TRINITY GRAMMAR SCHOOL SUMMER HILL CAMPUS - THE RENEWAL PROJECT

CFD Wind Assessment

Prepared for:

Trinity Grammar School
c/- Bloompark Consulting Pty Ltd
Suite 2.01, 41 Mclaren Street
NORTH SYDNEY NSW 2060

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Trinity Grammar School (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.18552-R03-v1.0	6 February 2020	Peter Hayman	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy

EXECUTIVE SUMMARY

SLR Consulting Pty Ltd (SLR) has been commissioned by Bloompark Consulting Pty Ltd to prepare a quantitative wind impact assessment for the proposed redevelopment of Trinity Grammar School with regard to the wind environment.

The Master Plan is classified as a State Significant Development on the basis that it falls within the requirements of Clause 13 of Schedule 1 of State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP), being a *"development that has a capital investment value of more than $100 million for the purpose of other tourist related facilities"*. This study has been prepared to accompany the SSD Development Application (DA) for the proposed Master Plan project.

Site Context

The development site is located within the inner west suburban areas of Sydney, bordered by Seaview Street to the north, Prospect Road to the east, Victoria Street to the west and Yeo Park to the south. Surrounding the site are low-rise residential areas and Yeo Park (bordering the school precinct to the south). The topography of the site and surrounds is gentle undulating terrain.

Project Site Wind Speed Characteristics

The wind climate model used for the site has been based primarily on Canterbury Racecourse Bureau of Meteorology wind data (BoM Station 66914), given the close proximity of this site to the school (just over 1.5 km to the southwest). Reference has also been made to the next nearest BoM Sites with relatively "clean" (ie unobstructed) terrain exposures: Sydney Kingsford Smith Airport (BoM 66037) and Bankstown Airport (BoM 66137), located 6.5 km to the southeast and 13 km to the west respectively.

Winds at the site fall into two primary seasons with short transition months in between:

- Summer winds (Nov-Feb) are from the northeast (NE) to east-northeast (ENE) and the southeast (SE) to south (S) - the former being generally milder sea breezes. The strongest winds during this period come from the SE-S quadrant;
- Winter-Spring winds (May-Sep) are from the west-southwest (WSW) to northwest (NW);
- In the transition months of March-April and October, winds exhibit a mix of both of the above seasonal trends with a roughly equal percentage of winds from the NE-ENE, SE-S and WSW-NW.

Existing Winds

Existing street level wind conditions in the vicinity of the site are likely to be close to the 16 m/s "walking comfort" criterion for some prevailing wind directions given the moderate shielding afforded to the site by the surrounding primarily low-rise environment, including the more open exposure of Yeo Park to the south, and alignment of surrounding streets with some stronger wind directions (S and W winds).

EXECUTIVE SUMMARY

Future Wind Environment

- It is understood that all street trees surrounding the school precinct are to be left undisturbed – this important wind mitigation feature should be maintained;
- The proposed Master Plan works for Trinity Grammar School are expected to have minimal impact on surrounding wind conditions: the proposed works are generally modest in nature, the "maximum" in terms of bulk envelope being the proposed 4-storey "General Learning" building and the majority of the new bulk envelope buildings are located centrally within the school precinct;
- With the proposed building design and already planned and proposed landscaping, locations surrounding the site will lie mostly within the "comfortable" walking criterion (refer **Section 6**).

SLR recommends the following:

- Additional landscaping at the northeast corner of No.2 Oval (refer **Figure 20**);
- Additional landscaping between buildings (refer **Figure 21**);
- Implement operable louvres or dense landscaping to the western elevation of the seating areas under the awning (refer **Figure 22**). The louvres can therefore be closed during high wind conditions; and
- 1.8 m parapet (balustrade or balustrade + Planters) along the roof terraces (refer **Figure 23**).

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1 INTRODUCTION

SLR Consulting Pty Ltd (SLR) has been commissioned by Bloompark Consulting Pty Ltd to assess the ground level wind environment within and around the proposed Master Plan for Trinity Grammar School, Summer Hill.

The assessment is in the form of a Computational Fluid Dynamics (CFD) study as recommended in SLR Qualitative Wind Report 610.18552-R01-v0.3 dated 4 November 2019. SLR uses the advanced 3D CFD-based (Computational Fluid Dynamics) Numerical Simulation software FLUENT for its CFD modelling.

The Master Plan is classified as a State Significant Development on the basis that it falls within the requirements of Clause 13 of Schedule 1 of State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP), being a *"development that has a capital investment value of more than $100 million for the purpose of other tourist related facilities"*. This study has been prepared to accompany the SSD Development Application (DA) for the proposed Master Plan.

2 DESCRIPTION OF THE PROPOSED MASTER PLAN DEVELOPMENT

2.1 Development Site Location

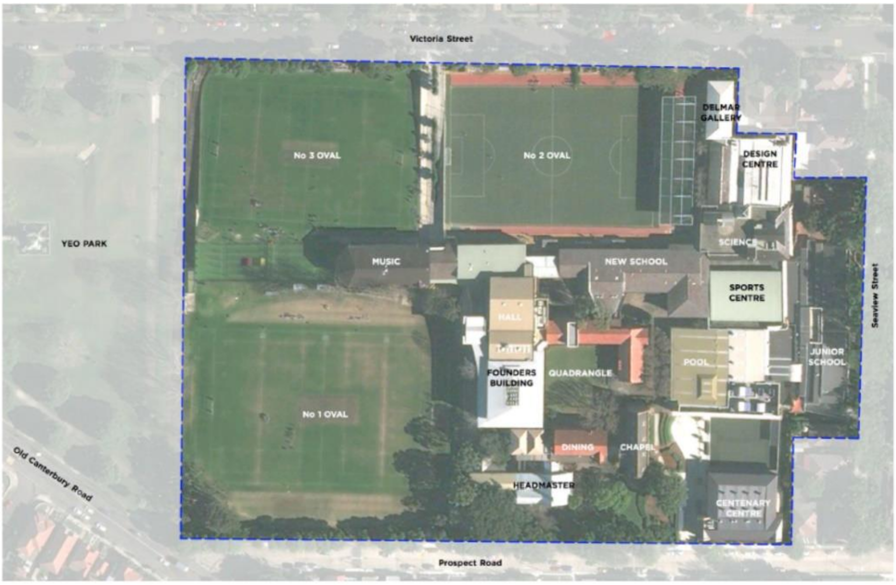
Trinity Grammar School - refer **Figure 1** - is located within the inner west suburban areas of Sydney, bordered by Seaview Street to the north, Prospect Road to the east, Victoria Street to the west and Yeo Park to the south. Surrounding the site are low-rise residential areas and Yeo Park (bordering the school precinct to the south). The topography of the site and surrounds is gentle undulating terrain.

Figure 1 Trinity Grammar School Master Plan Development Site Location

2.2 Proposed Development Description

The existing school plan is shown in **Figure 2**.

Figure 2 Existing School Built Environment



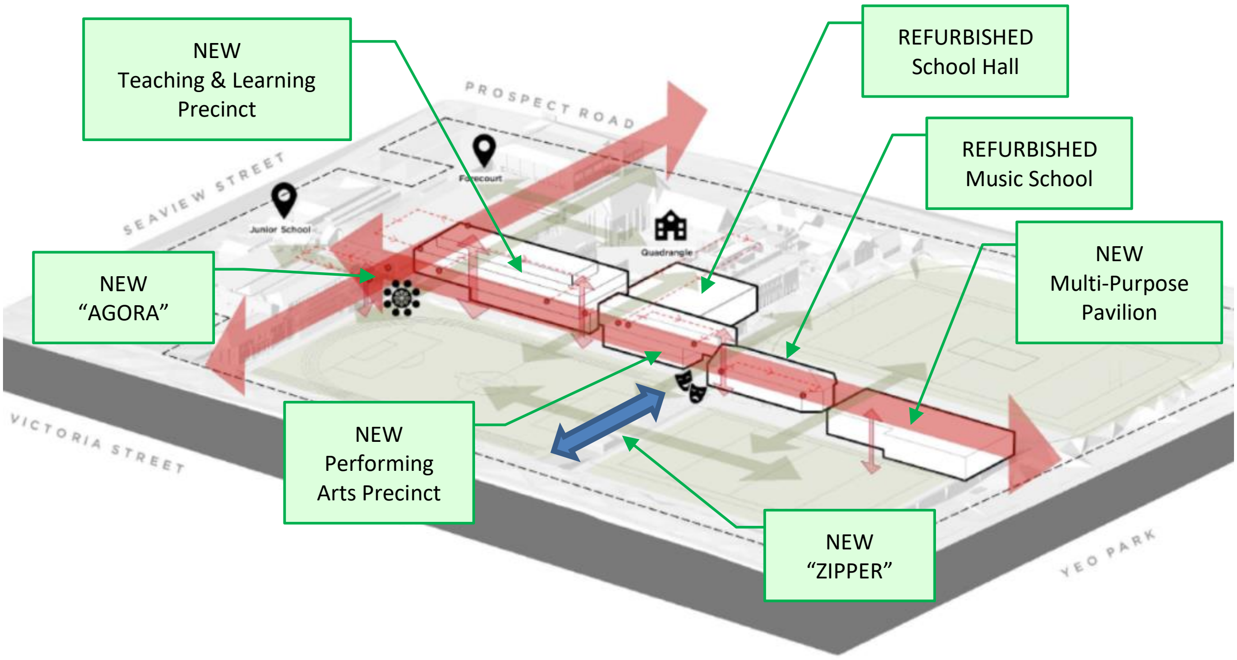
The proposed development seeks detailed built form approval of new teaching and educational facilities, as detailed below:

- ▪ New five (5) storey building at the heart of the Campus to accommodate modern, flexible teaching and learning spaces;
- ▪ Improve movement and flow for students, with better east-west and north-south links across the school grounds and between levels, including more accessible connections between the Junior School, ovals and car park, and providing strong visual and physical connections;
- Renewal and Refurbishment of existing teaching and learning facilities;
- Reconfiguration and connection of underground car park improve traffic flow for the school drop-off and pick-up zone and improve the safety of boys and visitors who enter the school grounds as pedestrians from Victoria Street;
- New multipurpose pavilion between Ovals 1 and 3 containing a multipurpose space and basketball court;
- Demolition of school-owned residences at 46, 48, 50 and 52 Seaview Street, improving the existing service, maintenance and delivery facilities;
- Improvement and extension to Junior School outdoor teaching area and outdoor assembly area.

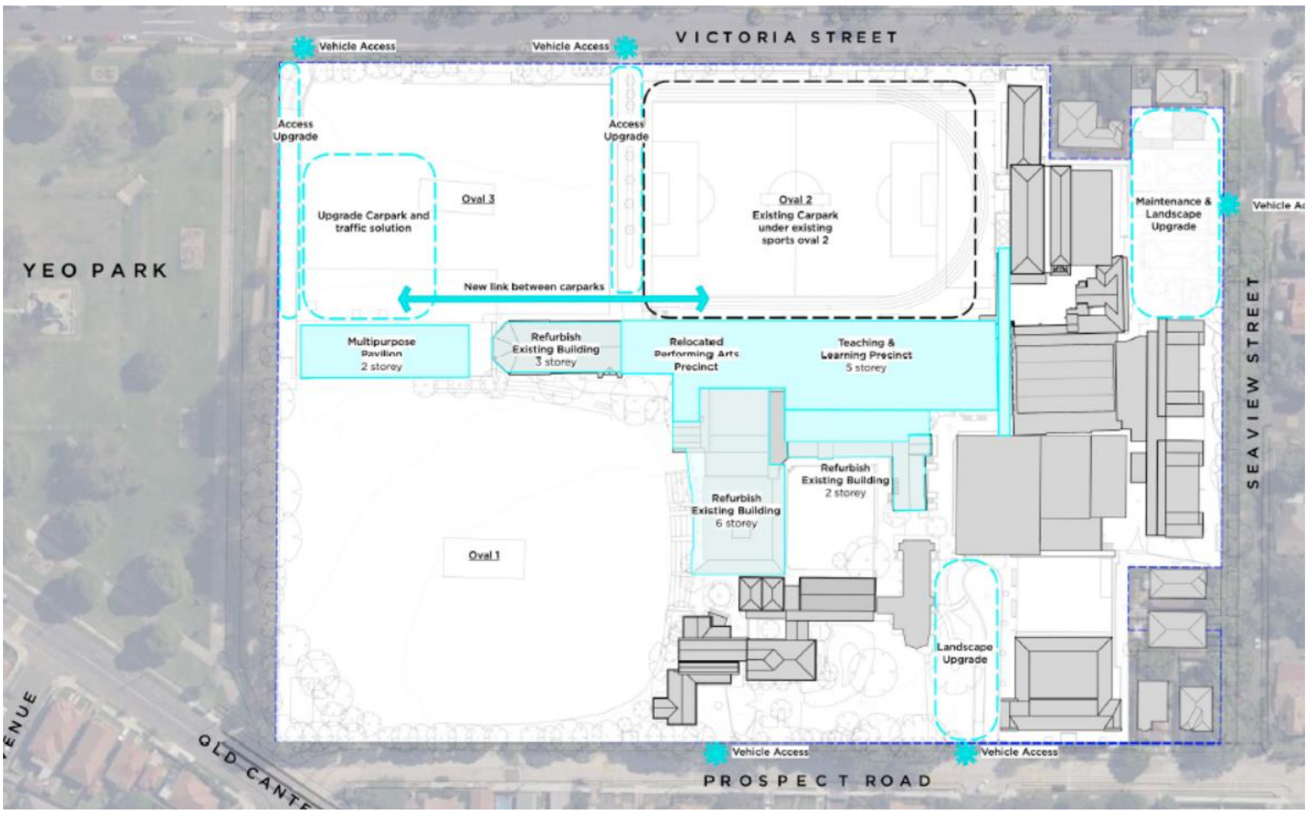
Overall, the proposed built form approval seeks to provide a framework for the future physical development of the Campus to ensure the best teaching and learning outcomes, and ongoing evolution of the School.

Figure 3 Representative Architectural View of the Proposed Master Plan Development

Perspective View from Southwest



Plan View Showing Key elements of the Renewal Project



3 PROJECT SITE WIND SPEED CHARACTERISTICS

The data of interest in this study are the mean hourly wind speeds and largest gusts experienced throughout the year (especially higher, less frequent winds), how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney Region wind seasons.

3.1 Sydney Region Winds and Seasonal Variations

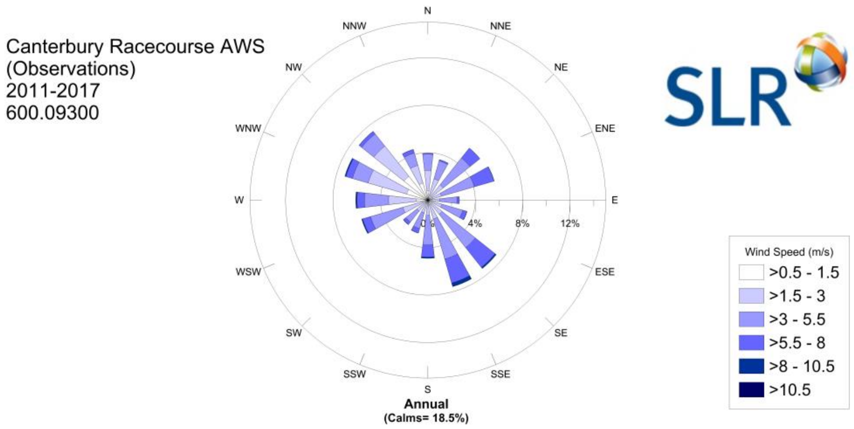
SLR has carried out a detailed study of Sydney Basin wind speeds using continuous records of wind speed and direction measured at the Bureau of Meteorology's (BoM) Sydney weather stations.

- SLR Technical Note: *"9300-TN-CW&E-v2.0 Sydney Region Design Winds"*, March 2018.

The wind climate model used for the site has been based primarily on Canterbury Racecourse Bureau of Meteorology wind data (BoM Station 66914), given the close proximity of this site to the school (just over 1.5 km to the southwest). Reference has also been made to the next nearest BoM Sites with relatively "clean" (ie unobstructed) terrain exposures: Sydney Kingsford Smith Airport (BoM 66037) and Bankstown Airport (BoM 66137), located 6.5 km to the southeast and 13 km to the west respectively.

Key wind characteristics are shown in **Figure 4** – annual wind rose, and **Figure 5** – seasonal wind roses.

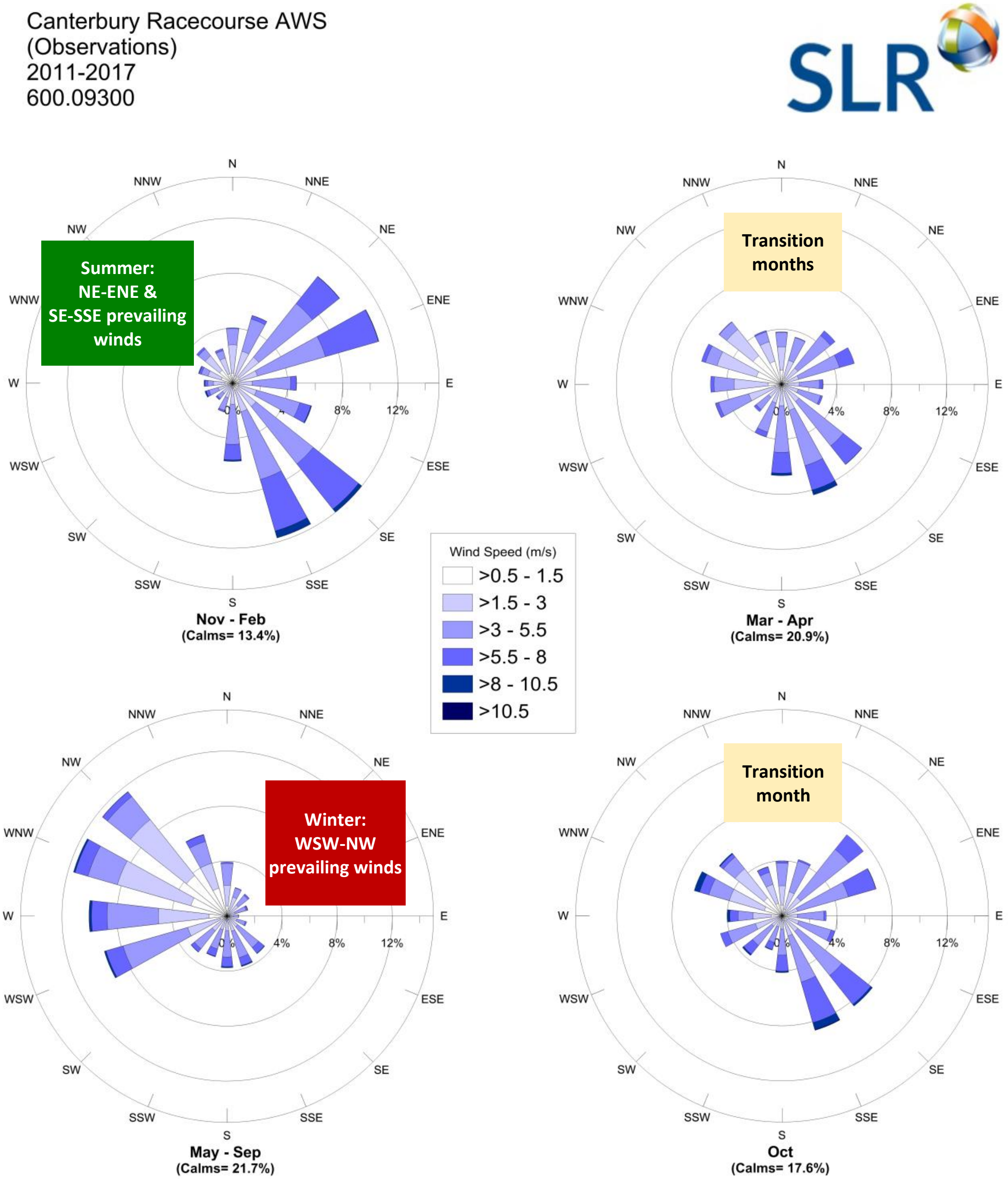
Figure 4 Annual Wind Roses for Canterbury Racecourse (BoM Station 66194)



The seasonal wind roses shown in **Figure 5** show that winds at the site fall into two primary seasons with short transition months in between:

- Summer winds (Nov-Feb) are from the northeast (NE) to east-northeast (ENE) and the southeast (SE) to south (S) - the former being generally milder sea breezes. The strongest winds during this period come from the SE-S quadrant;
- Winter-Spring winds (May-Sep) are from the west-southwest (WSW) to northwest (NW);
- In the transition months of March-April and October, winds exhibit a mix of both of the above seasonal trends with a roughly equal percentage of winds from the NE-ENE, SE-S and WSW-NW;
- The magnitude of the strongest winds – both mean winds and gusts - throughout the year (from the SE-S in summer and WSW-NW in winter-spring) is roughly equal.

Figure 5 Seasonal Wind Roses for Canterbury Racecourse (BoM Station 66194)



3.2 The “Local”’ Wind Environment

Close to the ground at any particular site, the “regional” wind speeds described in **Section 3.1** will be affected by the local terrain, topography and built environment, all of which influence the “local” wind environment.

For the Project Site, the approaching terrain and built environment characteristics vary only modestly, given the surrounding low-rise residential areas in almost all directions, except for the south, where winds can approach the school precinct over Yeo Park.

The overall general windflow patterns expected at the site are illustrated in **Figure 6.**

Figure 6 Exposure of the Site to Prevailing Winds

4 WIND ACCEPTABILITY CRITERIA

The choice of suitable criteria for evaluating the acceptability of ground level conditions has been the subject of international research over several decades. The acceptability criteria that have been developed from this research and currently referenced by most Australian Local Government Development Control Plans have been summarised below in **Table 1**.

Table 1 Melbourne-Derived Wind Acceptability Criteria

Type of Criteria	Gust Wind Speed Occurring Once Per Year	Activity Concerned
Safety	24 m/s	Knockdown in Isolated Areas
	23 m/s	Knockdown in Public Access Areas
Comfort	16 m/s	Comfortable Walking
	13 m/s	Standing, Waiting, Window Shopping
	10 m/s	Dining in Outdoor Restaurant

The primary objectives relating to the above wind impact criteria are as follows:

- The general objective is for annual 3-second gust wind speeds to remain at or below the 16 m/sec "walking comfort" criterion. Whilst this magnitude may appear somewhat arbitrary, its value represents a level of wind intensity above which the majority of the population would deem unacceptable for comfortable walking on a regular basis at any particular location;
- In many urban locations, either because of exposure to open coastal conditions or because of street "channelling" effects, etc, the 16 m/sec criterion may already be currently exceeded. In such instances a new development should ideally not exacerbate existing adverse wind conditions and, wherever feasible and reasonable, ameliorate such conditions;
- The recommended limiting wind speeds for spaces designed for activities such as seating, outdoor dining, etc, are lower (ie more stringent) than for "walking comfort".

The **Table 1** criteria should not be viewed as *"hard"* numbers as the limiting values were generally derived from subjective assessments of wind acceptability. Such assessments have been found to vary with the height, strength, age, etc, of the pedestrian concerned.

A further factor for consideration is the extent of windy conditions, and some relaxation of the above criteria may be acceptable for small areas under investigation which are used infrequently.

Finally, it is noted that the limiting wind speed criteria in **Table 1** are based on the maximum wind gust occurring (on average) once per year. Winds occurring more frequently, eg monthly winds, weekly winds, etc, would be of lesser magnitude. Accordingly, a location with a maximum annual gust of 10 m/sec would experience winds throughout the year of a much lower and hence generally mild nature, conducive to stationary activities (seating, dining, etc).

4.1 Application of the Standard Wind Criteria for the Current CFD Wind Modelling

Maximum wind gusts will differ from the corresponding mean wind speed modelled in the current CFD investigation (see Results Section of this report). For a normally distributed process it is reasonable to assume that the 2-3 second maximum gust may be up to 3.5 standard deviations above the mean. It is therefore conservative to assume that the mean wind speed would be approximately half the magnitude of gust wind speeds given the level of wind turbulence expected at the proposed site, particularly in high wind zones, eg near building corners, in area of wind channelling, etc.

The equivalent mean wind speed acceptability criteria for the CFD study are summarised in **Table 2**.

Table 2 Equivalent Pedestrian Level Mean Wind Acceptability Criteria

Type of Criteria	Limiting MEAN Wind Speed Occurring Once Per Year	Activity Concerned	Impacts
Safety	12 m/s	Knockdown in Isolated Areas	Generally impedes progress; great difficulty with balance; potential for people to be blown over by wind gusts
	11.5 m/s	Knockdown in Public Access Areas	
Comfort	8 m/s	Comfortable Walking	Inconvenience felt when walking, umbrellas used with difficulty, wind noise on ears unpleasant
	6.5 m/s	Standing, Waiting, Window Shopping	Force of wind felt on body, hair disarranged.
	5 m/s	Dining in Outdoor Restaurant	Raises dust, and loose paper, clothing flaps

5 CFD MODELLING, ASSUMPTION AND ANALYSIS

SLR has modelled the proposed development and the surrounds using specialised CAD and SpaceClaim software packages. This was then imported into ANSYS to prepare the model for solving.

Sydney's highest wind speeds come from the northeast, southeast, south and west (southwest to northwest). Of these, southerly and westerly winds have been identified as most critical to this project.

Ambient wind profiles have been created to simulate the annual maximum mean wind speeds from these directions utilising the Australian Wind Code (AS1170.2). This will be used to check the areas of interest for potential adverse wind areas.

5.1 Areas of Interest

5.1.1 The Agora

The "Agora" is a key "civic" space within the Master Plan that forms a critical social hub and provides a focus for movements within the school and its new buildings – it is shown in **Figure 7**. The ground level area beneath the proposed "General Learning" building is left open at its northern end to facilitate east-west student movements, thereby creating a "through-passage" open to the east and west. It is exposed to strong southwest winds.

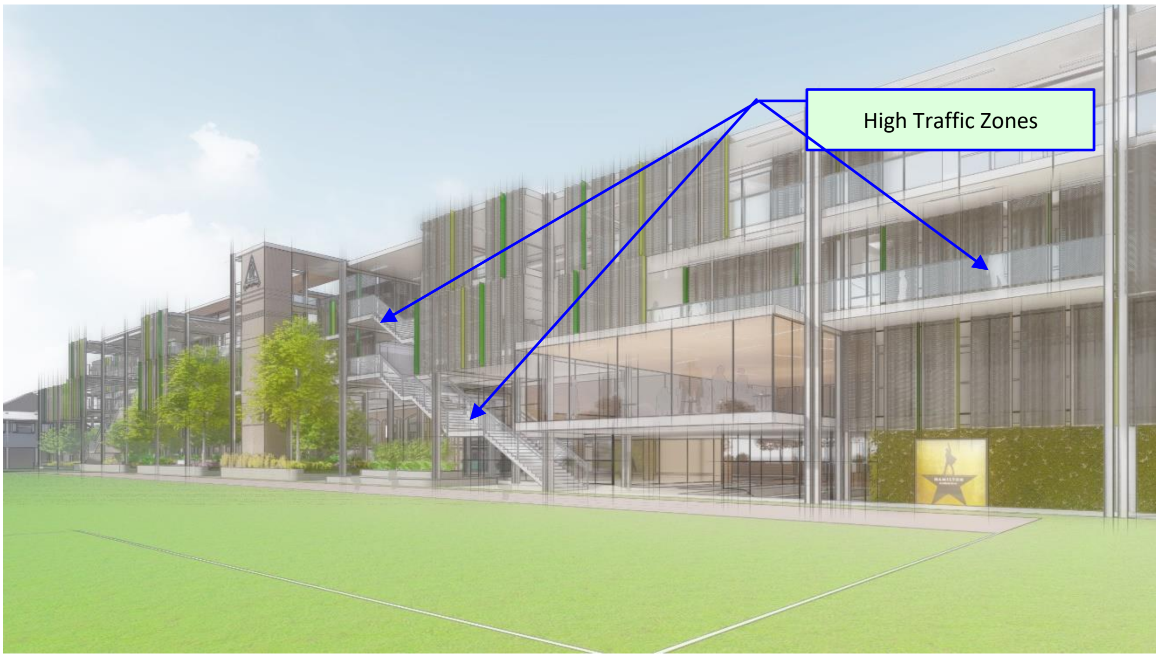
Figure 7 Proposed "Agora"

5.1.2 Western Façade of New Central Spine Buildings

The western façade of the combined new buildings within the Master Plan comprises a series of important traffic links for students, teachers, school visitors, etc, between all of the new buildings and the existing school to the north as well as the Junior School – refer **Figure 8**.

The intended usage of this space is expected to be high. Such usage would generally require a reasonable degree of wind sheltering, especially during the long winter period school terms.

Figure 8 New Western Façade "Traffic Zone" (View from No.2 Oval)



5.1.3 The New Terrace

A central new area serving a multitude of usages (transport link, meeting, sports viewing, etc) is the large "Terrace" area surrounding the refurbished Music School and connection to the new southern Pavilion - refer **Figure 9**.

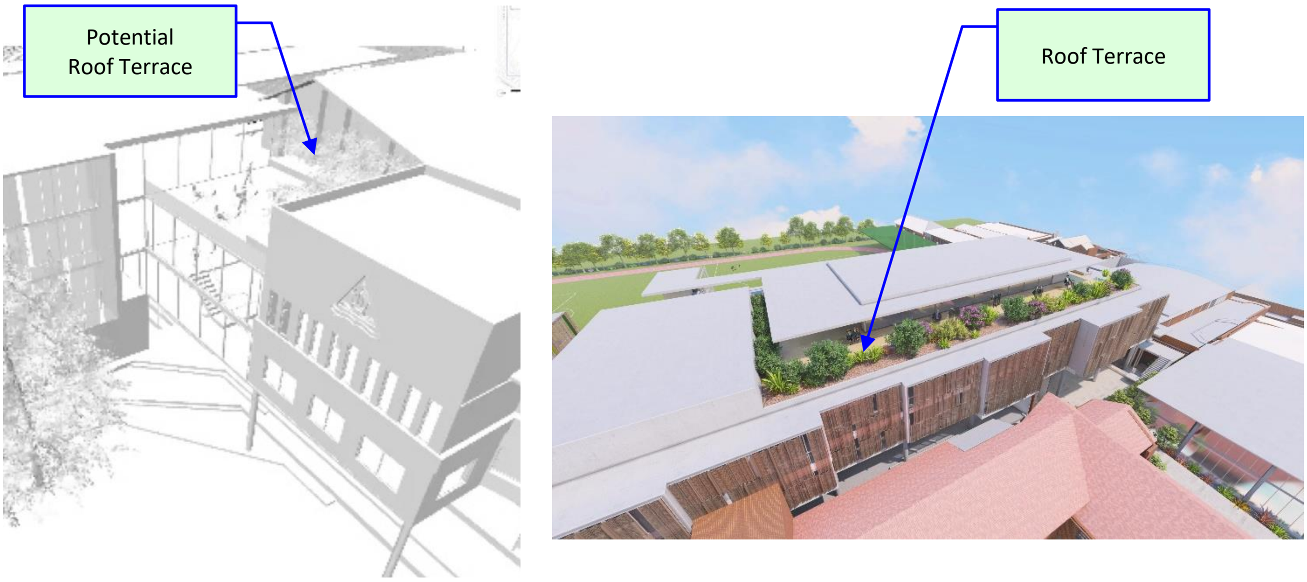
The intended usage of this space is expected to be high. Such usage would generally require a reasonable degree of wind sheltering, especially during the long winter period school terms.

Figure 9 New "Terrace" Providing a Bridge between No.1 Oval and No.3 Oval

5.1.4 Roof Terraces

There is potential for the development of new "Roof Terraces" over both proposed and existing buildings - refer **Figure 10**. The intended usage of these spaces is currently not confirmed - possible usages include an outdoor space for social gatherings, outdoor recreational space for students, etc. Such usages may require a high degree of wind sheltering if the wind criteria to be applied are for standing, sitting, outdoor eating, etc.

Figure 10 "Potential" Proposed "Roof Terrace" above Proposed School Hall Building



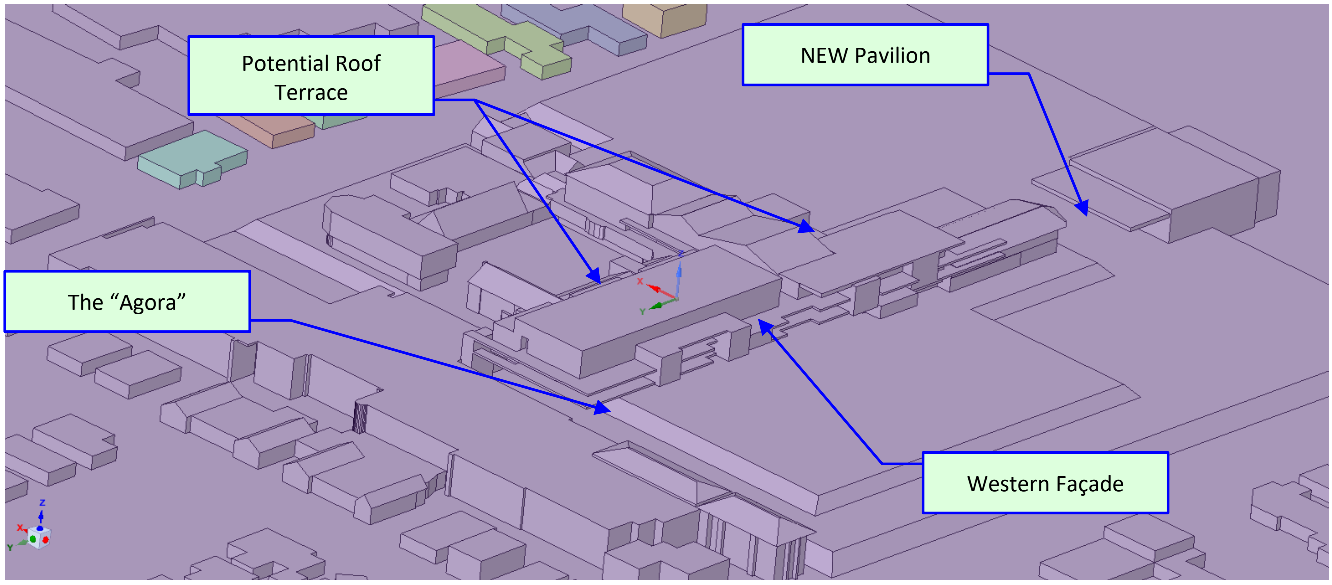
5.2 Modelling Parameters

The geometry for the CFD modelling is shown in Figure 12. The domain for the CFD modelling covers an area of 4 km^2 and extends 200 metres above the proposed development.

The influence of the immediate surrounding physical environment, all neighbouring buildings around the proposed development within a radius of 400 metres were included in the CFD model**.**

The surrounding buildings and terrain were simplified to reduce computational time. This includes the removal of all trees and vegetation, which means that the model can be considered conservative as the presence of trees and vegetation would reduce ground level wind speeds.

Figure 11 Modelled Geometry



5.3 Boundary Conditions

5.3.1 Wind Condition

The CFD study was undertaken to estimate the velocity and pressure profile during elevated wind conditions representing an annual exceedance probability. At the upwind free boundary inlet mean wind velocity profiles were derived from Bureau of Meteorology data and the Australian Wind Code AS1170.2 for Sydney's four prevailing wind directions. At the downwind and upper free boundaries constant pressure boundary conditions were applied.

The four key prevailing Sydney wind directions were modelled and the public locations were checked for any exacerbation of the current wind conditions caused by the proposed development. The modelled wind directions were:

- West Winds
- South Winds
- Northeast Winds
- Southeast Winds

The velocity boundary conditions were based on the 1-year return period and mean wind velocity profiles were based on AS1170.2 (for the relevant direction).

5.3.2 Other Boundary Conditions

The following additional boundary conditions were used

- Turbulence quantities (kinetic energy and dissipation rate) were calculated from empirical relationships
- A wall function data group was used to avoid using a very fine mesh near the wall and improve turbulent flow simulation

5.4 Discretization

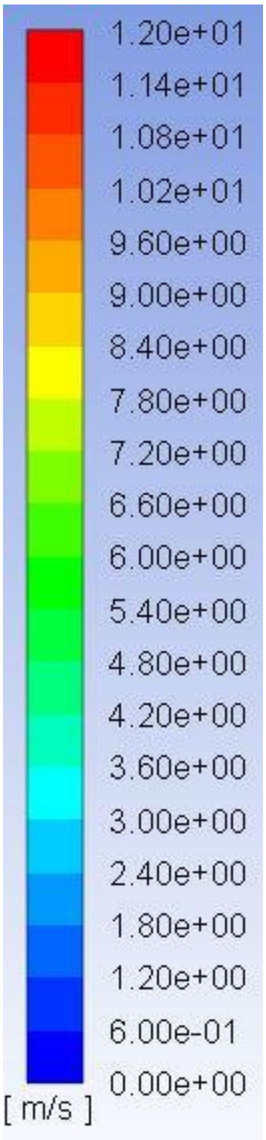
The software package utilised in the CFD analysis is the commercially available code Fluent. The CFD model solves continuity and momentum equations in the computational domain to predict the steady state airflow inside and around the redevelopment.

- For the current analysis mixed cells with a total of 22,287,066 elements was used to cover the computational domain. A solution adaptation technique is used to refine number of elements based on initial results of simulations to provide more accurate results at areas of interest.
- A Realizable KE turbulence model was used to capture flow separation and recirculation at areas of interest.
- A second order numerical scheme is used for discretization of pressure and momentum equations.
- An iterative procedure was used to estimate the air velocity in terms of three directions, pressure profile and turbulence parameters. For the pressure velocity coupling a global solver based on the SIMPLE algorithm was employed.

5.5 Results and Discussion

The scale shown below is applicable to all the following images. Velocity magnitudes are plotted on a colour coded scale between 0 m/s and 12 m/s. Dark blue represents still conditions at 0 m/s with red shading representing the strongest wind speeds.

Figure 12 Velocity Scale

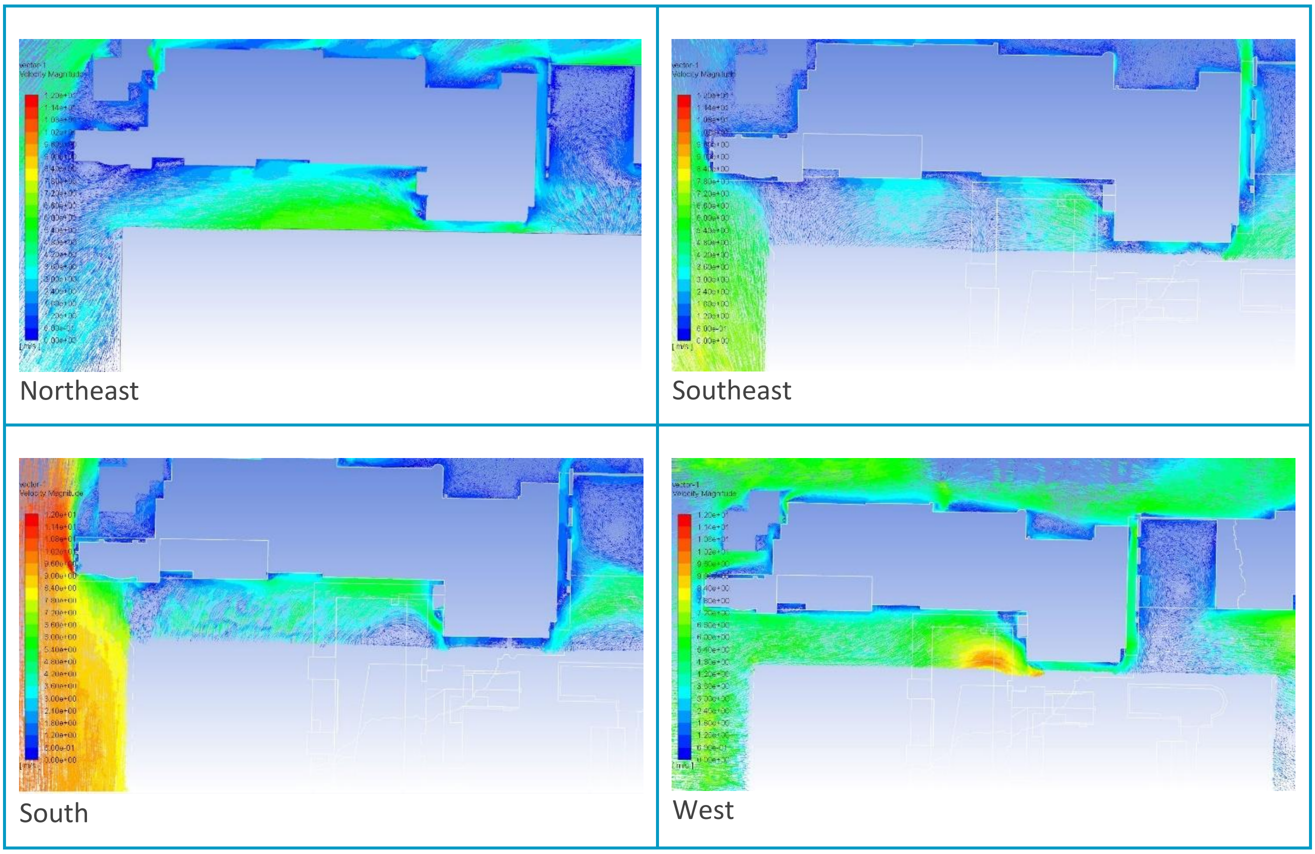


5.5.1 The “Agora”

Results of simulation at various 2D horizontal sections above ground are shown in Figure 13 and Figure 14. The following conclusions can be reached from the above figures:

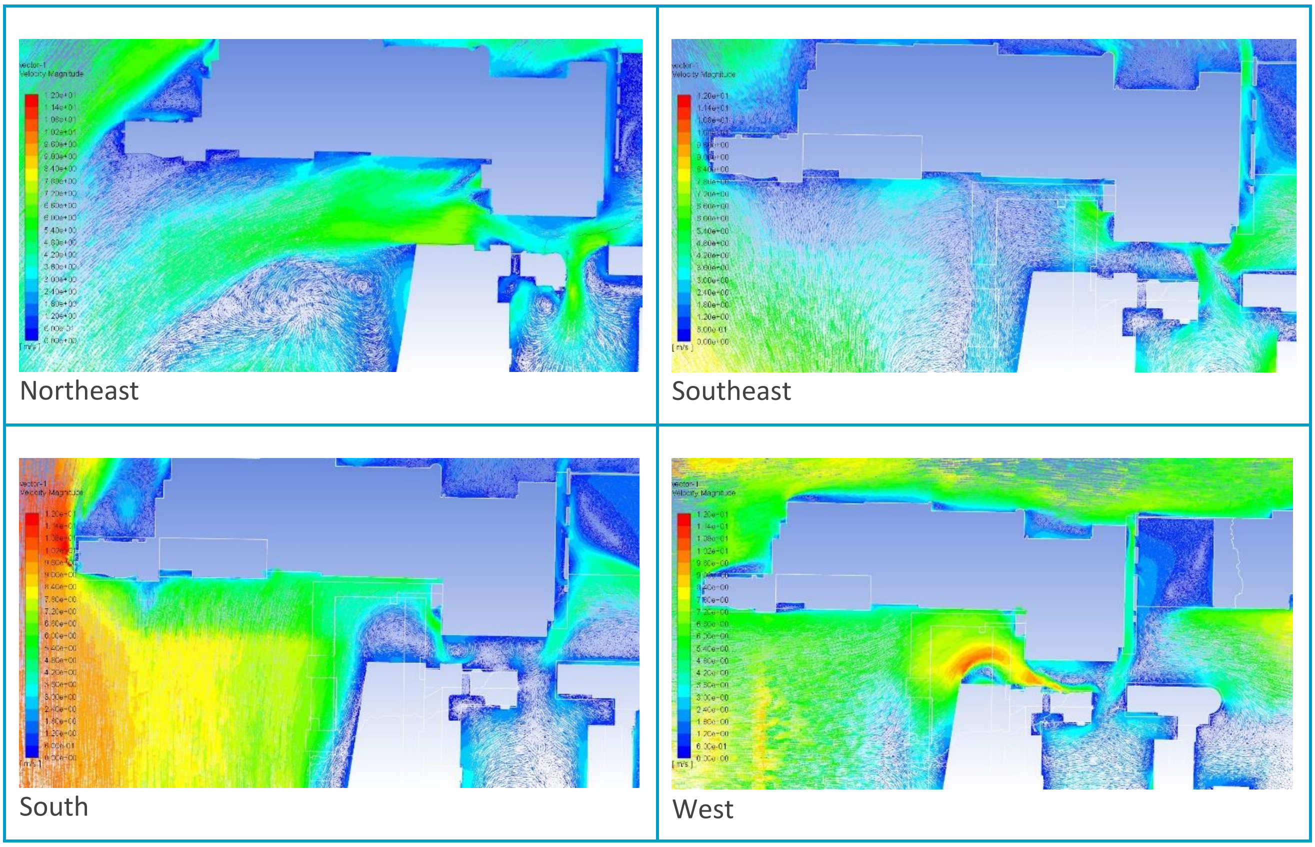
- Windspeeds through this area are generally quite reasonable for the northeast, southeast and south directions with the modelling showing maximum speeds around 6-6.6 m/s.
- Westerly winds however show higher wind speeds as they accelerate around the corner of the building. The maximum wind speed is approximately 11.4 m/s thereby exceeding the comfort criteria for standing and approaching the safety criteria.

Figure 13 Lower Part



Northeast | Southeast | South | West

Figure 14 Upper Part



5.5.2 Western Façade of New Central Spine Buildings

Results of simulation at various 2D horizontal sections above ground are shown in Figure 15 and Figure 16. The following conclusions can be reached from the above figures:

- In general, these areas receive good shielding form the central spine buildings in northeast and southeast winds.
- There is some acceleration in northeast winds around the northern part of the building and through the channel between the buildings with winds approaching 8.4 m/s in the model thereby exceeding the comfort criteria for walking.
- There is some penetration and recirculation through these areas in southerly wind with modelling showing average maximums of 6.6-7.2 metres particularly in the northern most part of the building and through the channel between the two main buildings.
- Westerly wind speeds reach 11.5 m/s through the channel between the building, thereby approaching the safety criteria for walking.
- The average wind speed at the stair and upper level trafficable area is approximately 7.4 m/s thereby satisfying the criteria for walking.

Figure 15 Level 1

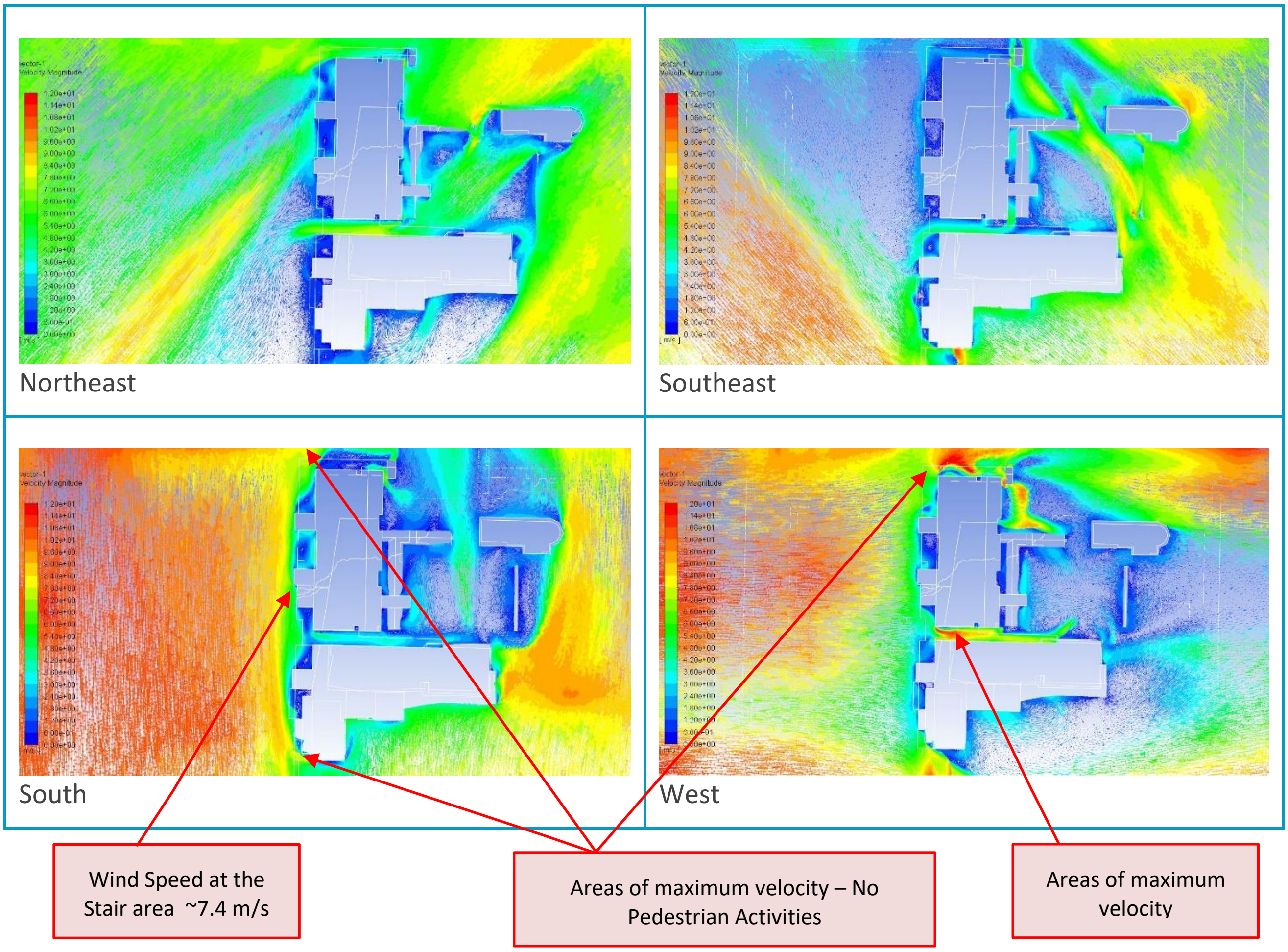
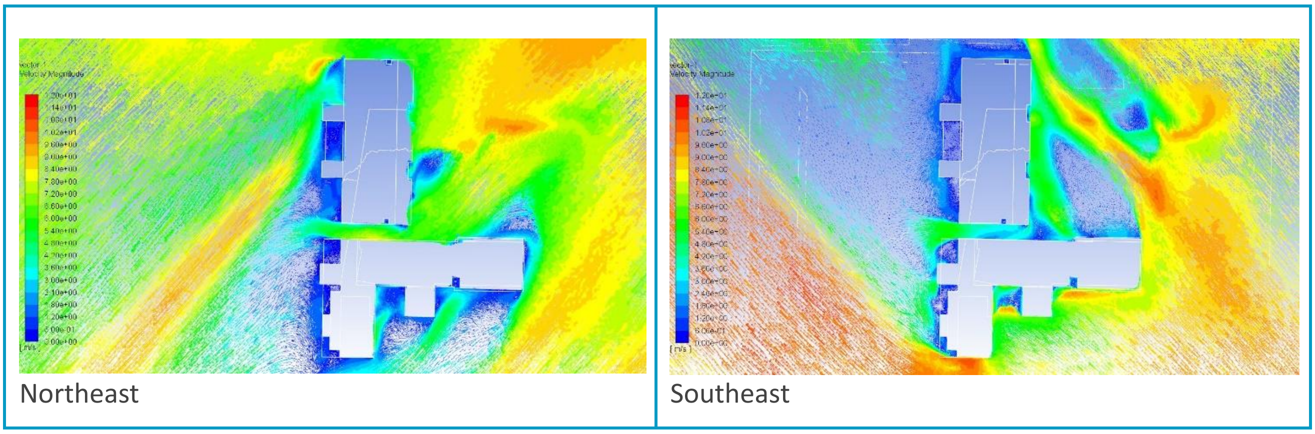
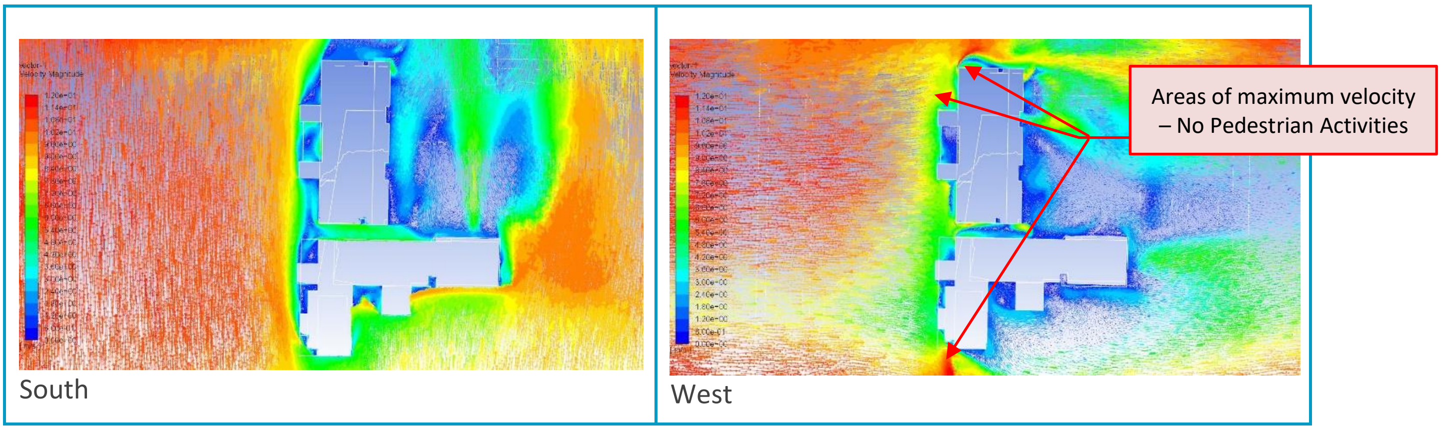


Figure 16 Level 2

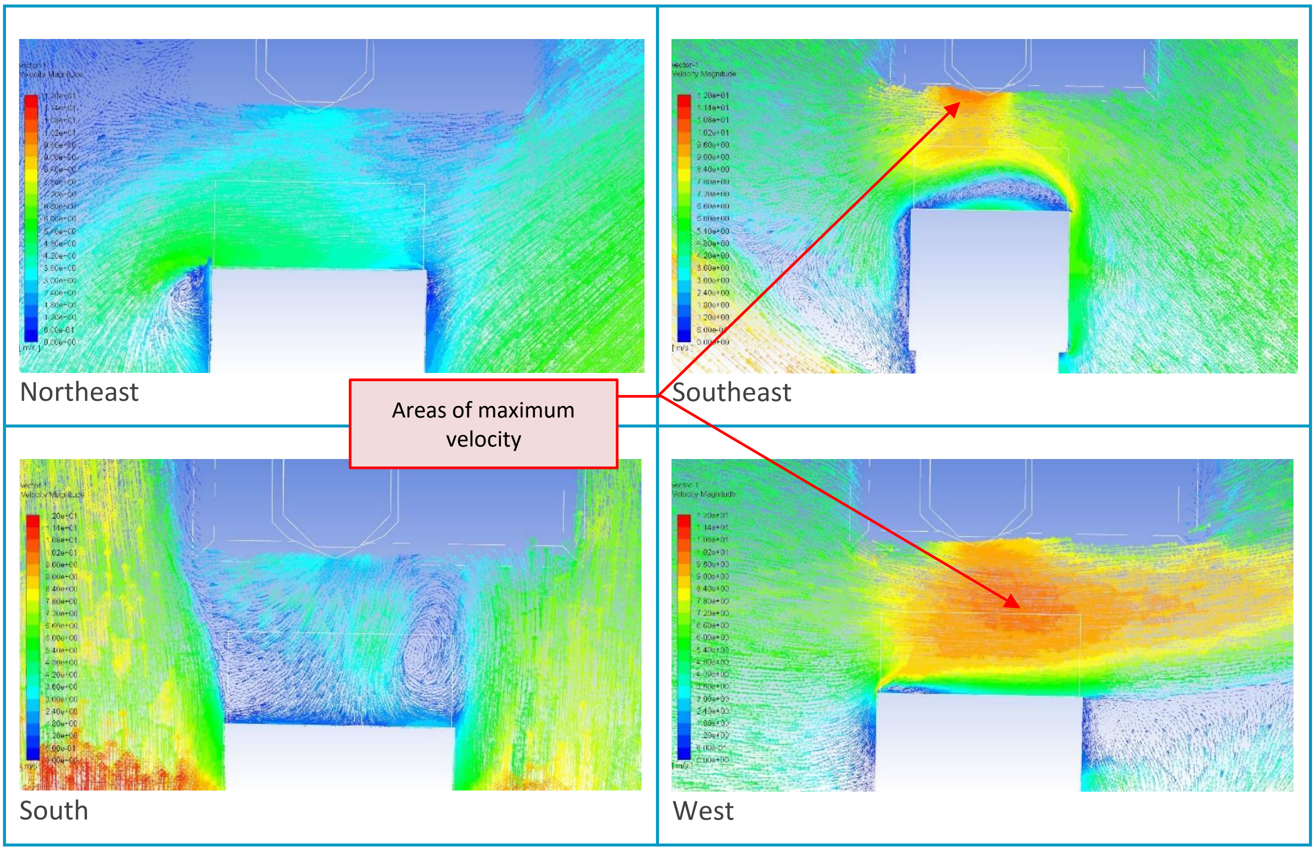




5.5.3 Pavilion Terrace

- This area has good shielding in northeast and southerly winds from the buildings immediately upstream. For these directions modelling showed average maximum speeds of around 5.4-6 m/s.
- Southeast and westerly winds accelerate through the channel and around the corners with a maximum wind speed of 10.2 m/s, thereby exceeding the comfort criterion for walking.

Figure 17 Terrace



5.5.4 Roof Terraces

Results of simulation are shown in Figure 18 and Figure 19. The following conclusions can be reached from the above figure:

- The north terrace runs along the eastern side of the central spine building.
  - There are quite low wind speeds in westerly winds where the terrace receives good shielding from the school buildings.
  - Southerly winds are moderately shielded with the potential to reach 6.5 m/s, thereby satisfying the comfort criteria for walking.
  - Roof terraces were shown to have the potential to experience wind speeds up to 8.4 m/s for the northeast and southeast conditions, thereby exceeding the comfort criteria for walking.
- The southern terrace has good shielding in northeast and westerly winds
  - There is some penetration into the terrace in south and southeast wind with winds showing a maximum of 9 m/s thereby exceeding the comfort criteria for walking.

Figure 18 North Terrace

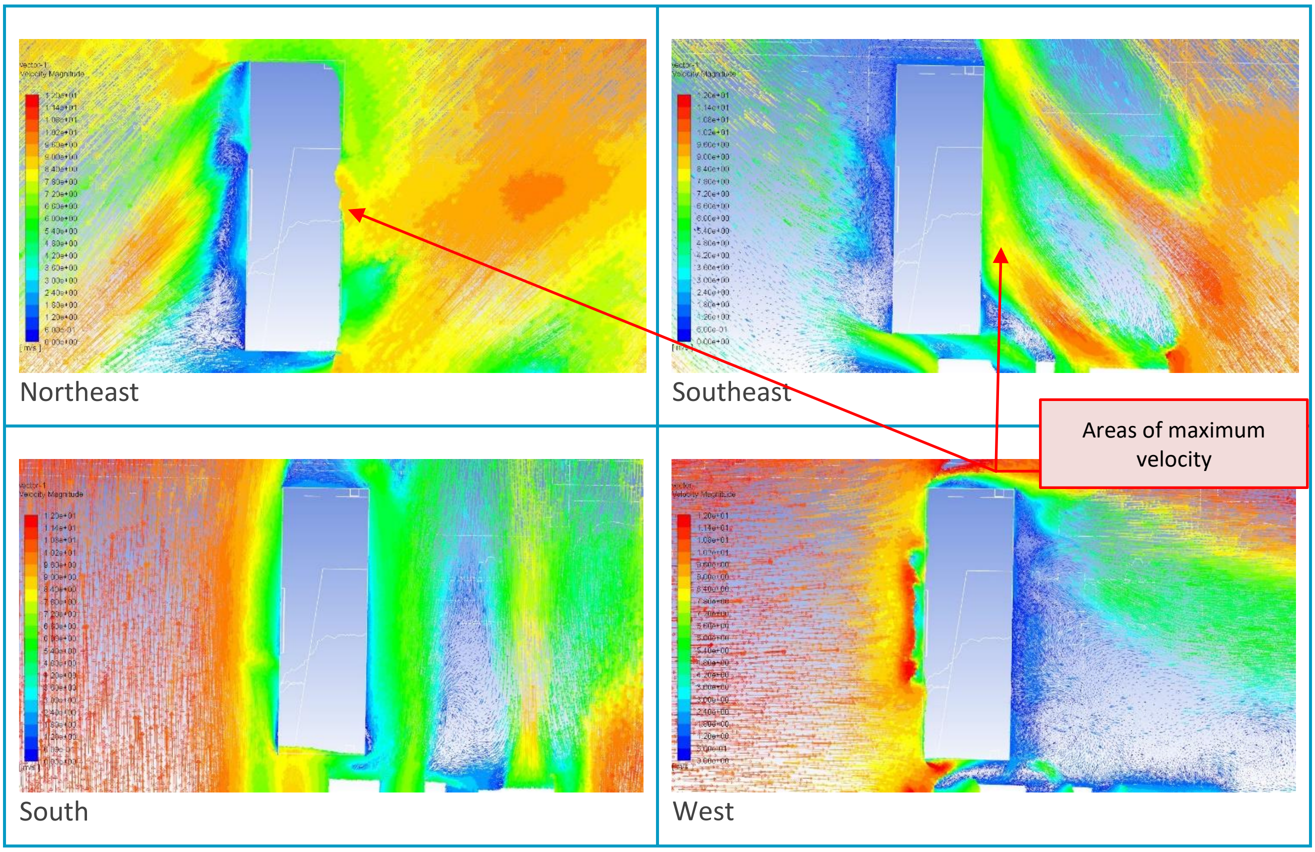
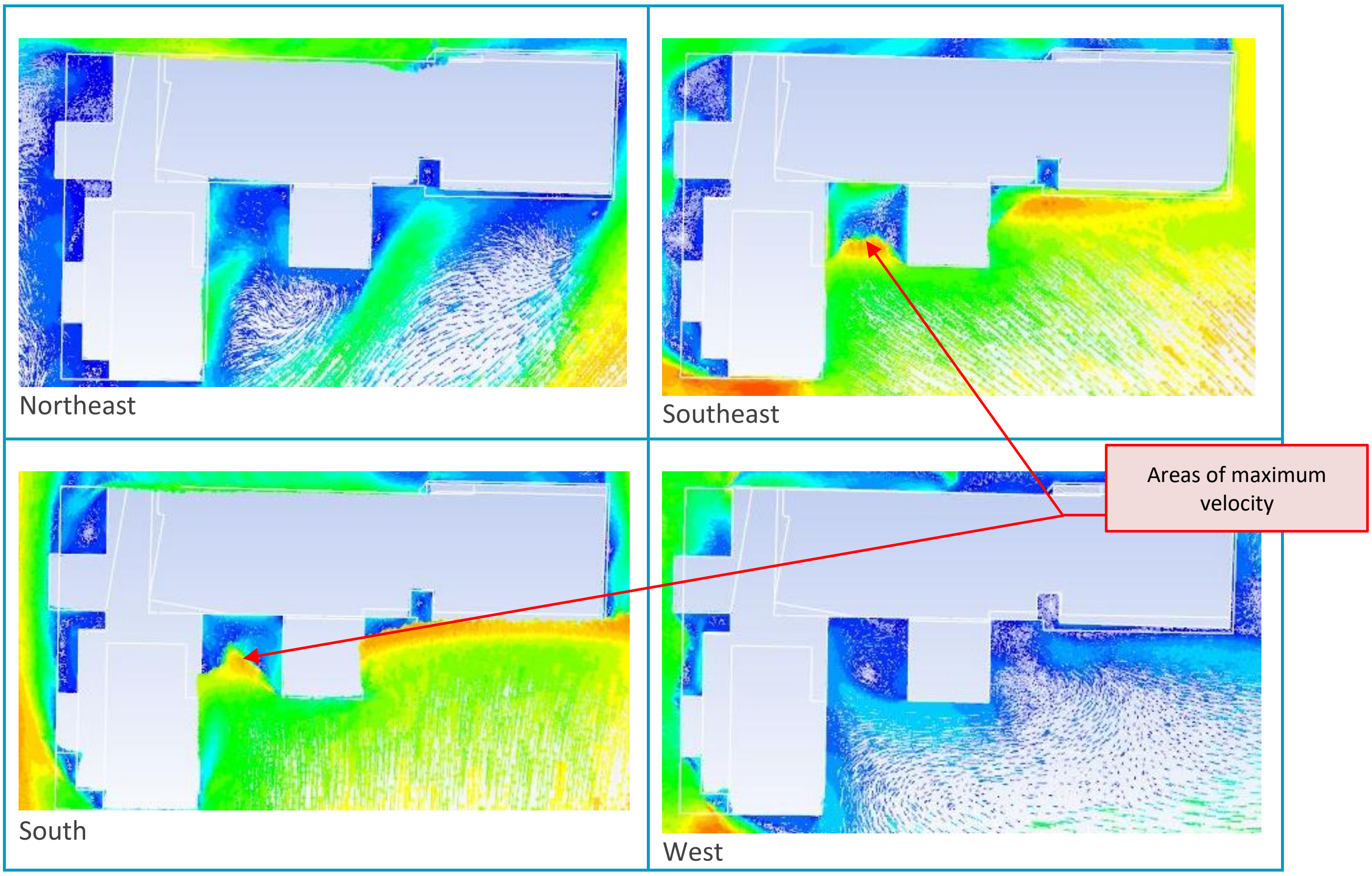


Figure 19 South Terrace



6 RECOMMENDATIONS

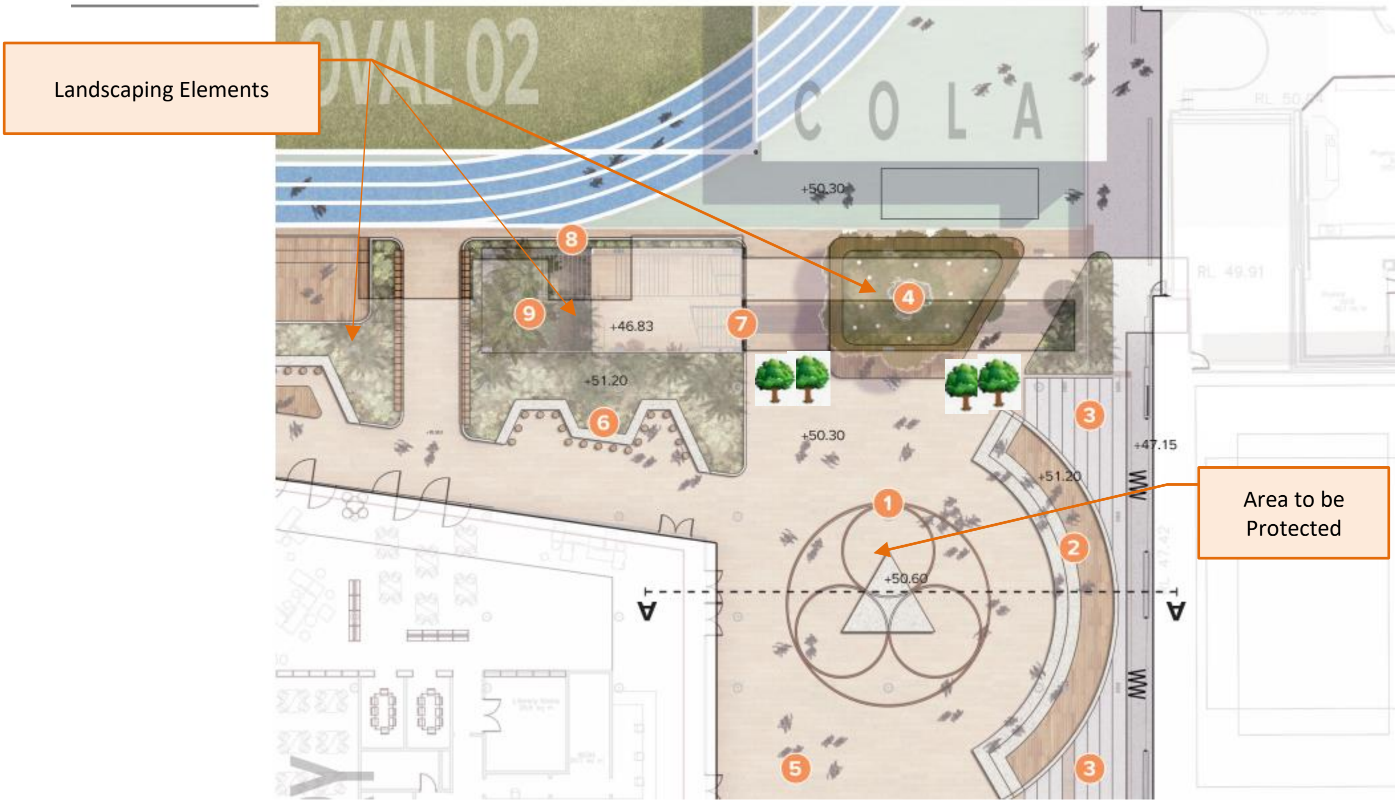
Section 5 provided guidance as to the areas where the adopted wind acceptability criterion had the potential to be exceeded and an indication as to the likely local optimum wind treatment strategy, ie whether the wind condition of interest is likely to arise from accelerating winds which require vertical windbreaks (such as landscaping) or downwash winds which require horizontal windbreaks (such as awnings, canopies).

The following recommendations are made based on results of simulations:

6.1 Agora

There are landscaping elements planned at the northeast corner and along the side of No.2 Oval – refer **Figure 20.** These should all be retained. Additional shielding elements will be required to fill the gaps of the currently planned elements as the wind speeds are particularly strong through this area. This could be in the form of screens or vegetation and could be staggered with the current elements to create a continuous barrier.

Figure 20 Agora Ground Level Mitigation

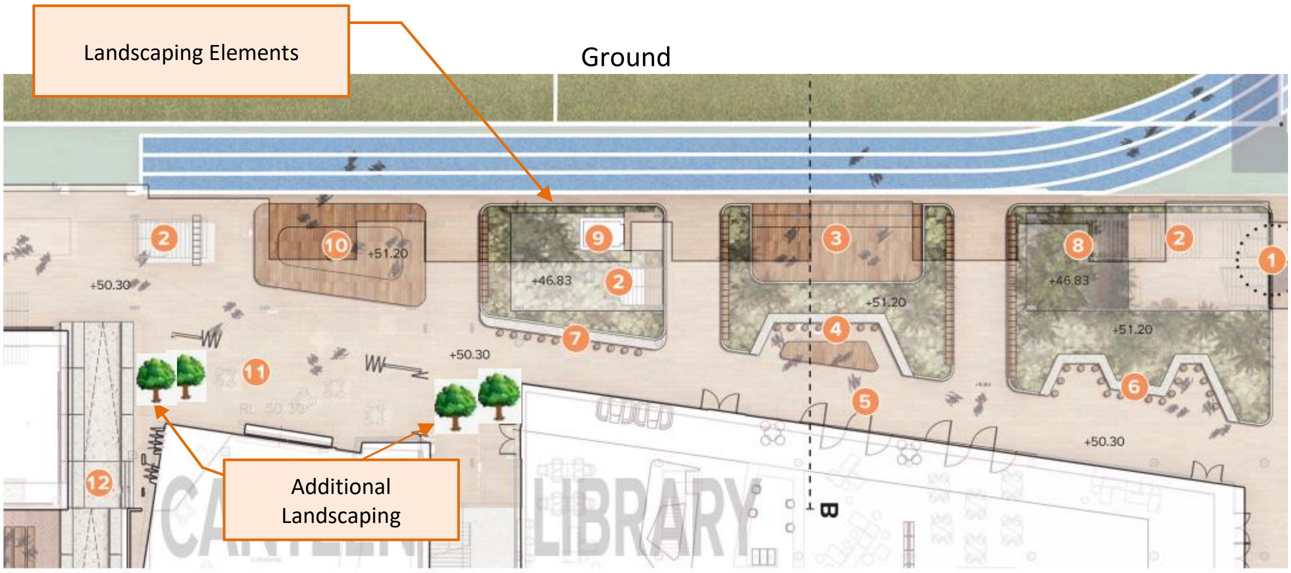


6.2 New West Facing Traffic Zone Facade

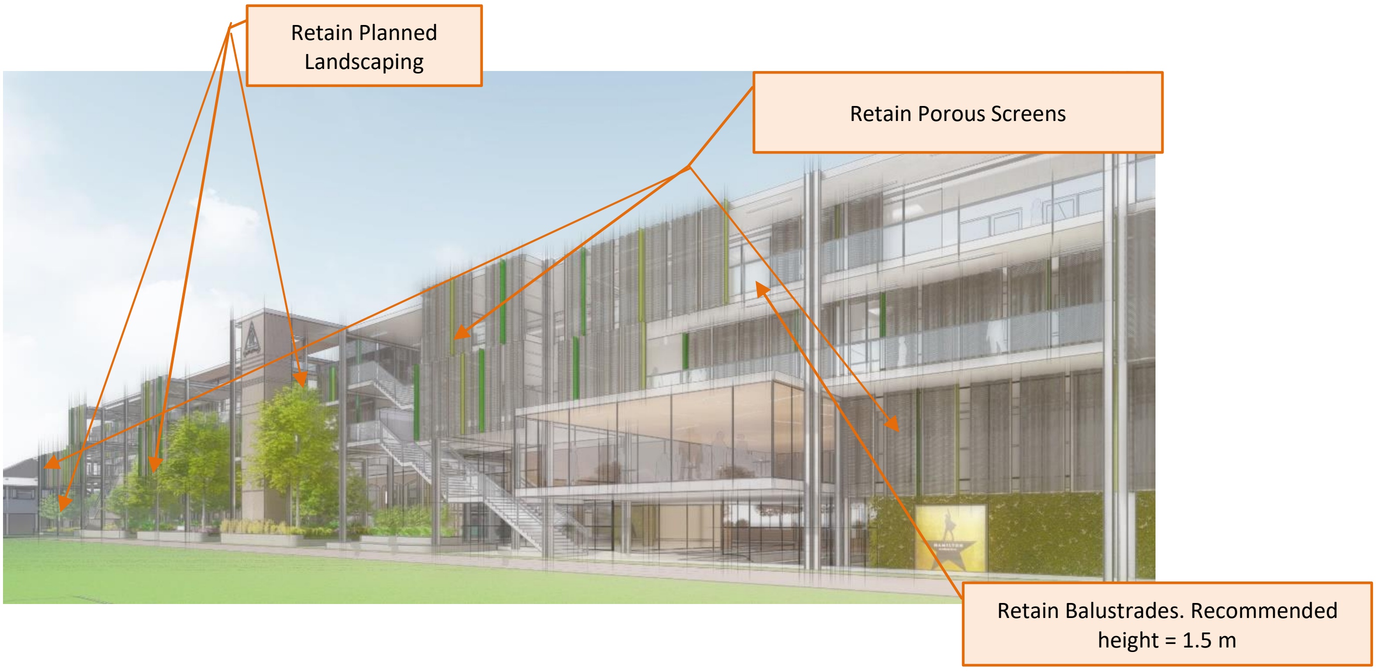
This area will need protection from winds from the south and west, which will be largely horizontal in nature. Areas will benefit from a variety of wind mitigation features: balustrades with planter boxes, louvred screens, operable louvres, etc - refer **Figure 21**

The ground level has some landscaping elements which should be retained and enhanced to form a continuous barrier. Focus should be given to the gaps between the buildings as there are accelerations through these areas.

Figure 21 New Western Facade Traffic Zone Mitigation



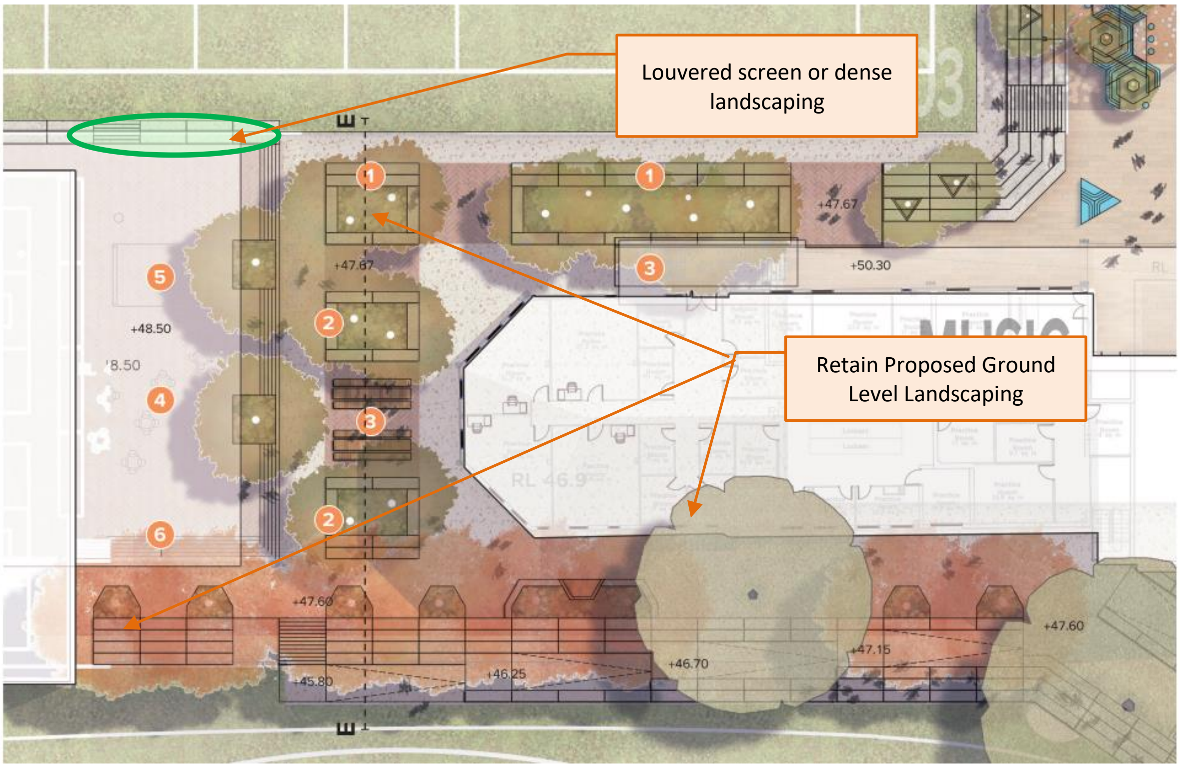
Elevation



6.3 New No.2-No.3 Oval Pavilion Terrace

This area will need protection from winds from the westerly direction as well as the southeast, which will be largely horizontal in nature. Areas will benefit from a variety of wind mitigation features: landscaping, planter boxes, glazed or louvred screens, operable louvres, etc - refer **Figure 22**. Planned landscaping and trees should be retained. The shielding should be enhanced with lower level elements like screens and vegetation especially around the seating areas under the awning.

Figure 22 Terrace Zone Mitigation



6.4 Roof Terraces

The south terrace should have a balustrade at least 1.8 metres in height. This could be solid or glazed and could also include landscape features. The north terrace will also require a 1.8 metre balustrade and the vegetation shown in the figure below should be retained.

Figure 23 Roof Terraces Mitigation

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