

137 Cambridge Terrace – wind impact report

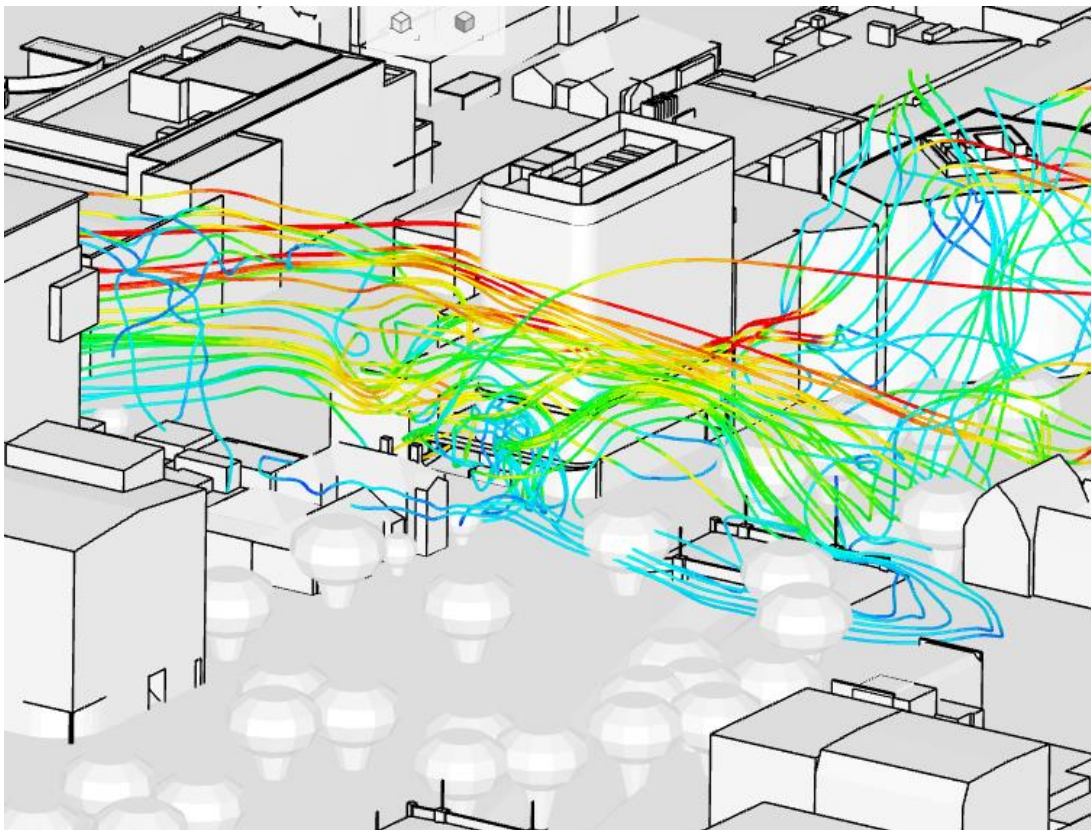
Meteorology Solutions

Using meteorology expertise to optimise engineering solutions

Mike Green, Engineering Meteorologist

2 May 2024

Rev 3



Contents

1. Introduction 3

2. Computation Fluid Dynamics (CFD) overview.....3

3. Background wind conditions 3

4. 3D models.....4

5. Modelling Methodology 4

6. Wind Standards 4

7. Results 6

 7.1. All Sector – Existing Build scenario with the Harley Chambers building 6

 7.2. All Sector – New Build scenario with proposed new building - Lawson LDDC 8

 7.3. Single wind direction sectors – New Build scenario with proposed new building 11

8. Conclusions and recommendations.....14

1. Introduction

Christchurch City Council has commissioned Meteorology Solutions to investigate potential wind impacts resulting from the proposed new development at 137 Cambridge Terrace, Christchurch. 137 Cambridge Terrace is in an area where there is pedestrian activity, including along the Avon River corridor, Cambridge Terrace, and Worcester Boulevard.

The scope of this work was to use Computational Fluid Dynamics (CFD) to compare pedestrian level wind conditions of existing (current) and the new build scenarios. The new build scenario includes consented buildings in the vicinity of 137 Cambridge Terrace.

2. Computation Fluid Dynamics (CFD) overview

This modelling utilises a new branch of the Computation Fluid Dynamics (CFD) model known as the Lattice Boltzmann Method (LBM) to evaluate wind speeds at 1.5 m above ground level. The LBM solver by SimScale is used for complex fluid systems including wind flow around buildings and structures, and through porous objects such as trees and hedges. This form of CFD has been adapted and evaluated by SimScale for wind tunnel type applications such as wind loading on buildings, pedestrian wind safety analysis, automotive aerodynamics, and other external flow applications. SimScale allows for pedestrian comfort and safety results to be given any recognised standards, some of which are used below.

3. Background wind conditions

Reliable background wind conditions are a key input for the statistical analysis used in the wind standard criteria. The wind rose of the hourly wind data used, which is from Christchurch Airport data for a 10-year period, is shown in Figure 1. While the airport is some distance from the Christchurch CDB, it is assessed to be representative of the background wind conditions for the city.

For context, Christchurch is a relatively windy city with a background mean wind speed of about 4 m/s (at 10 m above the ground). At the airport for example, the wind speed exceeds 4 m/s about 45% of the time, and exceeds 6 m/s about 21% of time, and exceeds 8 m/s about 11% of the time.

In general, the 'roughness' of a city, which is caused by buildings and trees/vegetation, results in a reduction of wind speeds. However, higher buildings can intercept and deflect stronger winds towards the ground. Also, channeling of wind along streets and across open areas (such as parks), can result in localised higher wind speeds.

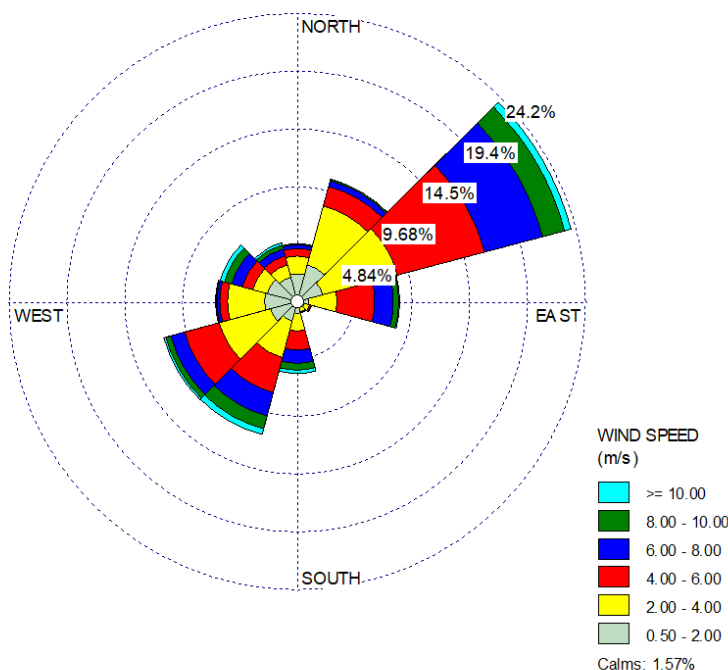


Figure 1: Wind rose for Christchurch Airport for a 10-year period (showing the direction the wind comes from)

4. 3D models

3D models have been built to extend at least two blocks from 137 Cambridge Terrace and include buildings, bridges, other structures, and larger trees. The first model is for the existing build scenario and includes the current building at 137 Cambridge Terrace. The second model has the proposed development at 137 Cambridge Terrace as well as other consented buildings in the vicinity.

5. Modelling Methodology

The CFD model was run for 12 wind direction sectors to capture how wind interacts with buildings and vegetation. These CFD modelling results are combined with background wind climate statistics to give spatial pedestrian wind comfort and wind safety levels based on wind standards, as described below. The results show:

- where wind conditions will change if the proposed building is constructed; and
- if the resultant conditions, when compared to accepted wind standards, exceed what is suitable for pedestrian activities in the vicinity of the development.

Looking deeper into the CFD modelling results can help assess what causes adverse wind effects and which allows for potential mitigation options to be evaluated.

6. Wind Standards

For this assessment, the Lawson LDDC standard was used to assess wind comfort levels, including using 5% exceedance levels and the maximum of both mean wind speed and Gust Equivalent Mean (GEM). Details of this standard are given in Table 1. Note that the descriptions of the Lawson LDDC standard have been adapted to fit a Christchurch context, but the criteria for each level remain the same. For safety considerations, the NEN 8100 Wind Danger Criteria was used (Table 2).

Wind standards are designed to give guidance around how wind conditions are suitable for intended pedestrian activities in urban settings. When wind assessment results show that comfort and/or safety levels exceed what is suitable for intended pedestrian activities, and it is indicator of potential adverse effects on pedestrians.

While there is no universal wind comfort/impact standard, a number of standards can be used to assess how a new building will affect the surrounding wind environment. Wind criteria in these standards use wind speed and frequency of wind speeds to categorise the wind environment, such as from sitting for extended periods (which would be suitable for outdoor cafes and restaurants) through to uncomfortable and/or dangerous levels. Common standards used are Lawson and related variations such as London LDDC, Lawson 2001, and Lawson LDDC.

For pedestrian wind comfort, a typical approach was to use mean wind speed for the comfort calculations. However, it has been accepted that short duration wind gusts give added discomfort to pedestrians, and the GEM formulation is a way to account for these sudden wind accelerations. Note that while the GEM is given as a mean wind speed, gust speeds can be estimated by multiplying the GEM by a (gust) factor, which is usually 1.85. For example, GEM of 13.5 m/s gives potential wind gusts speeds of about 25 m/s.

Wind standards are made up of the following components:

- Comfort and/or safety considerations,
- Wind speed thresholds,
- Percentage of wind speed occurrence,
- Use of mean wind speed or GEM, or the maximum of both.

The NEN8100 index is based on a Dutch wind nuisance standard adapted to advise on danger caused by wind. Using the danger criteria, wind speeds of 15+ m/s occurring less than 0.05% of the time at a particular location is regarded as being 'No Risk', and with speeds 15+ m/s occurring more than 0.3% of the time is regarded as 'Dangerous'¹.

¹ While it is not relevant for this report, for a hospital environment, where there is more likely to be vulnerable people in outdoor areas, a more conservative 'Limited Risk' criteria (15+ m/s wind speeds occurring between 0.05 and 0.3% of the time) could be used to assess wind risk.

Table 1: Lawson LDDC criteria for spatial wind impacts

	Category	Maximum of mean and GEM wind speed (5% exceedance)	Description
A	Outdoor dining	0 - 2 m/s	Acceptable for frequent outdoor sitting use such as outdoor restaurants and cafés.
B	Pedestrian Sitting	2 - 4 m/s	Acceptable for occasional outdoor seating, such as public outdoor spaces, balconies and terraces intended for occasional use.
C	Pedestrian Standing	4 - 6 m/s	Acceptable for entrances, bus stops, covered walkways, or passageways beneath buildings.
D	Pedestrian Walking	6 - 8 m/s	Acceptable for external pavements and open walkways.
E	Pedestrian Uncomfortable	8 - 10 m/s	Not comfortable for regular pedestrian access.
U	Uncomfortable and potentially dangerous	10 m/s	Not comfortable for regular pedestrian access, and potentially dangerous for some people.

Table 2: NEN 8100 standard adapted to show 'dangerous' locations.

	Wind speed (maximum of mean or GEM)	Frequency	Description
A	15 m/s	Less than 0.05%	No Risk
B	15 m/s	Less than 0.3%	Limited Risk
C	15 m/s	Greater than or equal to 0.3%	Dangerous

7. Results

The results from the CFD assessment in Sections 7.1 and 7.2 are for all sectors using the Lawson LDDC and NEN 8100 Wind Danger Criteria standards. These graphics combine all 12 sectors modelled in the CFD analysis with background wind statistics. Section 7.3 graphics provide information for individual wind directions/sectors. All results are 1.5 m above ground.

7.1. All Sector – Existing Build scenario with the Harley Chambers building - Lawson LDDC and NEN 8100

Figure 2 show the existing wind conditions within about one block of 137 Cambridge Terrace are at appropriate levels for pedestrians. Figure 3 shows that there are no wind safety issues for the existing environment which includes the Harley Chambers building on the subject site and consented buildings to be constructed (Current Build Scenario).

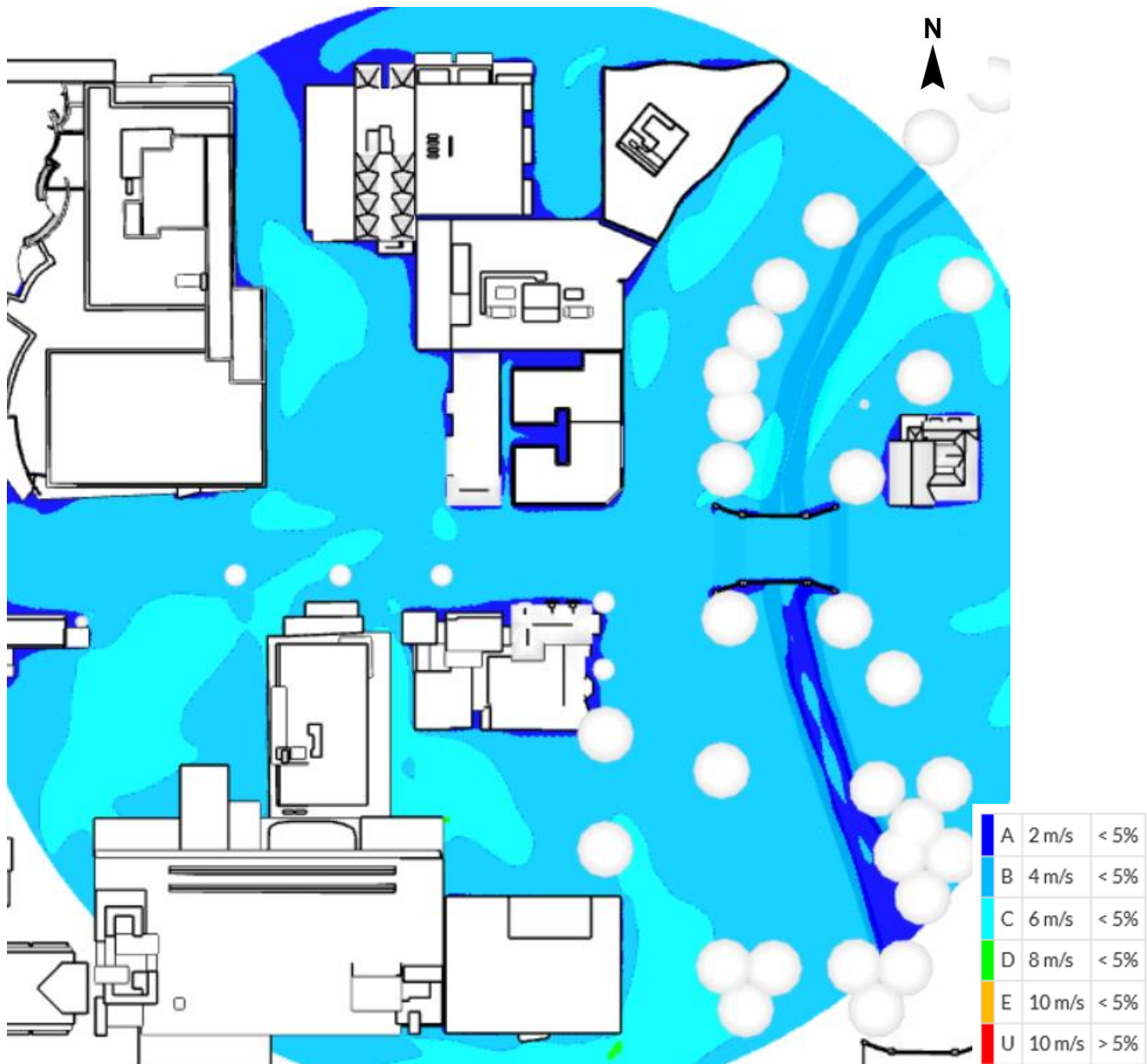


Figure 2: All sector pedestrian wind comfort for Existing Build scenario - Lawson LDDC

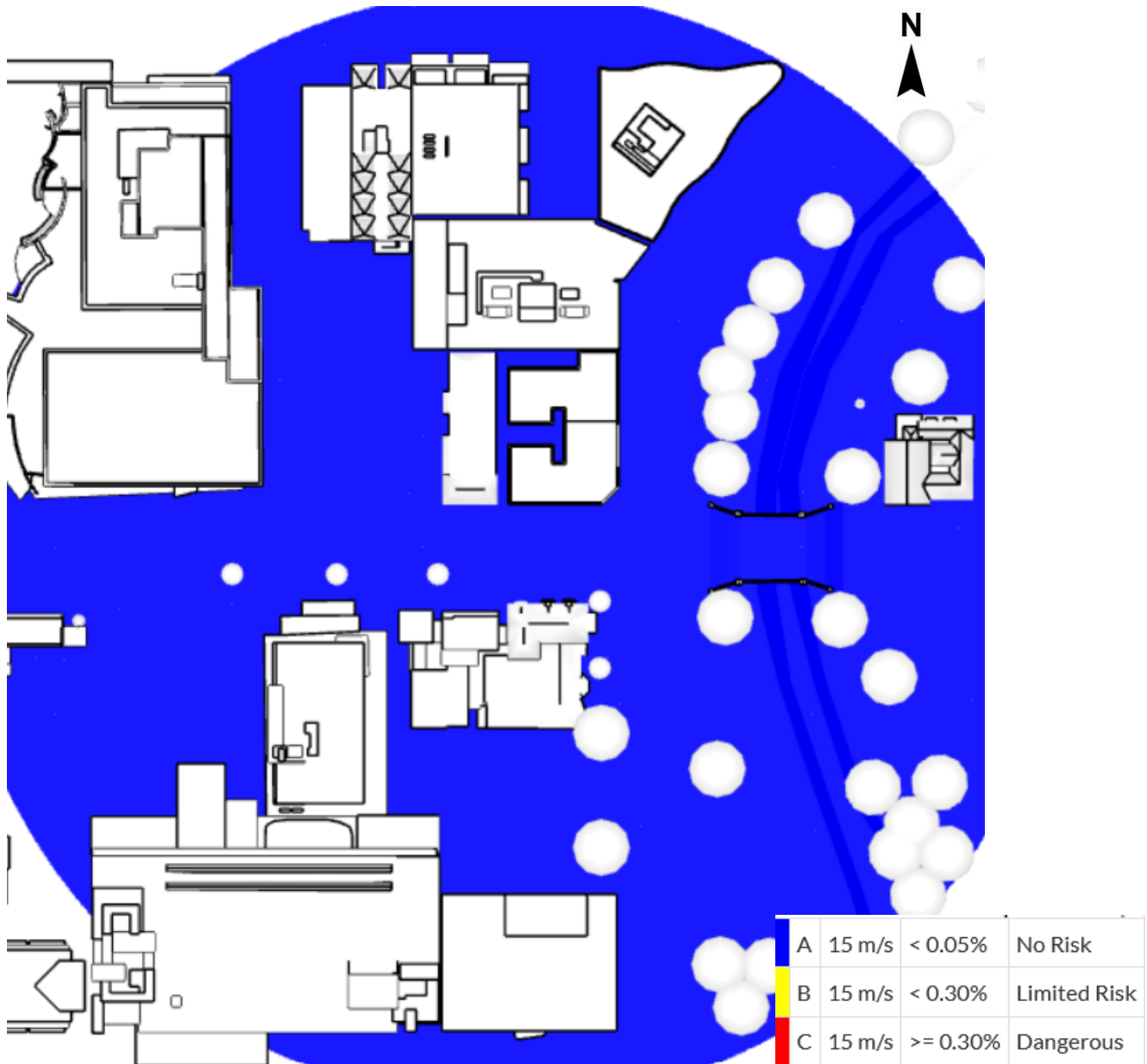


Figure 3: All sector pedestrian wind safety for current build scenario - NEN 8100

There were no wind safety risks associated with the current build scenario.

7.2. All Sector – New Build scenario with proposed new building - Lawson LDDC and NEN 8100

Figures 4 and 5 show the 'all sector' results for wind comfort and safety for the new build scenario (with Harley Chambers demolished). There is deterioration of wind comfort levels on Cambridge Terrace and Worcester Boulevard next to the proposed new building, especially around the north corner of Cambridge Terrace and Worcester Boulevard, and on the south side of Worcester Boulevard adjacent to the Canterbury Club building. Even though some locations have reduced to Level D comfort levels (Lawson LDDC criteria), wind conditions still are mostly appropriate for these locations (such as 'acceptable for external pavements and open walkways').

There is no significant deterioration of wind conditions further away from 137 Cambridge Terrace. Also, there are no unacceptable pedestrian safety adverse effects with new build scenario (Figure 6).



Figure 4: All sector pedestrian wind comfort with the proposed new building and Harley Chambers demolished - Lawson LDDC

However, there are two park benches adjacent to the Canterbury Club on Worchester Boulevard that turn their back rests to the proposed building as shown in Figure 5. The comfort levels for people using these benches will on occasions be at Level C, and close to Level D using the Lawson LDDC scale. This means that these benches will experience wind speeds of 6 m/s or higher for about 5% of the time.

While mitigation modelling has not been done, in our opinion the general building bulk and surface area will most likely force the wind down into the general park bench area regardless of the façade design. Mitigation options are the park benches be moved, or screening be placed on the east and north sides of the benches. Screening options could be vegetation, which would need to be up to 1.5 m high and extend down to close to the ground, or another sort of porous type screen.



Figure 5: Park benches on Worchester Boulevard near the corner of Cambridge Terrace.



Figure 6: All sector pedestrian wind safety for new build scenario - - NEN 8100

7.3. Single wind direction sectors – New Build scenario with proposed new building

This part of Section 7 provides information on why wind conditions have deteriorated in the vicinity of 137 Cambridge Terrace due to the new building. The figures show graphics for a stronger wind scenario from the east-northeast and southwest wind directions. These wind regimes mostly contribute to the reduction in wind comfort levels, especially the east-northeast winds. The diagrams are intended to provide information about relative wind speed, and not exact wind speeds since the results are for only one background wind speed scenario. Therefore, the wind speed scale in Figure 7 can be used as a guide in all figures in this section - with low speeds being dark blue and higher speeds being red. (Note that this wind scale is not related to the wind comfort scales in Sections 7.1 and 7.2.)

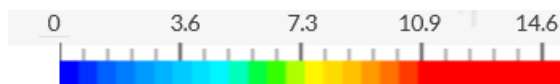


Figure 7: Wind speed scale used for single sector graphics below.

The deterioration of wind conditions with the new building is because the higher building intercepts stronger higher-level winds from the prevailing east-northeast winds and to a lesser extent for southwest winds. This is illustrated for east-northeast wind directions in Figures 8 and 9, and for southwest winds in Figures 10 and 11.

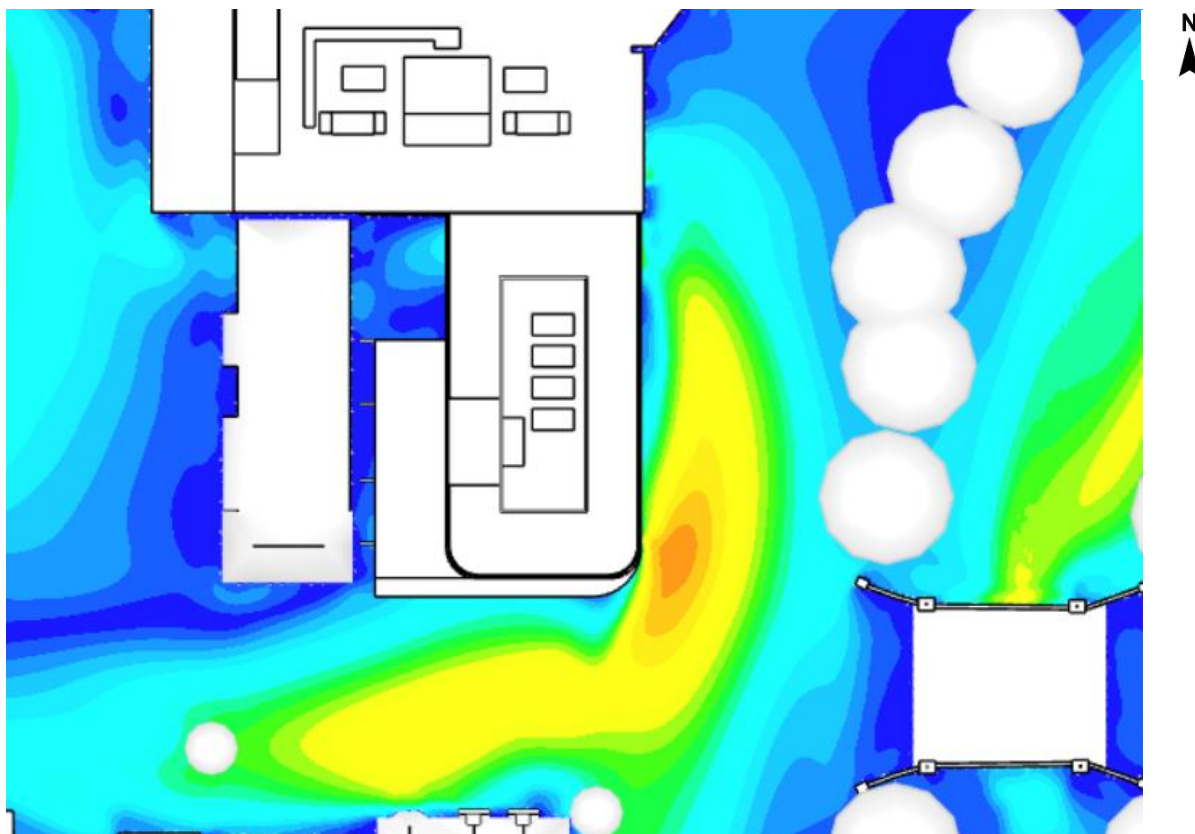


Figure 8: Showing wind speed enhancement in east-northeast winds because of the new building

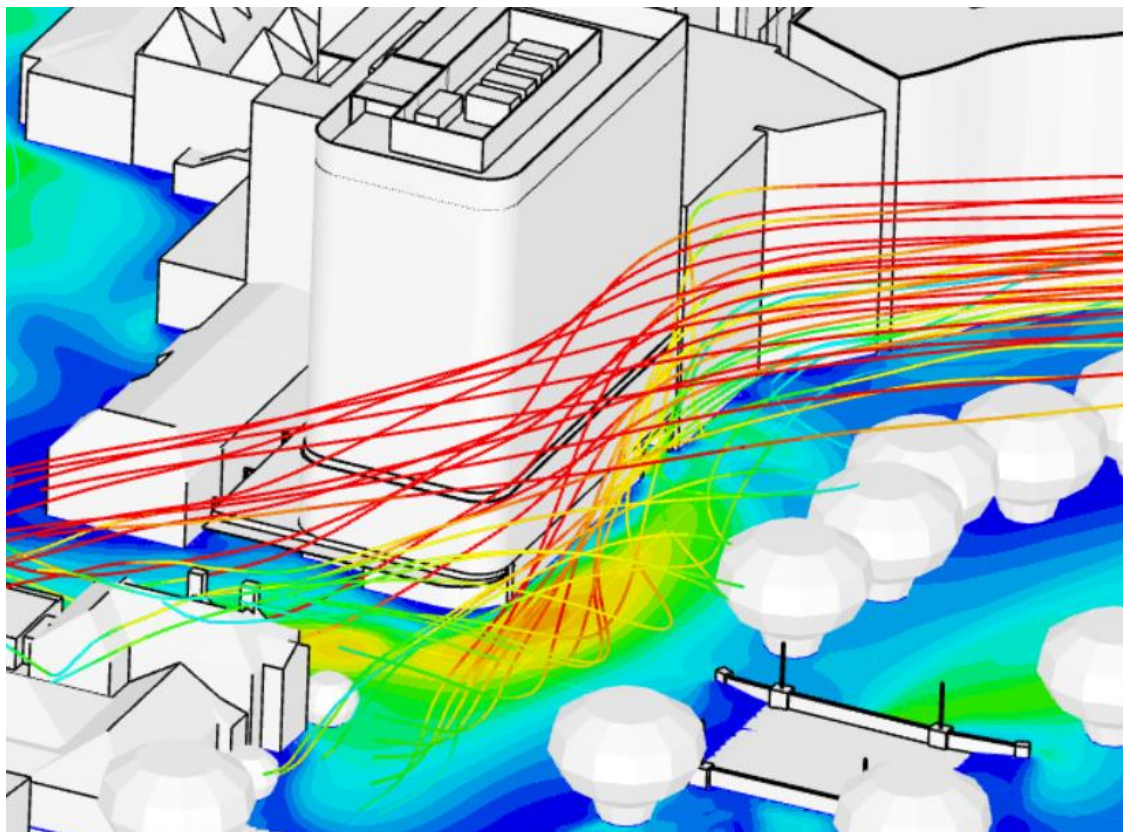


Figure 9: Showing streamlines of stronger east-northeast winds due to new building

Figures 8 and 9 show how stronger east-northeast wind deflect off the façade on the Cambridge Terrace side of the building and onto the ground on Cambridge Terrace and footpath area near the corner of Cambridge Terrace and Worchester Boulevard. Most of the reduction in pedestrian comfort levels comes from this effect.

A strong southwest wind scenario is shown in Figures 10 and 11. There is enhanced wind speeds in some places as a result of wind deflecting off the west façade and coming out of the accessways around the building (including onto Cambridge Terrace). Since this wind scenario occurs less than the east-northeast winds it has overall less influence on the overall wind comfort.

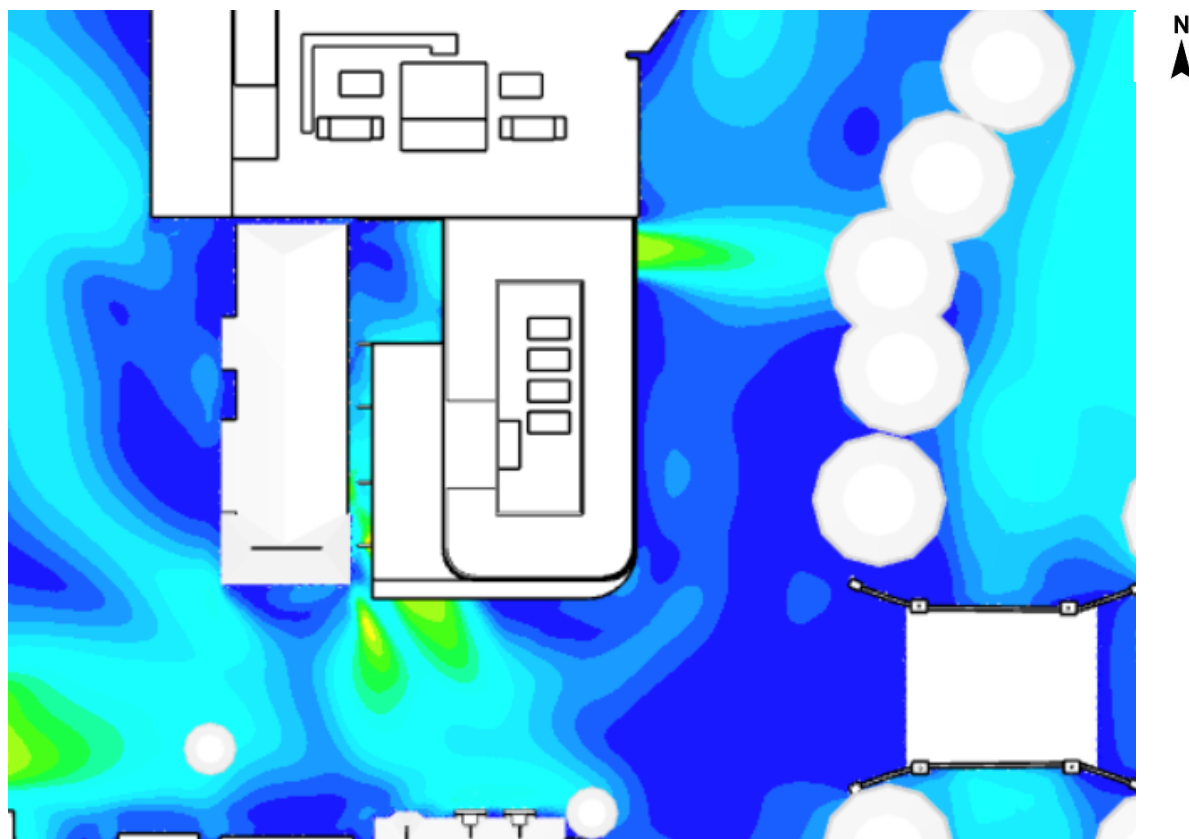


Figure 10: Showing areas of higher wind speed in background southwest winds because of the new build

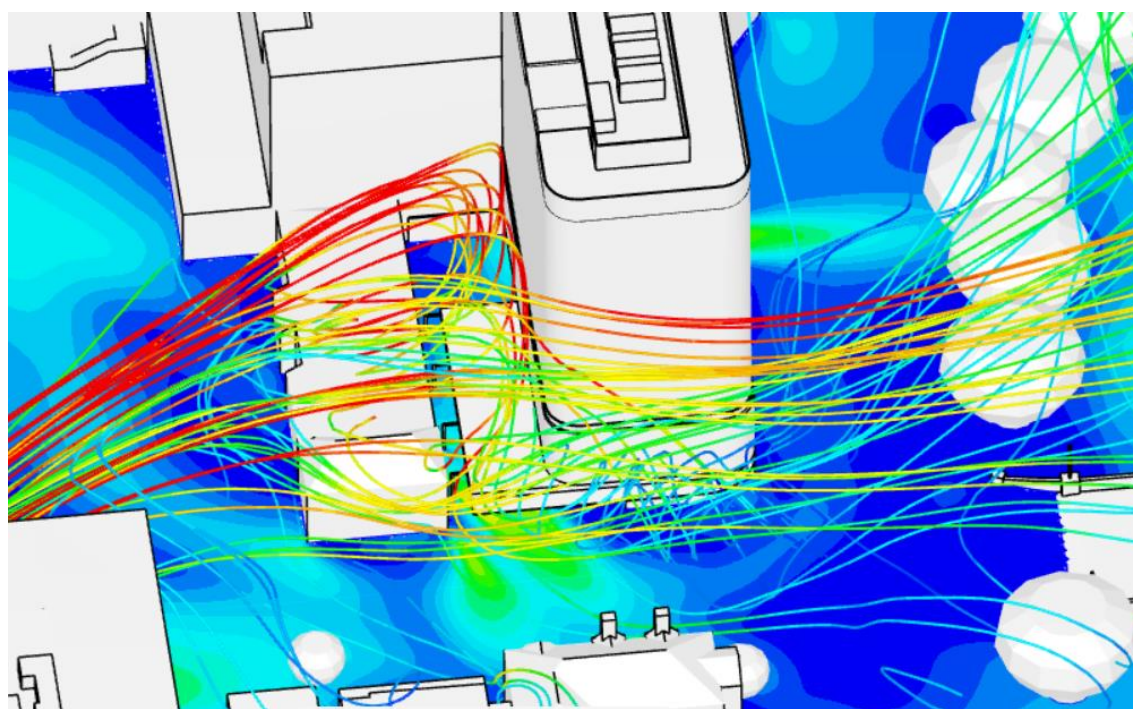


Figure 11: Showing streamlines of stronger southwest winds.

8. Conclusions and recommendations

Below are the main conclusions from the wind impact assessment.

- With the new building at 137 Cambridge Terrace there are increased wind effects on the east and south sides of the building on Cambridge Terrace and Worcester Boulevard. This is caused by the taller building and larger façade area intercepting stronger winds at higher levels and deflecting them towards ground level. Most of the deterioration in wind comfort is in the prevailing east-northeast winds, and in some places comfort levels have decreased from level B to level D based on the Lawson LDDC criteria.
- There is public seating on Worcester Boulevard where wind conditions have decreased from Level B to Level C which based on the Lawson LDDC would be uncomfortable for pedestrian seating with wind speeds 6 m/s or higher for about 5% of the time.
- It would be difficult to reduce wind effects at the park benches due to the new taller building deflecting winds into the park bench area. While mitigation modelling has not been done, in our opinion the general building bulk and surface area will most likely force the wind down into the general park bench area regardless of the façade design. Also, the addition of a canopy etc. would likely make no significant difference to wind comfort levels.
- In our opinion, the most practical mitigation options are that the park benches be moved or that screening be placed on the east and north sides of the benches. Screening options could be vegetation, which would need to be up to 1.5 m high and extend down to close to the ground, or another sort of porous type screen.
- The wind assessment has shown that there is no significant deterioration of wind conditions further away from 137 Cambridge Terrace, and there are no unacceptable pedestrian safety adverse effects with new building.
- The wind assessment has shown that there are no unacceptable pedestrian safety adverse effects with the new building 137 Cambridge Terrace.
- It is also worth noting that the wind assessment showed that there are no wind issues for both the Cambridge Terrace and Worcester Boulevard entrances.