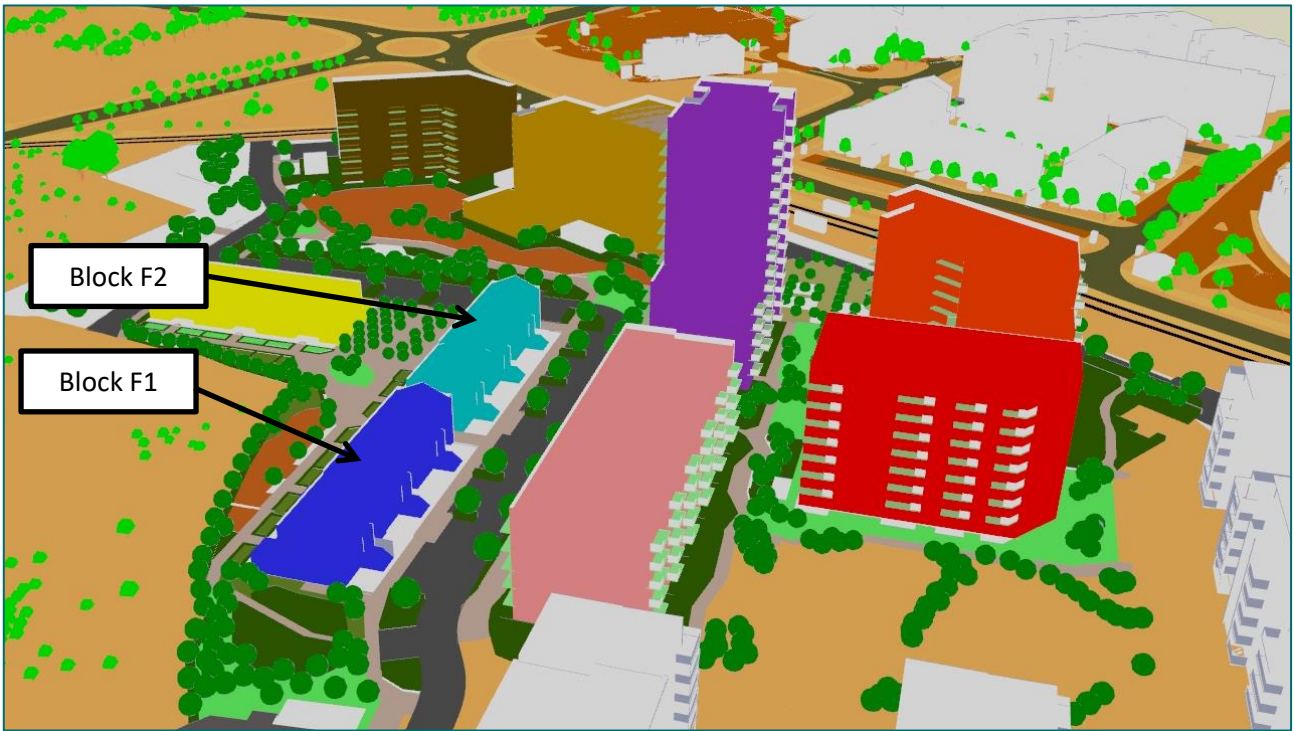


Figure 15: Closer view of Cairn Homes Citywest plot from northwest

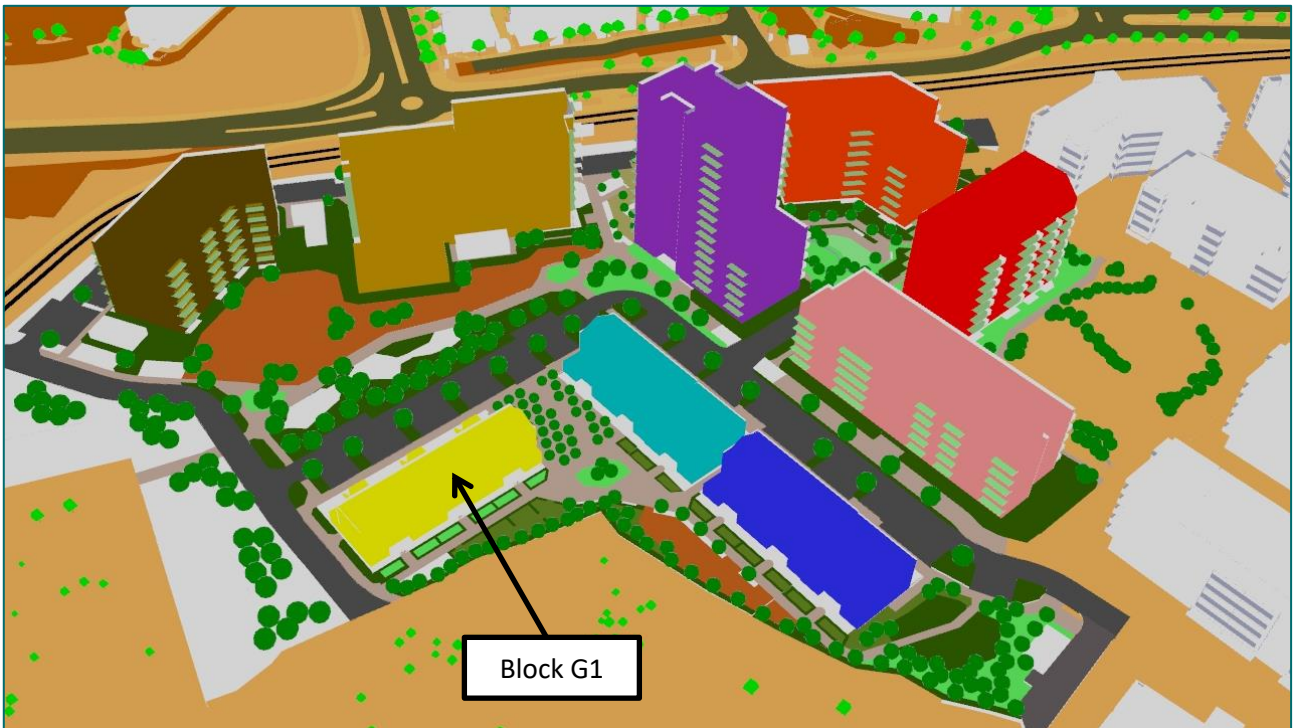


Figure 16: Closer view of Cairn Homes Citywest plot from north

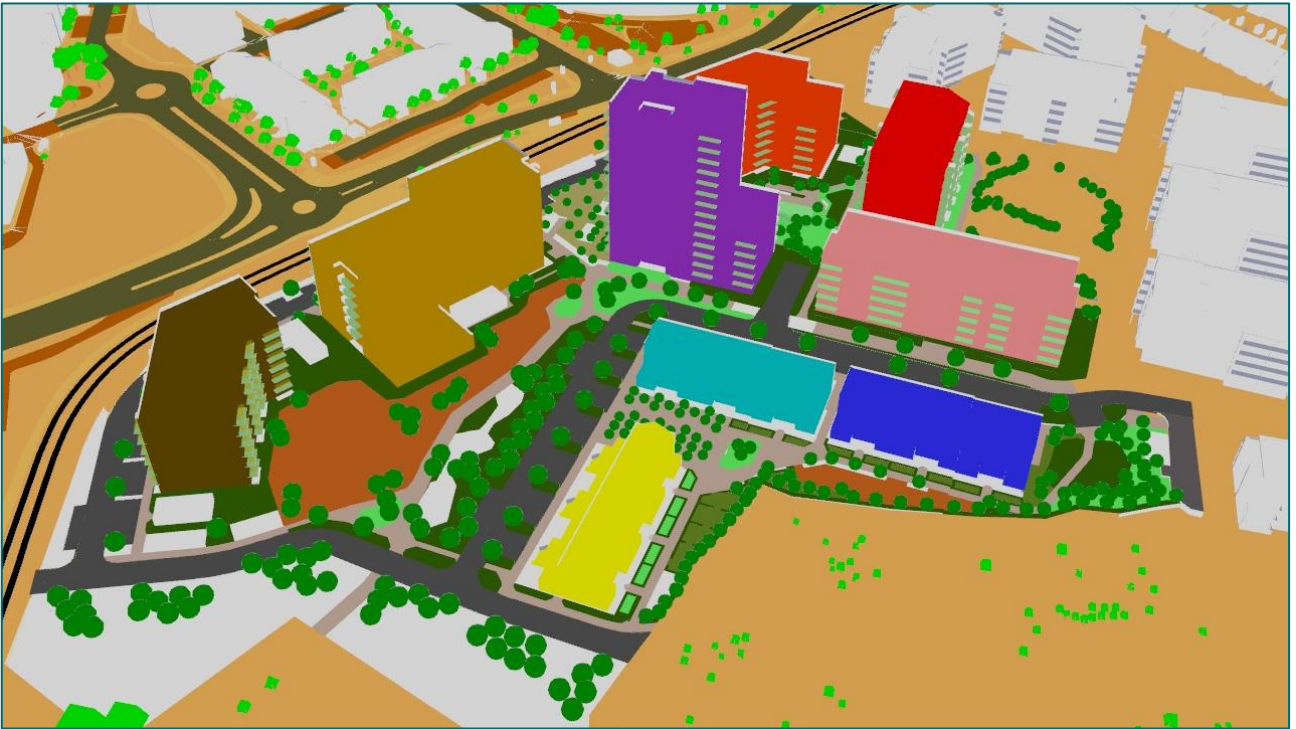


Figure 17: Closer view of Cairn Homes Citywest plot from northeast

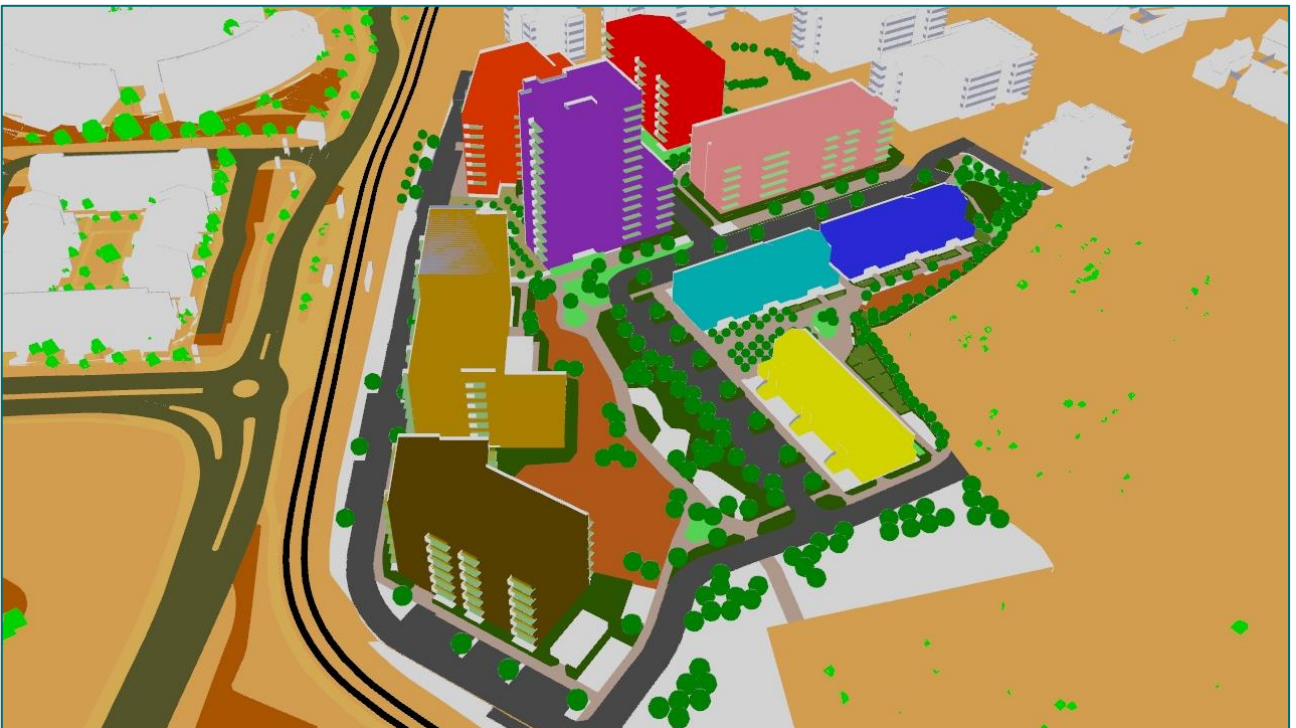


Figure 18: Closer view of Cairn Homes Citywest plot from east

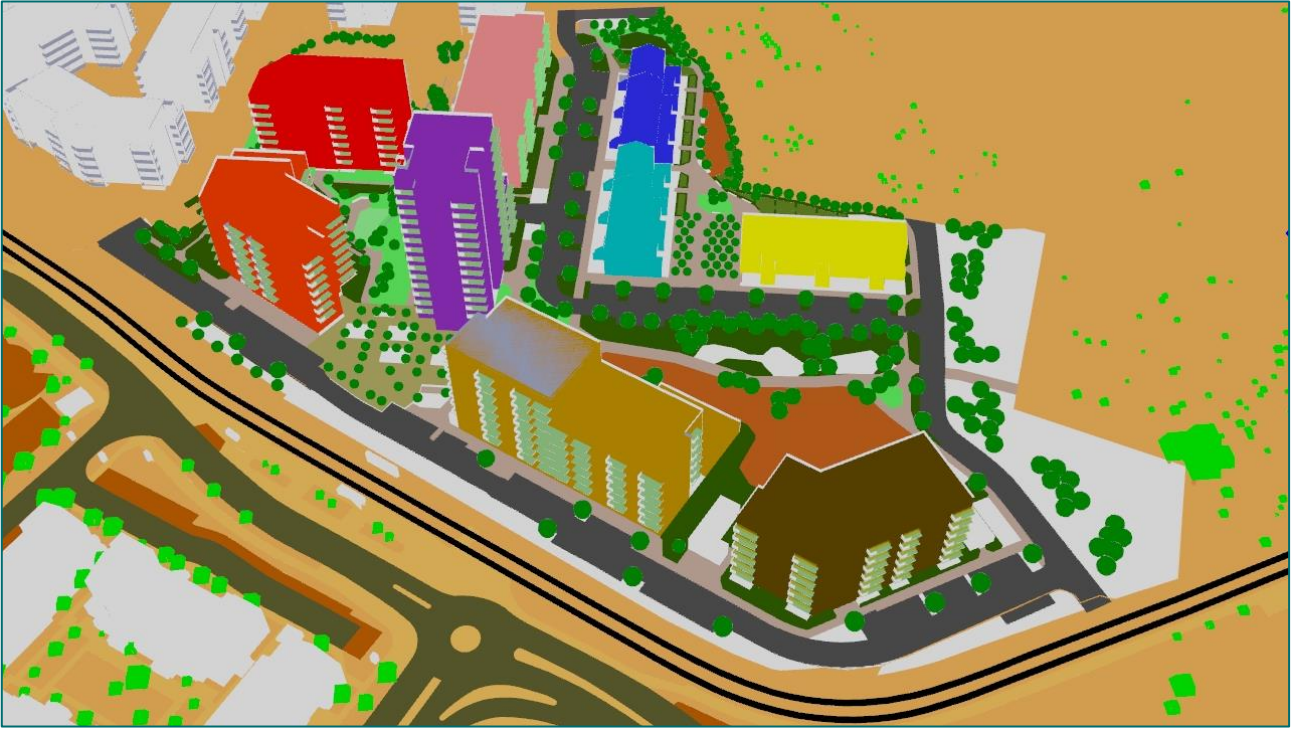


Figure 19: Closer view of Cairn Homes Citywest plot from southeast



Figure 20: Closer view of Cairn Homes Citywest plot: Public Amenities

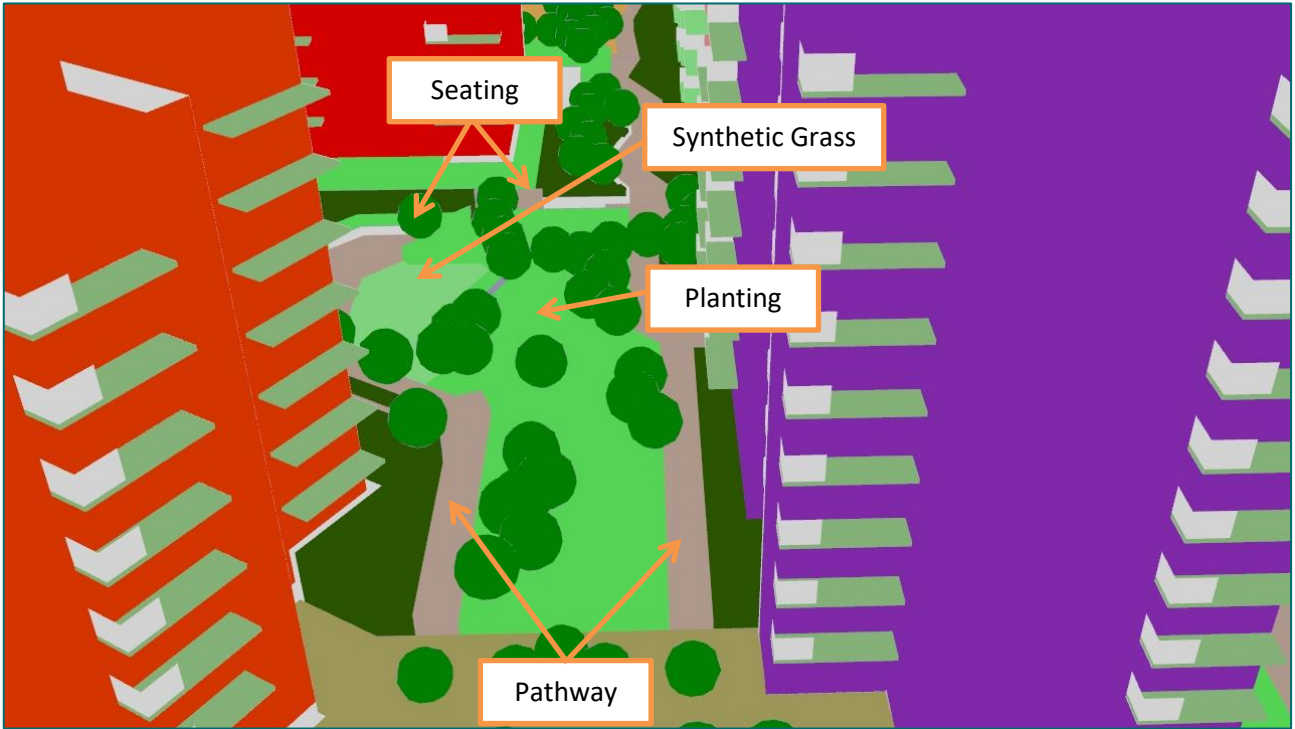


Figure 21: Closer view of Cairn Homes Citywest plot: Public Amenities

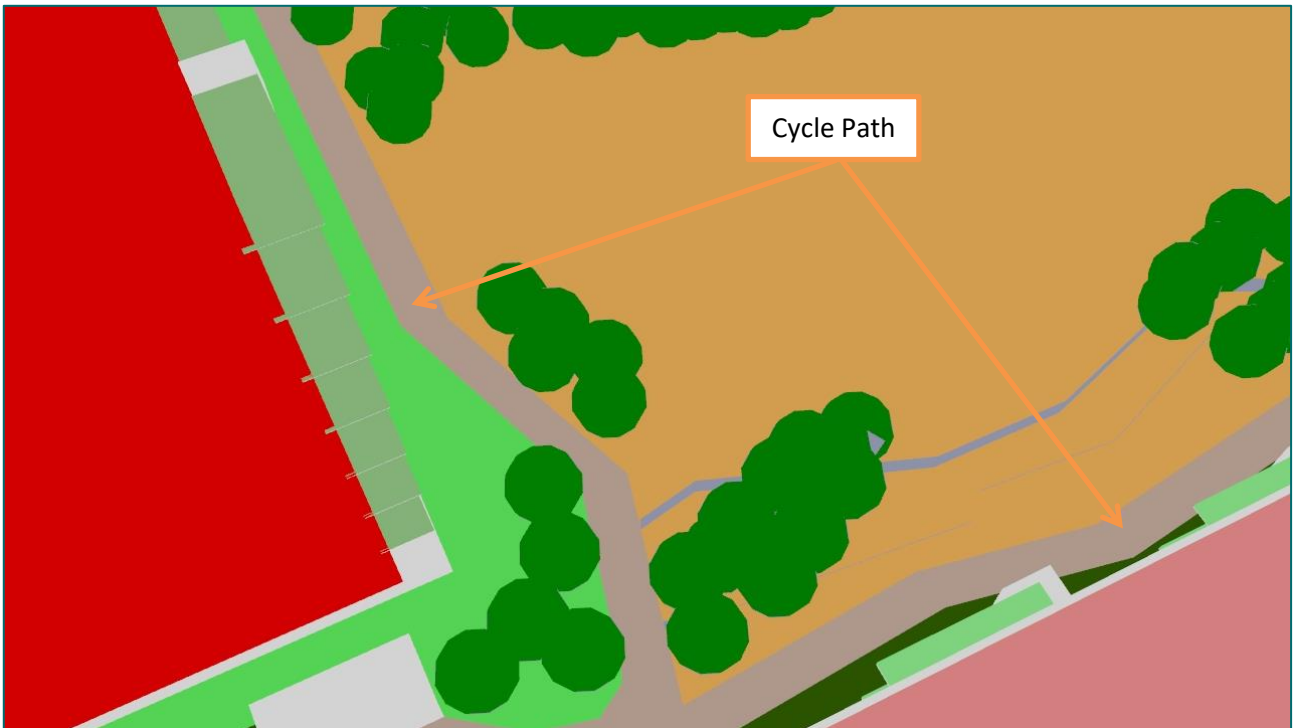


Figure 22: Closer view of Cairn Homes Citywest plot: Public Amenities



Figure 23: Closer view of Cairn Homes Citywest plot: Public Amenities



Figure 24: Closer view of Cairn Homes Citywest plot: Public Amenities

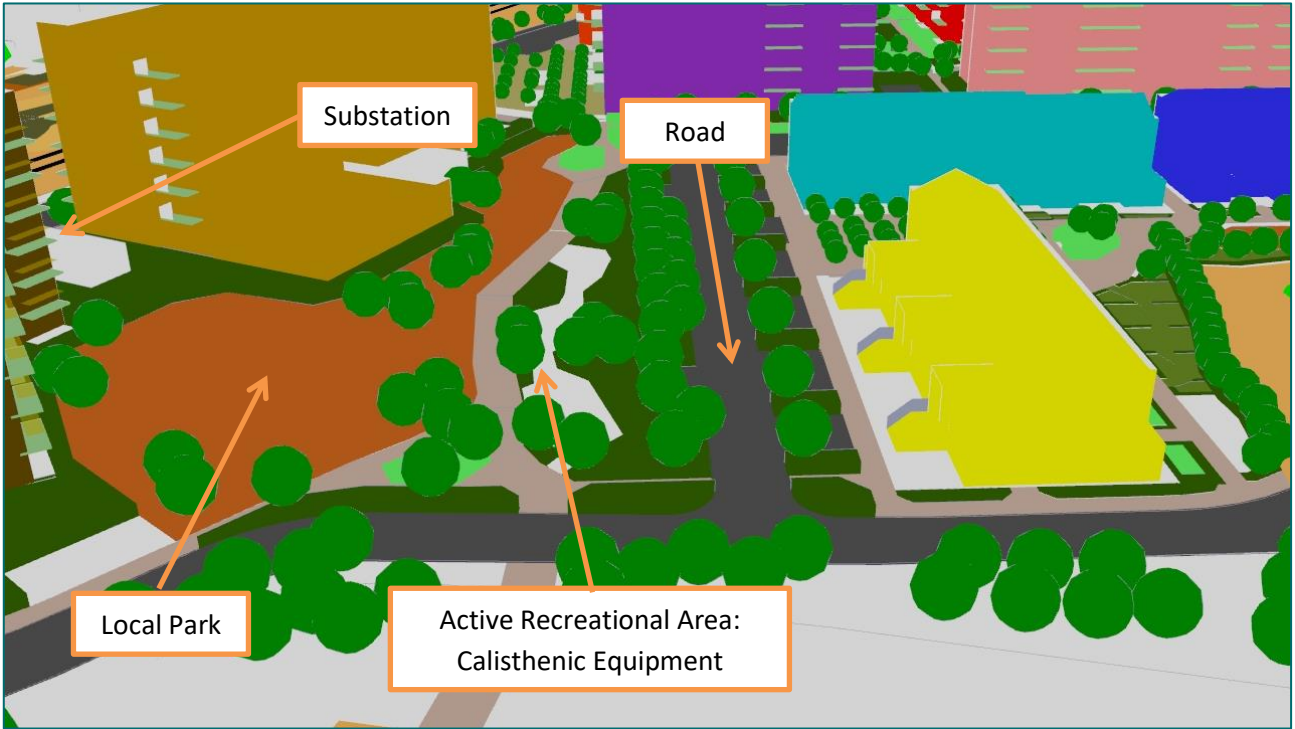


Figure 25: Closer view of Cairn Homes Citywest plot: Public Amenities

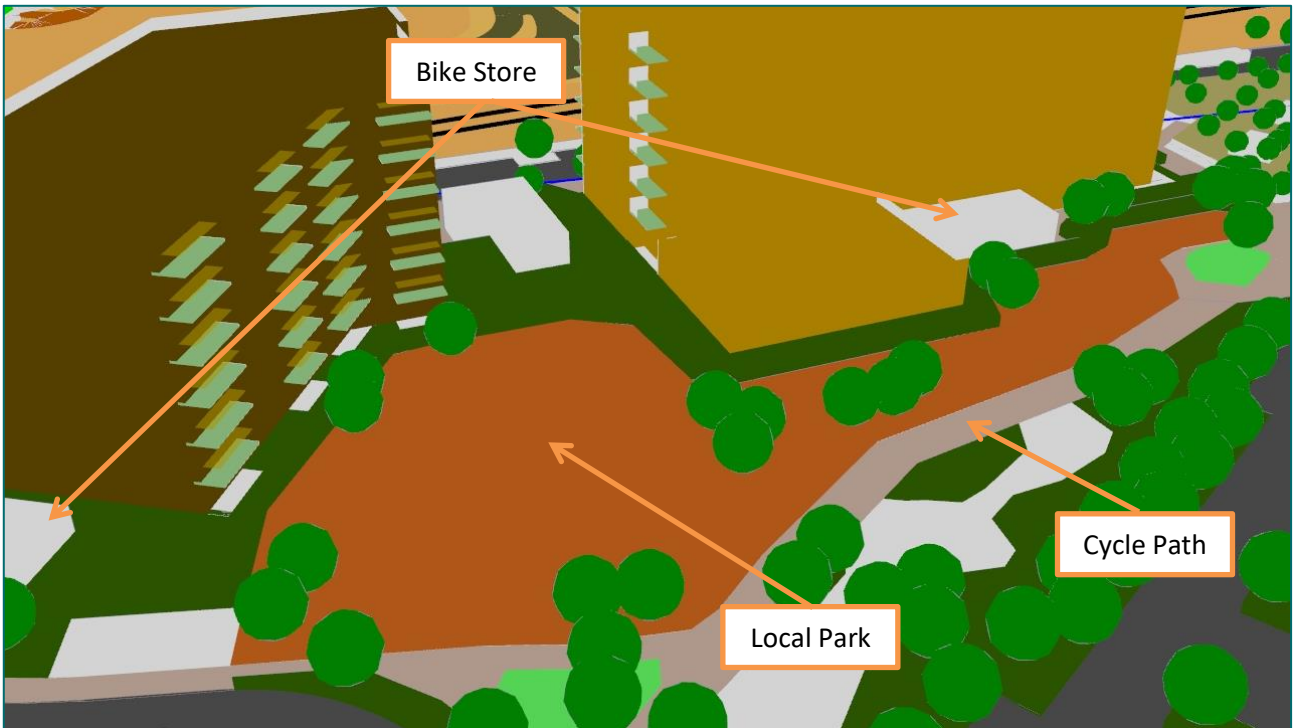


Figure 26: Closer view of Cairn Homes Citywest plot: Public Amenities

6.2 Comfort Activities

The following table lists the various activities according to the amenity type will be focused mainly in the simulation.

Amenity Area	Business Walking	Leisurely Walking	Standing	Sitting
Seating areas on ground	✓	✓	✓	✓
Balconies of all plots			✓	✓
Tenant amenities	✓	✓	✓	✓
Streets/Walkways	✓	✓		
Public Realm	✓	✓		

7 Results

7.1 Comfort Criteria: All Seasons: Public Amenities

Figures 26 to 34 show the percentage of the year the hourly wind speed exceeds the threshold value for the comfort criteria for public amenities such as Sitting, Standing, Leisurely Walking and Business Walking for all seasons. The threshold values are 4m/s, 6m/s, 8m/s and 10m/s respectively.



Figure 27: Comfort Criteria: All Seasons: View from above

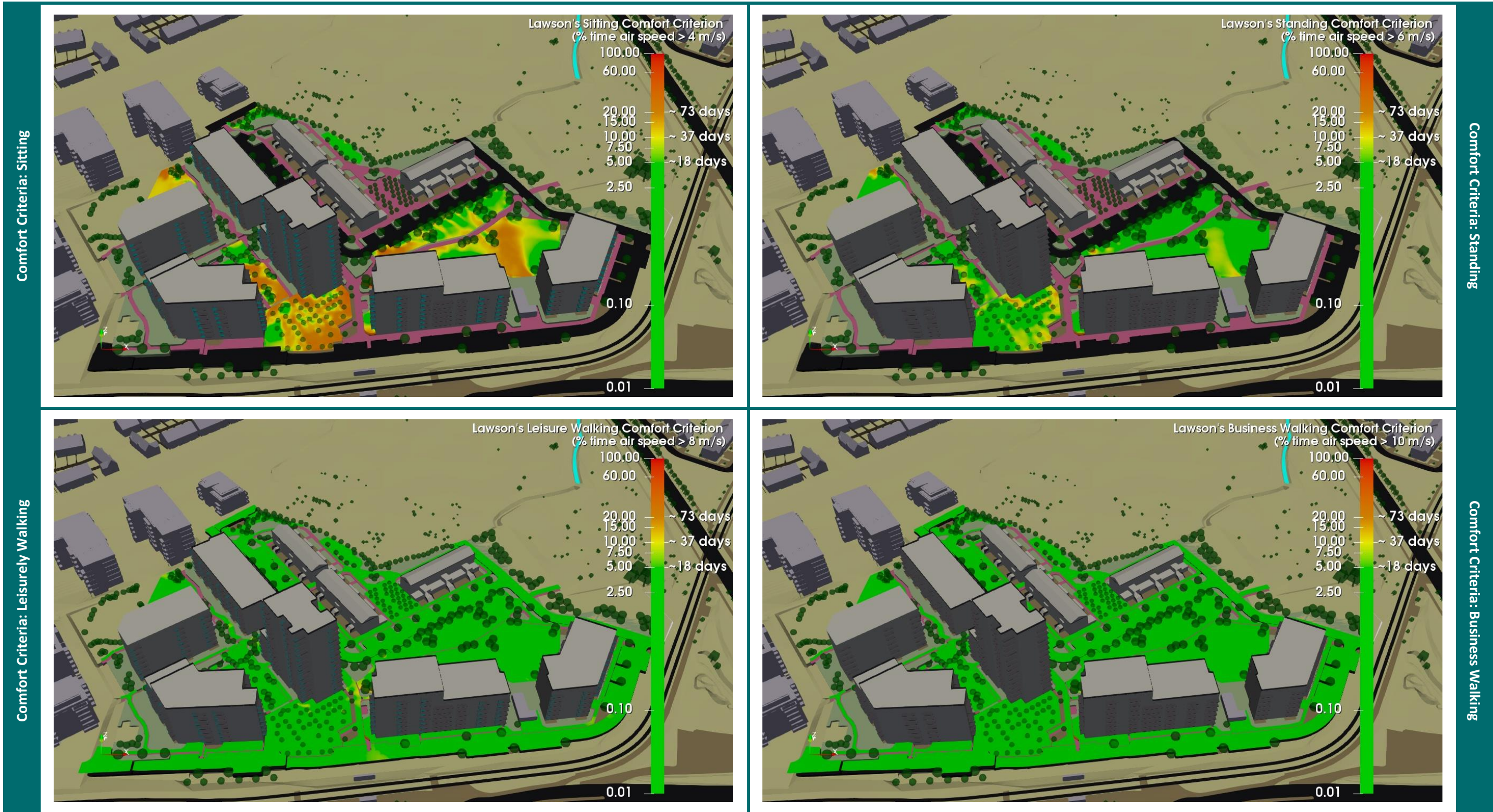


Figure 28: Comfort Criteria: All Seasons: View from the south

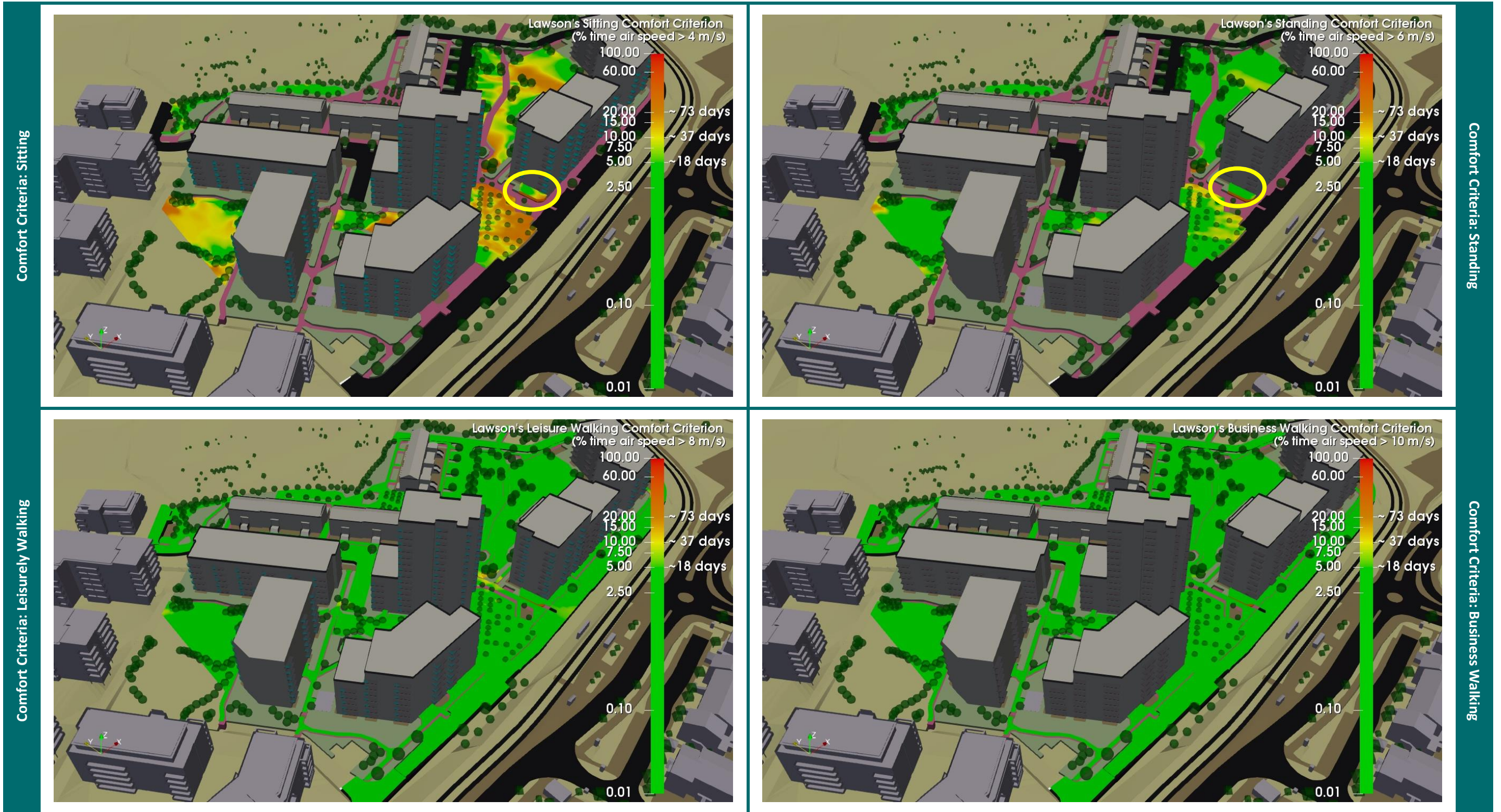


Figure 29: Comfort Criteria: All Seasons: View from the southwest

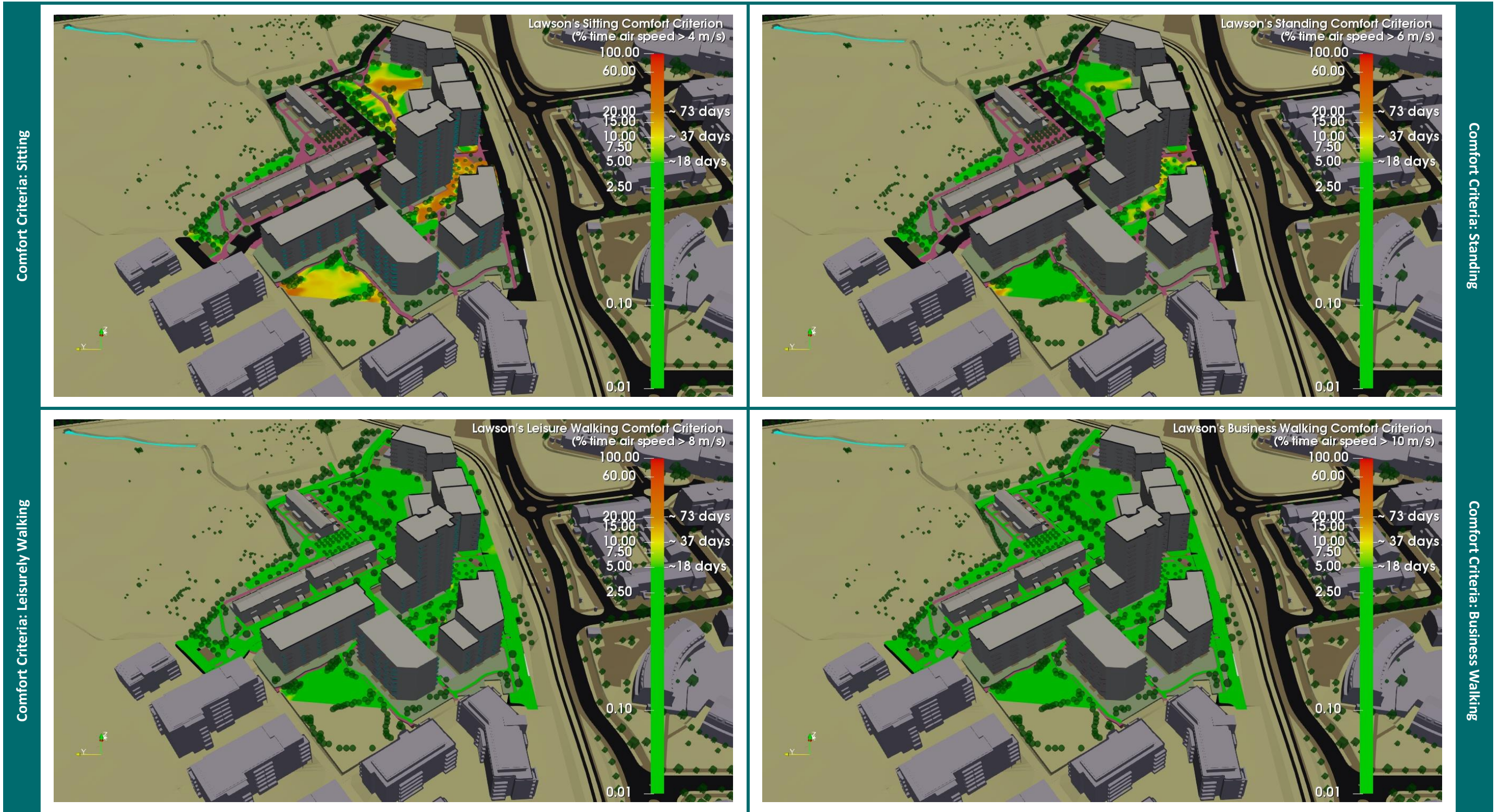


Figure 30: Comfort Criteria: All Seasons: View from the west

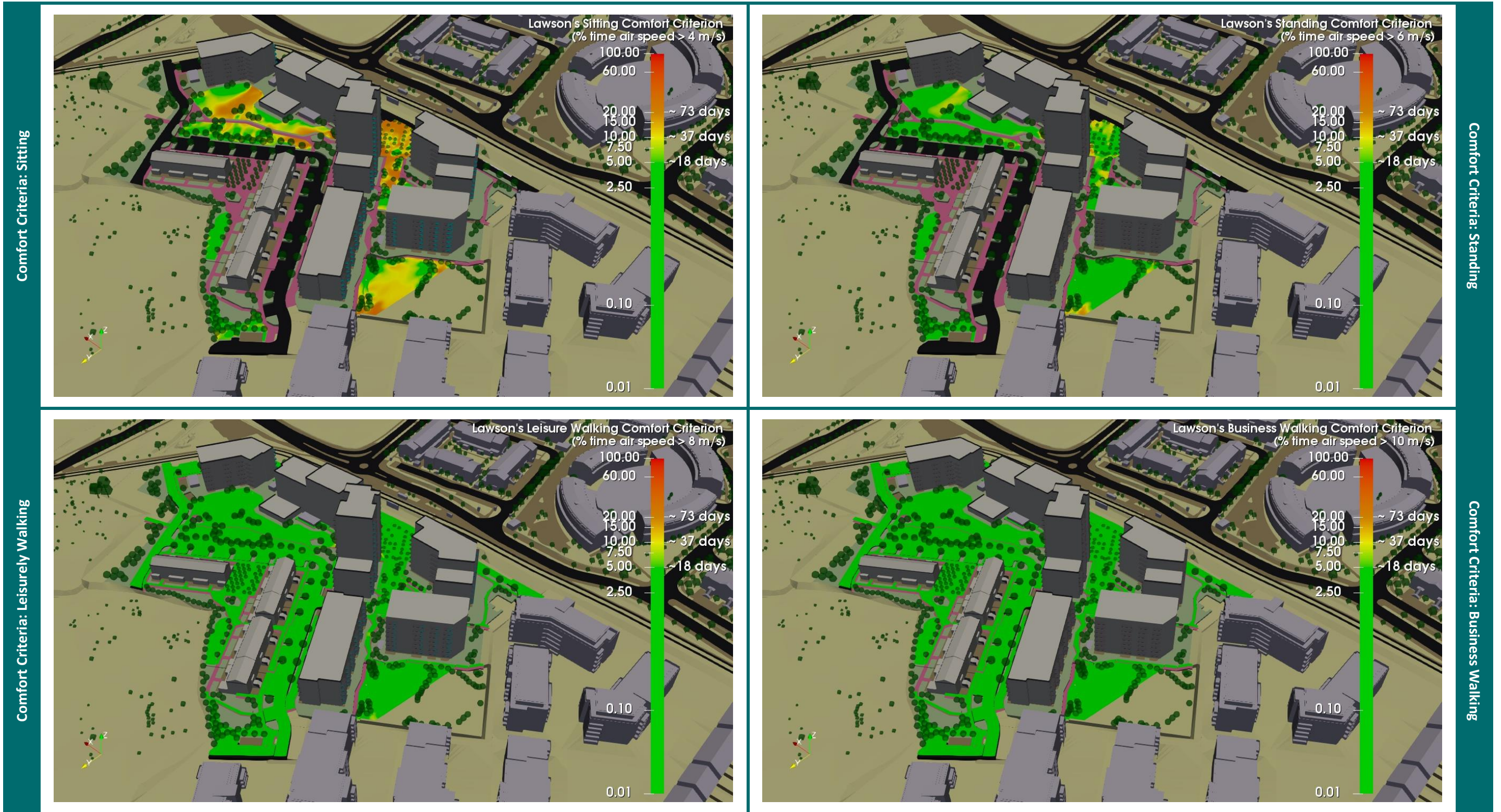


Figure 31: Comfort Criteria: All Seasons: View from the northwest

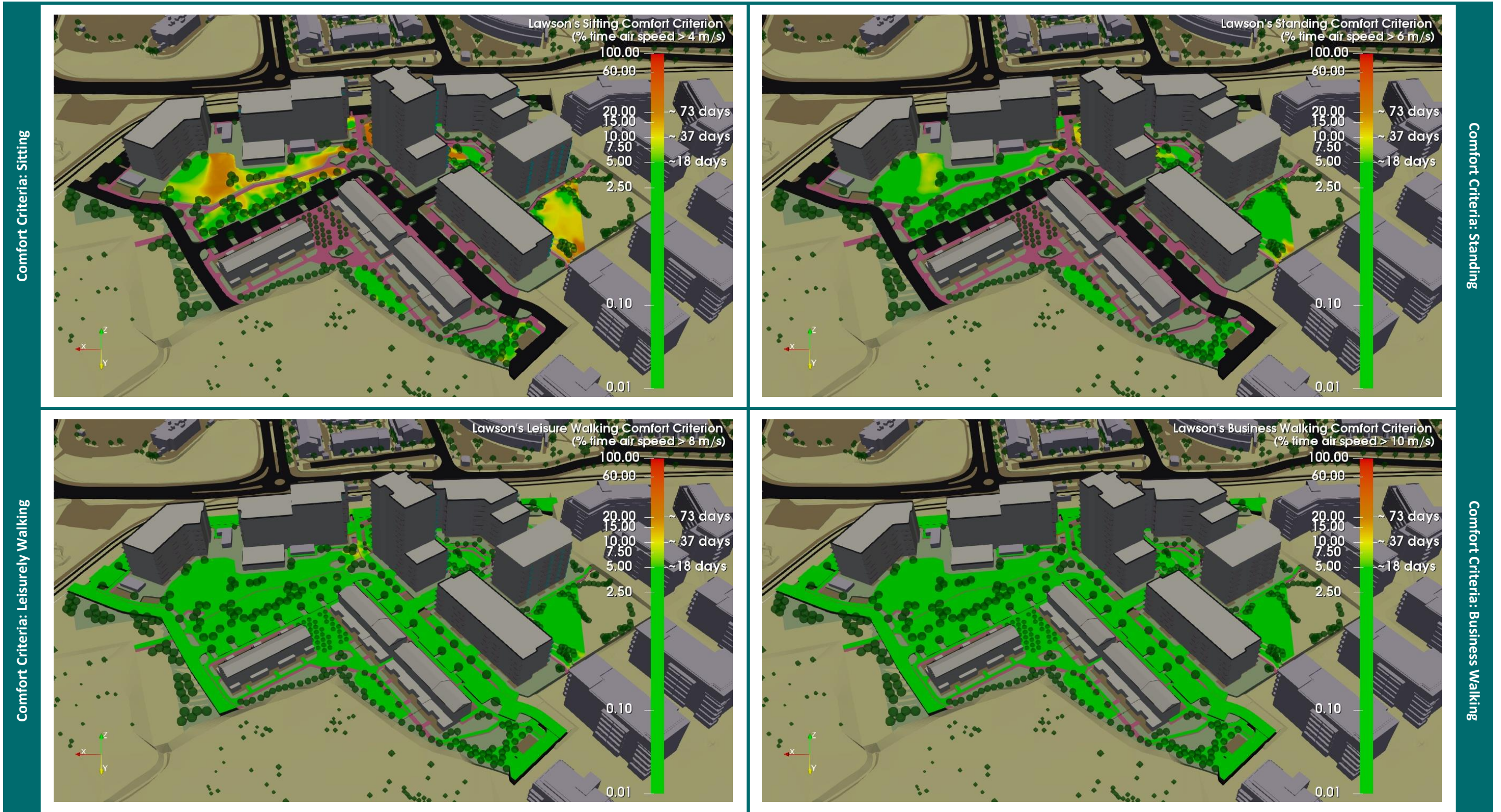


Figure 32: Comfort Criteria: All Seasons: View from the north

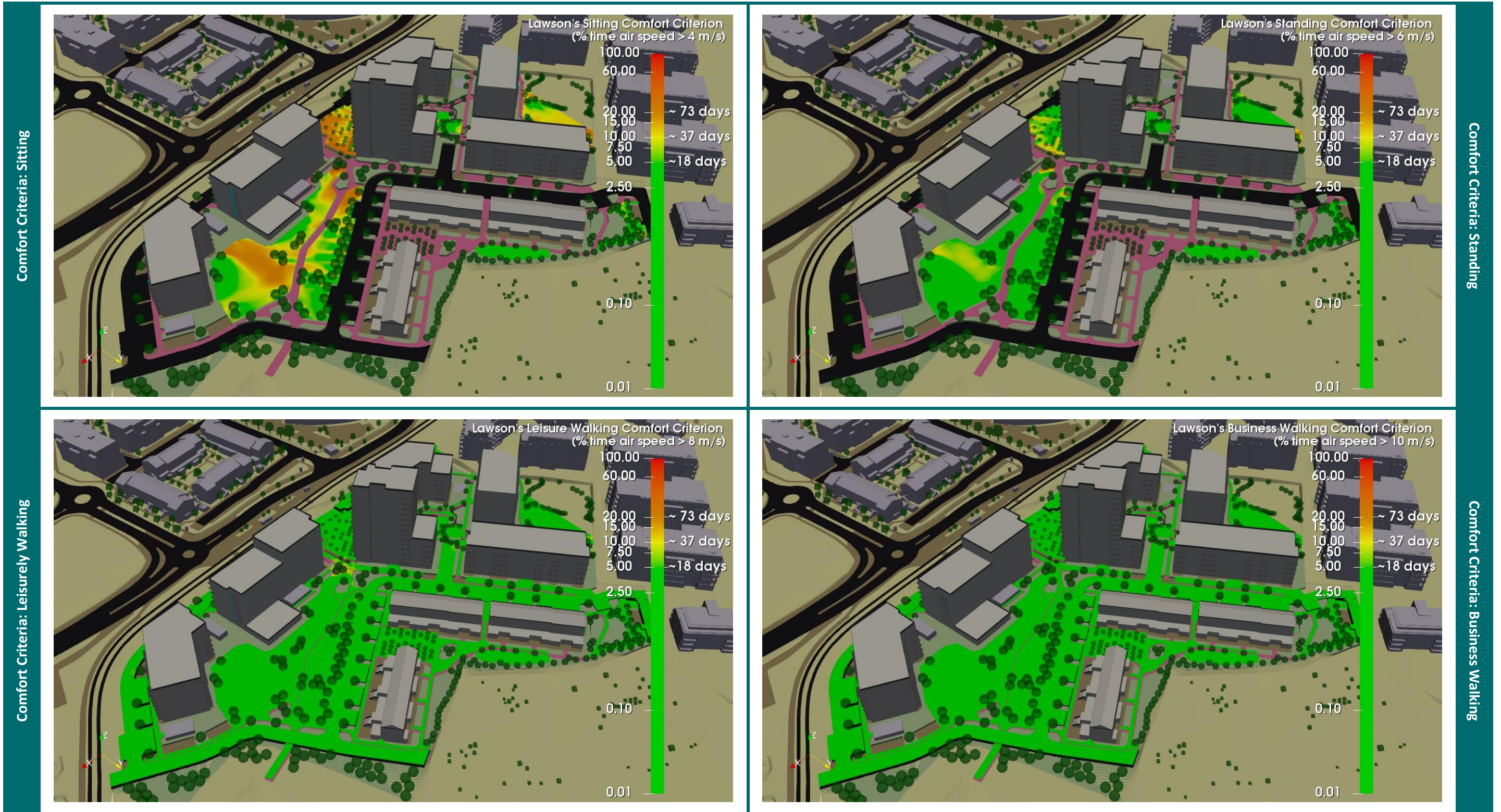


Figure 33: Comfort Criteria: All Seasons: View from the northeast

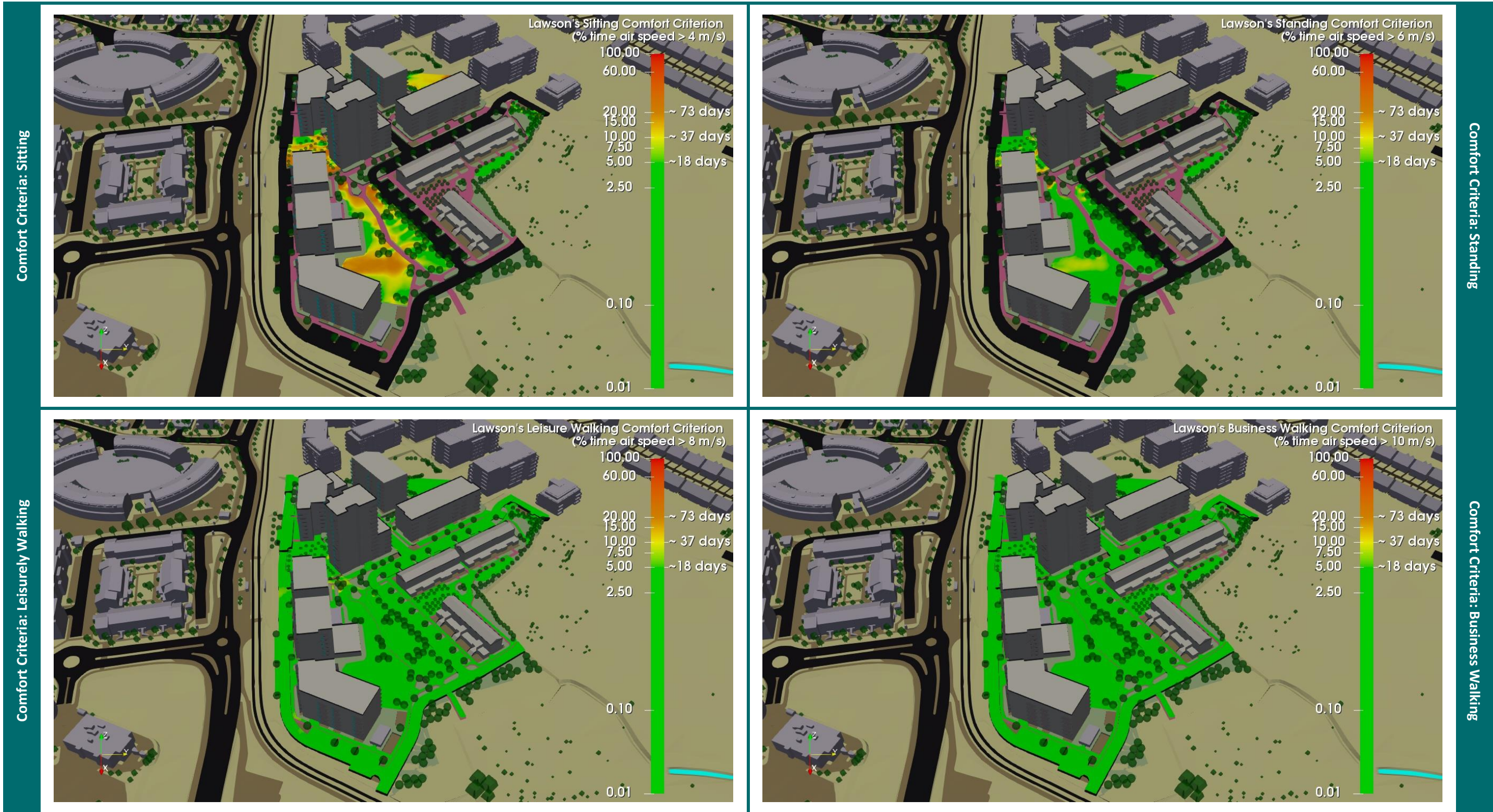


Figure 34: Comfort Criteria: All Seasons: View from the east

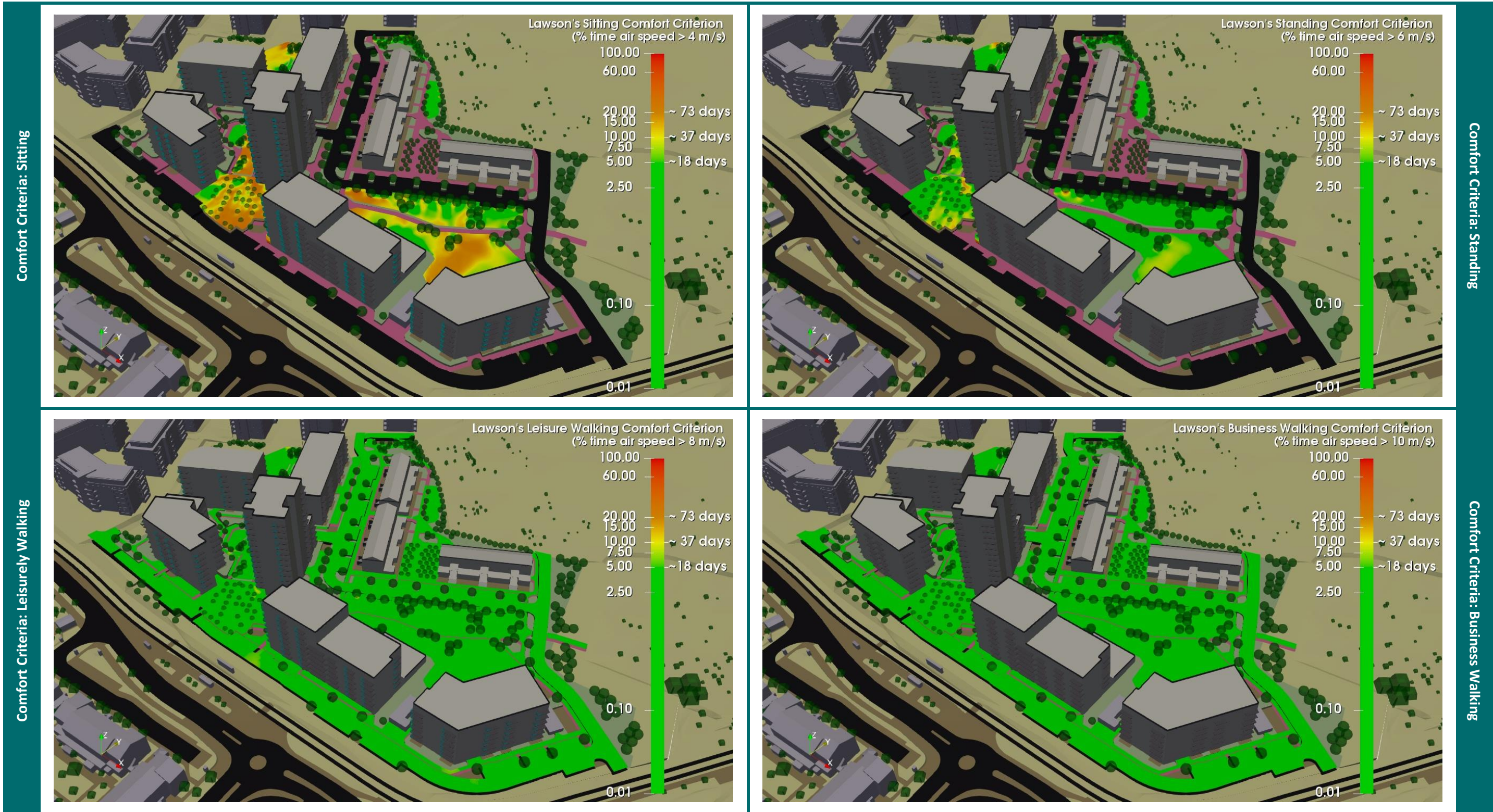


Figure 35: Comfort Criteria: All Seasons: View from the southeast

7.2 Safety Criteria: All Seasons: Public Amenities

Figure 35 to 43 show the percentage of the year the hourly wind speed exceeds the threshold value for the safety criteria for all seasons for public amenities. The threshold values are 20m/s for normal pedestrian and 15m/s for sensitive pedestrian.

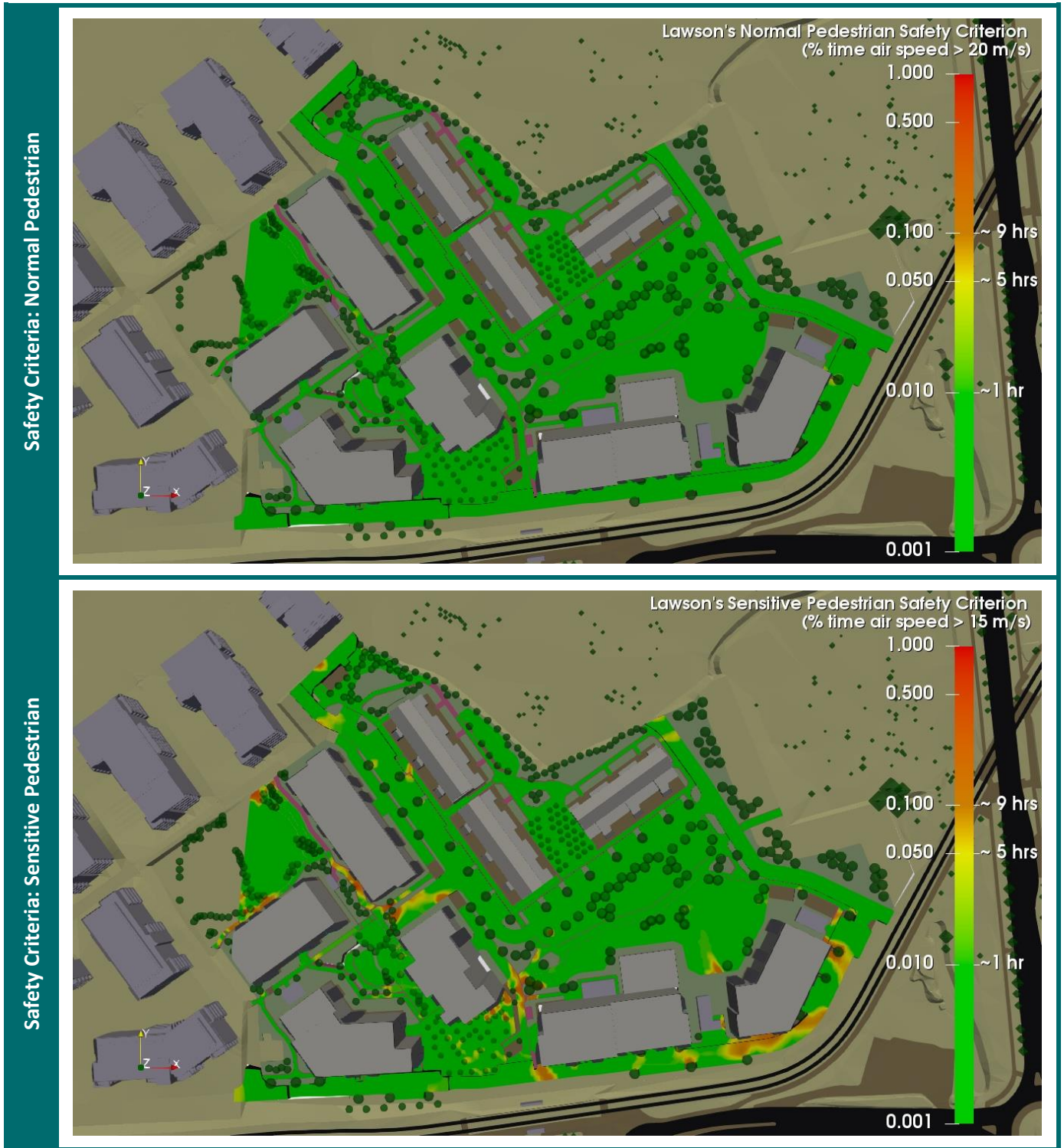


Figure 36: Safety Criteria: All Season: View from above



Figure 37: Safety Criteria: All Season: View from the south

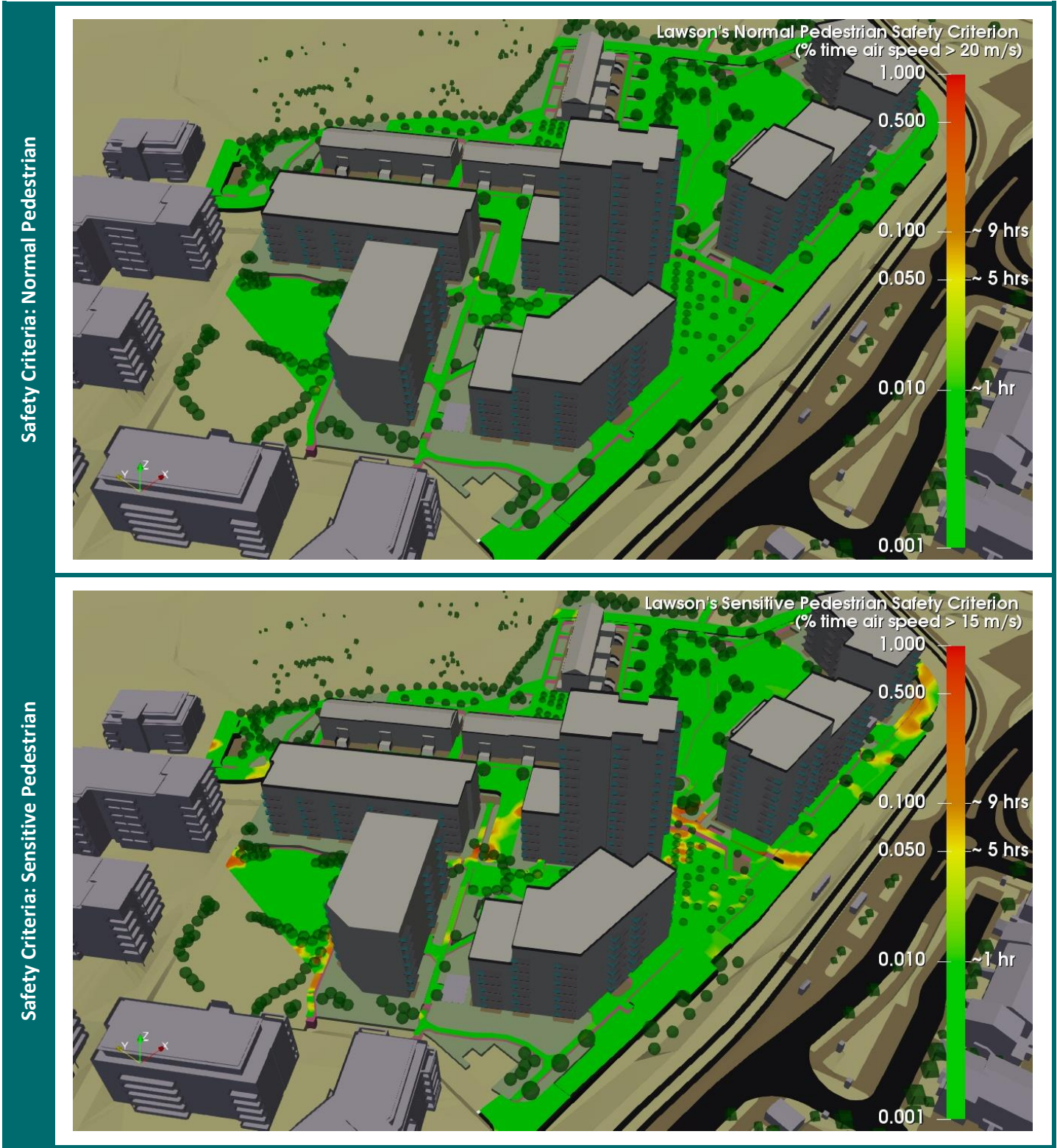


Figure 38: Safety Criteria: All Season: View from the southwest



Figure 39: Safety Criteria: All Season: View from the west

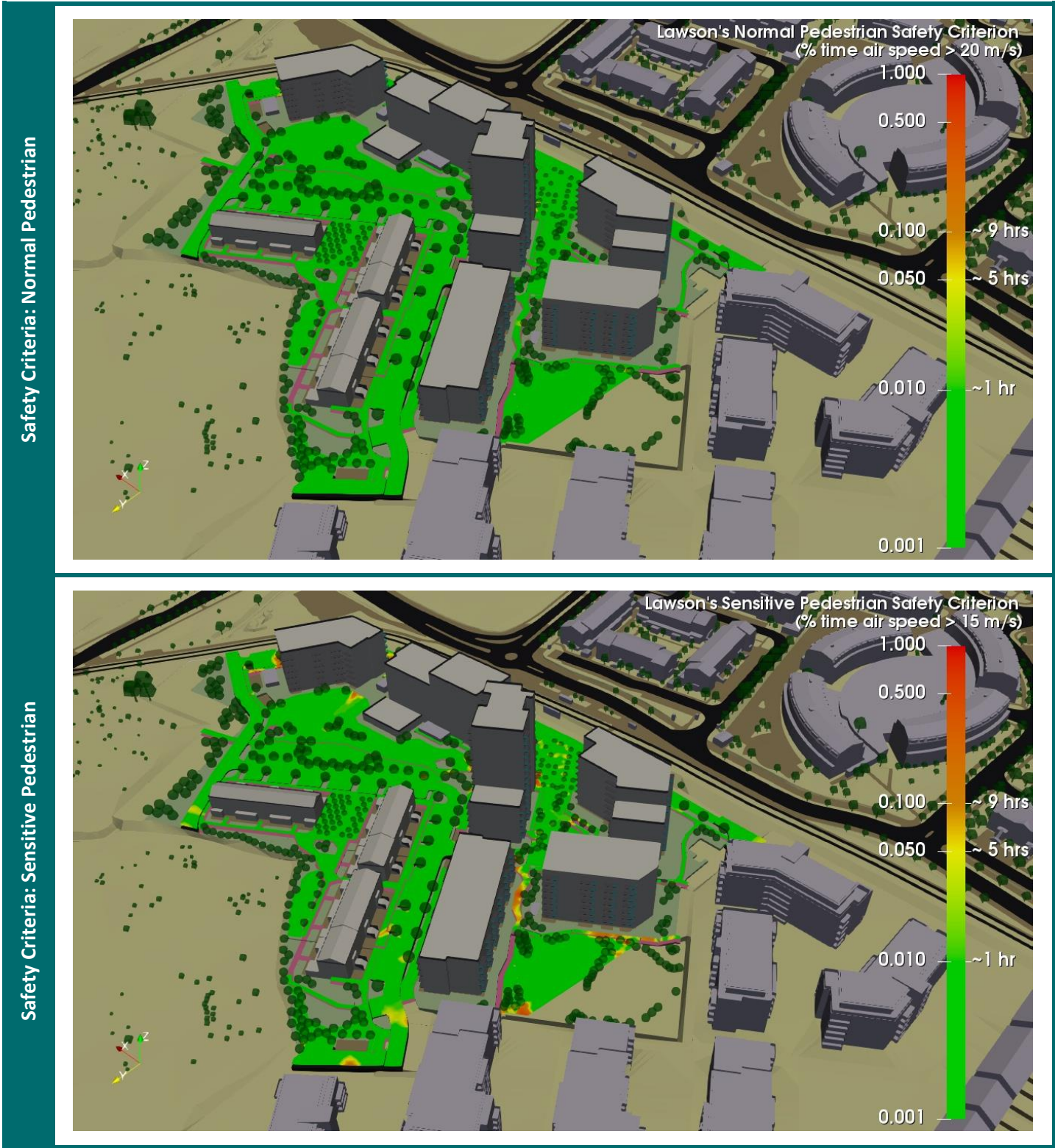


Figure 40: Safety Criteria: All Season: View from the northwest

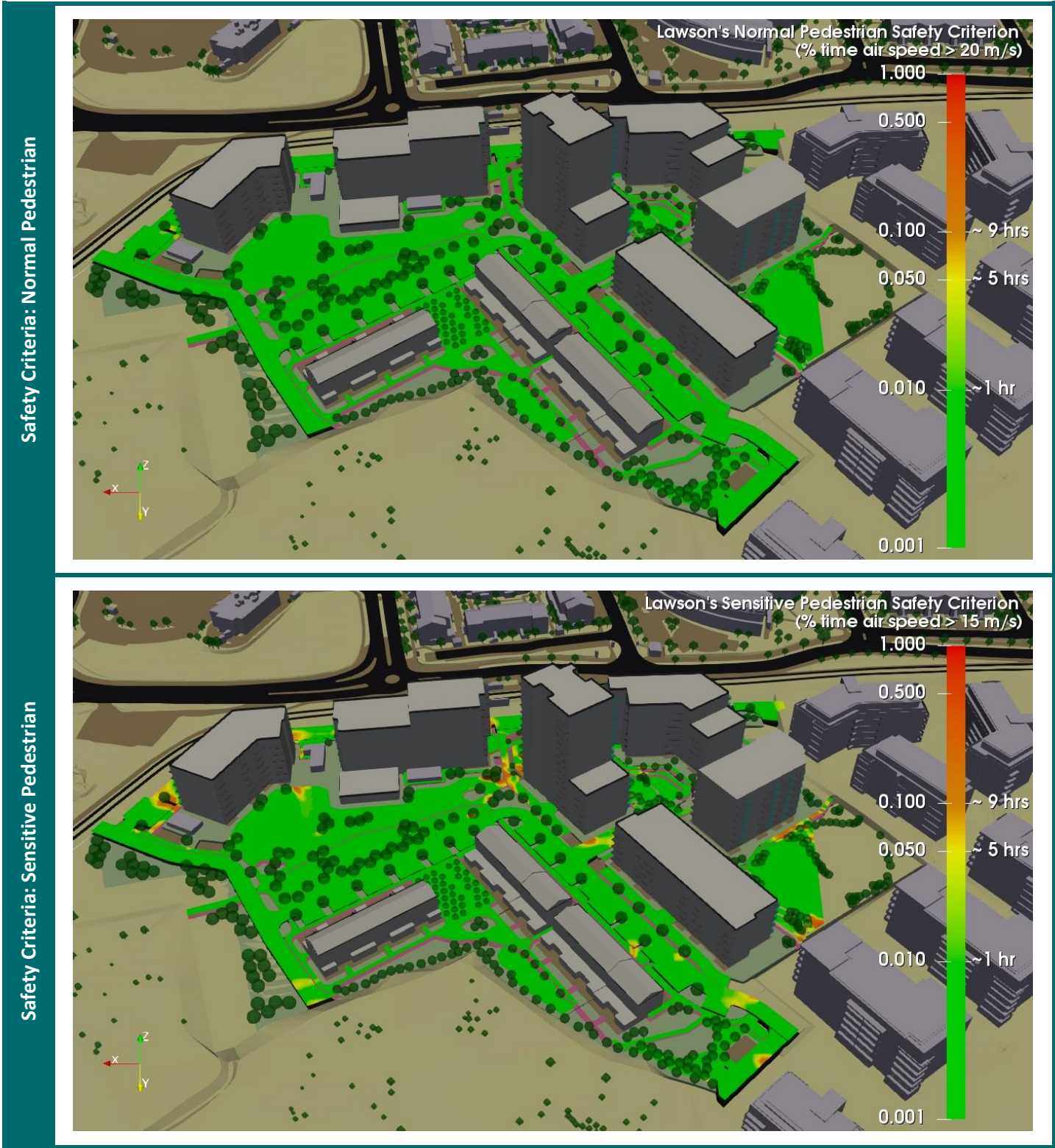


Figure 41: Safety Criteria: All Season: View from the north



Figure 42: Safety Criteria: All Season: View from the northeast

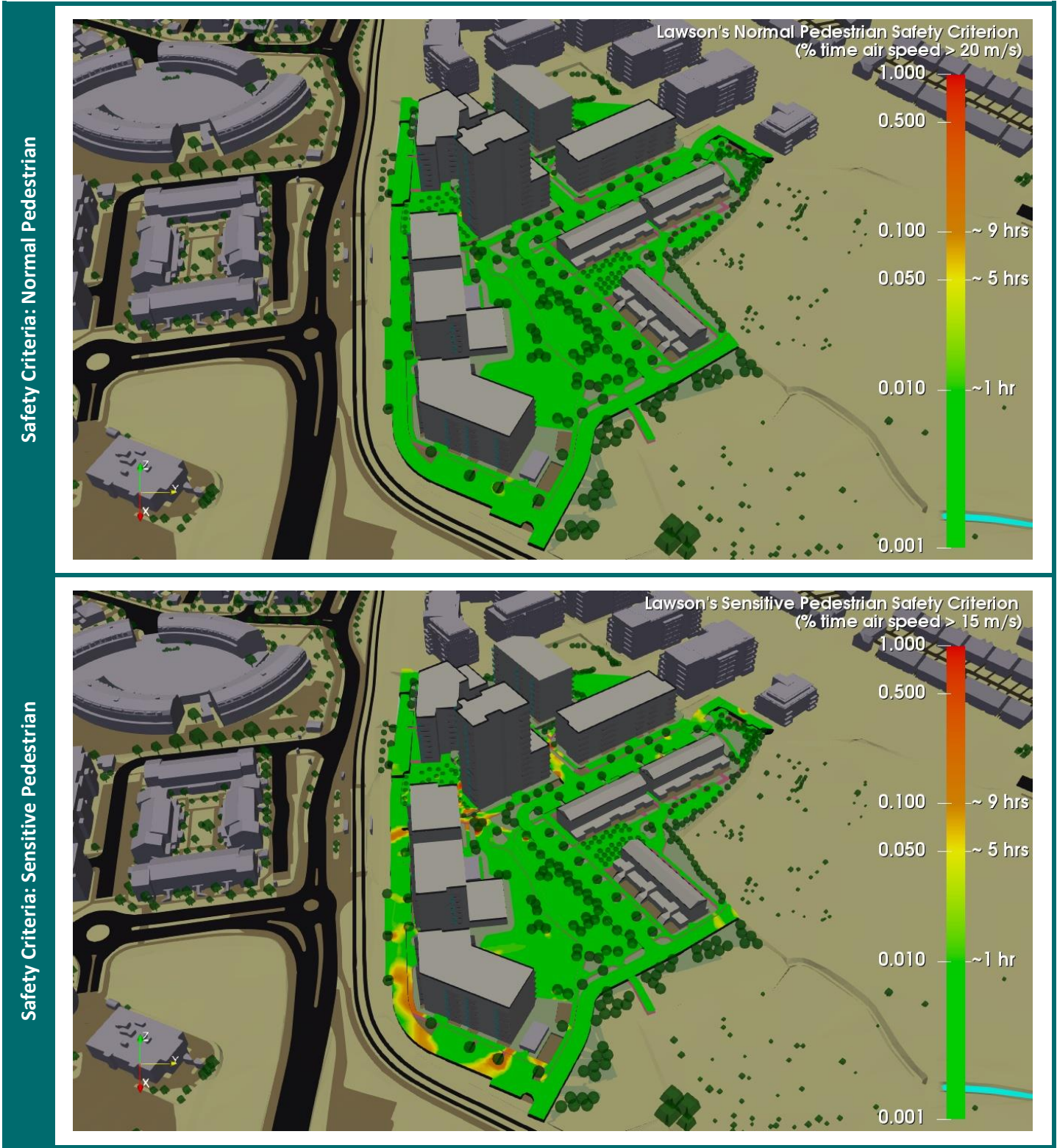


Figure 43: Safety Criteria: All Season: View from the east

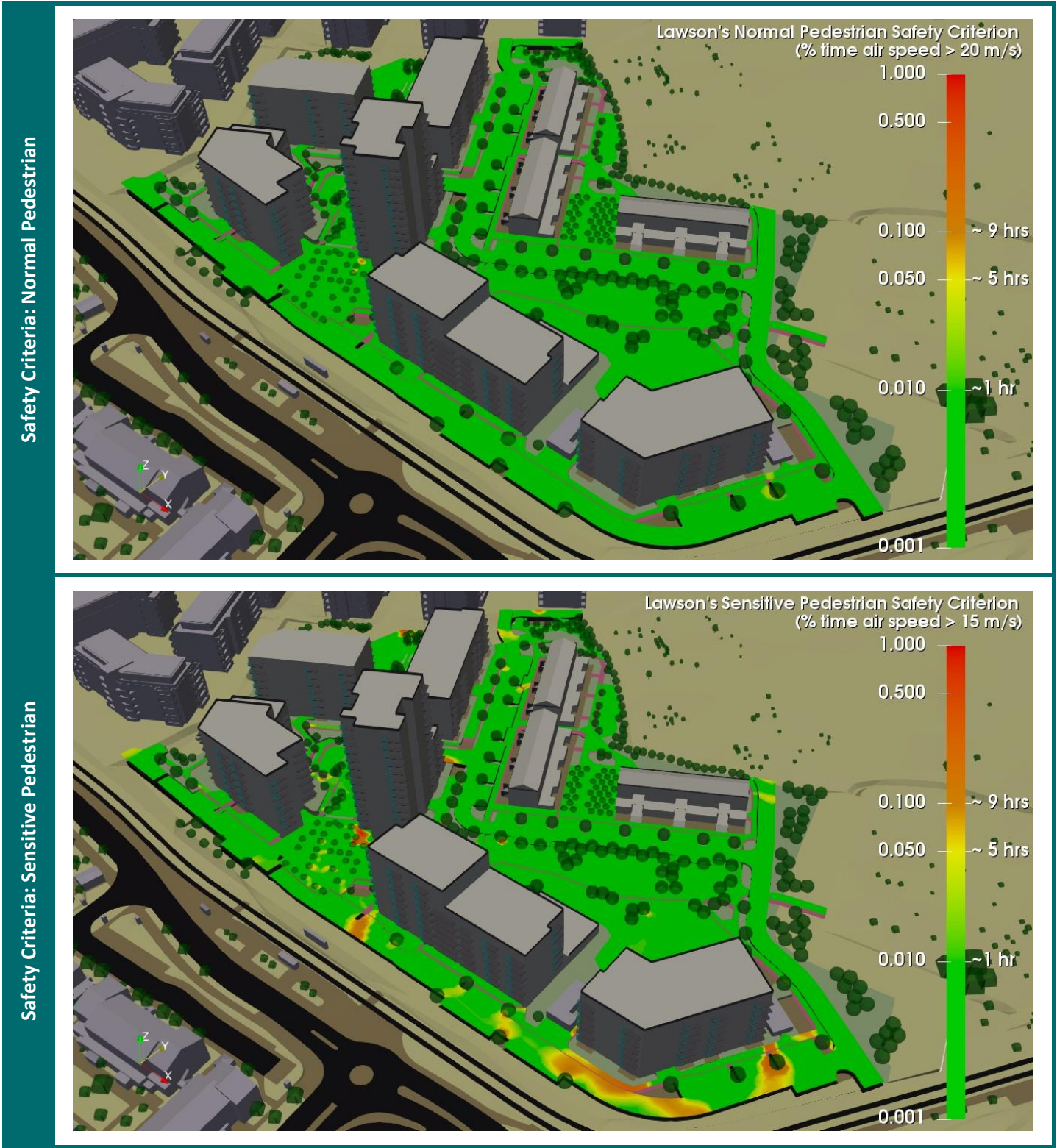


Figure 44: Safety Criteria: All Season: View from the southeast



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