



# PEDESTRIAN WIND ENVIRONMENT STATEMENT

SSD-10381

WG072-01F02(REV3)- WS REPORT

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# DOCUMENT CONTROL

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# EXECUTIVE SUMMARY

This report presents an assessment of the amenity impacts of the proposed Green Square Integrated Community Facility and School development (State Significant Development Application Ref 10381), on the local wind environment at critical outdoor areas within and around the subject site. The effect of wind activity has been examined for the three predominant wind directions for the region, namely the north-easterly, southerly, and westerly winds. The analysis of the wind effects relating to the proposed development have been carried out in the context of the local wind climate, building morphology and land topography.

The conclusions of this report are drawn from our extensive experience in this field and are based on an examination of the latest architectural drawings. No wind tunnel testing has been undertaken for the subject development, and hence this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection of the architectural drawings provided (Architectural Design Report, Issue B, dated: 08.04.2021, received April 14, 2021). Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind environment effects.

The results of this assessment indicate that the development receives moderate shielding of the prevailing north-easterly and southerly winds due to the neighbouring mid-rise surrounding developments. However, the site remains relatively exposed to the prevailing westerly winds due to the potential for the winds to travel along Geddes Avenue and The Drying Green Public Park. The development will incorporate several design features and wind mitigating strategies and is expected to be suitable for the intended use for the majority of the outdoor trafficable areas.

To address the potential for adverse wind effects impacting pedestrians/patrons within and around the development, consideration of the following treatment strategies into the design of the development is expected to improve wind conditions:

- Ground Level:
  - Retention of proposed densely foliating evergreen tree planting along Zetland Avenue and Portman Street.
  - Retention of hedge planting along the perimeter of the games court capable of growing to a minimum height of 1.0m above the ground.
  - Retention of proposed densely foliating evergreen tree planting and hedge planting within the Outdoor Learning area.
- Level 1:
  - Retention of proposed porous balustrading and façade panels along the terrace perimeter.
  - Recommended full height porous end screen at the southern end of the western aspect terrace.
- Level 2:
  - Retention of proposed porous balustrading and façade panels along the terrace perimeter.

- Recommended full height porous end screen at the southern ends of the western and eastern aspect terrace.
- Retention of the proposed canopies situated over the amphitheatre.
- Recommended strategic tree/vegetation planting within the amphitheatre space.
- Rooftop Terrace:
  - Retention of 3.6m high porous screening along the northern and eastern aspects and 2.0m high porous screening along the southern aspect of the Library Learning Space.
  - Retention of 3.6m high porous screening along the northern, southern and western perimeter and 2.0m high porous screening along the eastern perimeter of the Mound Play Space.
  - Retention of PV panels over the Library Learning Space and Mound Play Space.
  - Retention of proposed vegetation and tree planting. It is recommended that dense evergreen species are chosen to provide year-round protection.

With the inclusion of the abovementioned in-principle recommendations, it is expected that wind conditions for the various trafficable outdoor areas within and around the development will be suitable for their intended uses.

Wind tunnel testing is recommended to be undertaken at a more detailed design to quantitatively assess the wind conditions within and around the development site to ensure a suitable level of amenity is achieved. Wind tunnel testing will allow for the required treatment size, screen porosity and extents to be optimised to ensure wind conditions are safe and suitable for patrons.

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# INTRODUCTION

The purpose of the report is to address the expected wind amenity within and around the development site in accordance with the Secretary's Environment Assessment Requirements (SEARs) No.6 Environmental Amenity requirement. The analysis of wind effects relating to the proposed development has been carried out in the context of the predominant wind directions for the region, building morphology of the development and nearby buildings, and local land topography. The conclusions of this report are drawn from our extensive experience in the field of wind engineering and studies of wind environment effects.

This report addresses only the general wind effects and any localised effects that are identifiable by visual inspection, and any recommendations in this report are made only in-principle.

Wind tunnel testing is recommended to be undertaken at a more detailed design stage to quantitatively assess the wind conditions within and around the development site to ensure a high level of amenity is achieved in accordance with SEARs No.6 requirement.

## DESCRIPTION OF DEVELOPMENT AND SURROUNDINGS

The site is located at 3 Joynton Avenue, Zetland. The development is known as the Green Square Integrated Community Facility and School (GSICFS). This is a joint project between School Infrastructure NSW and the City of Sydney. The development is bounded by Zetland Avenue to the north, Portman Street to the west, Joynton Avenue to the east along with an Early Education Centre and mid-rise residential buildings to the south. The subject site is surrounded predominantly by mid-rise buildings, with a 3-building development located at 811 Elizabeth Street directly north, to the north-west are mixed-use buildings located at 77-93 Portman Street, to the west is the Drying Green Park, to the south-west and north-east are mixed-use buildings, to the south is the Community and Cultural precinct and mixed-use buildings and to the west is the Aquatic Centre. A survey of the land topography indicates no major elevation changes in the area immediately around the site.

An aerial image of the subject site and the local surroundings is shown in Figure 1, with the frequency and magnitude of the prevailing winds superimposed for each wind direction.

The existing site consists of 1-3 storey residential buildings. The proposed development will comprise a four storey building made up of various indoor and outdoor functional spaces including:

- Primary education facilities for up to 600 kindergarten to Year 6 students:
  - Indoor and outdoor learning spaces
  - Administration and staff rooms
  - Library and School community hall
- Shared multi-function spaces for school and community use:
  - 2 multipurpose community facilities rooms to be operated solely by City of Sydney
  - 2 multipurpose rooms to be shared by the City of Sydney and the primary school
- At ground level:
  - Play spaces which will be a shared use between school and community
  - Multipurpose games court

The critical outdoor trafficable areas associated with the proposed development, which are the focus of this assessment with regards to wind effects, are listed as follows:

- Ground Level Pedestrian Areas
- Terraces and Outside Learning Areas (Level 1 - Level 2)
- Rooftop Terrace

**Legend**

- Line thickness represents the magnitude of the regional wind from that direction
- Line length represents the frequency that the regional wind occurs for that direction

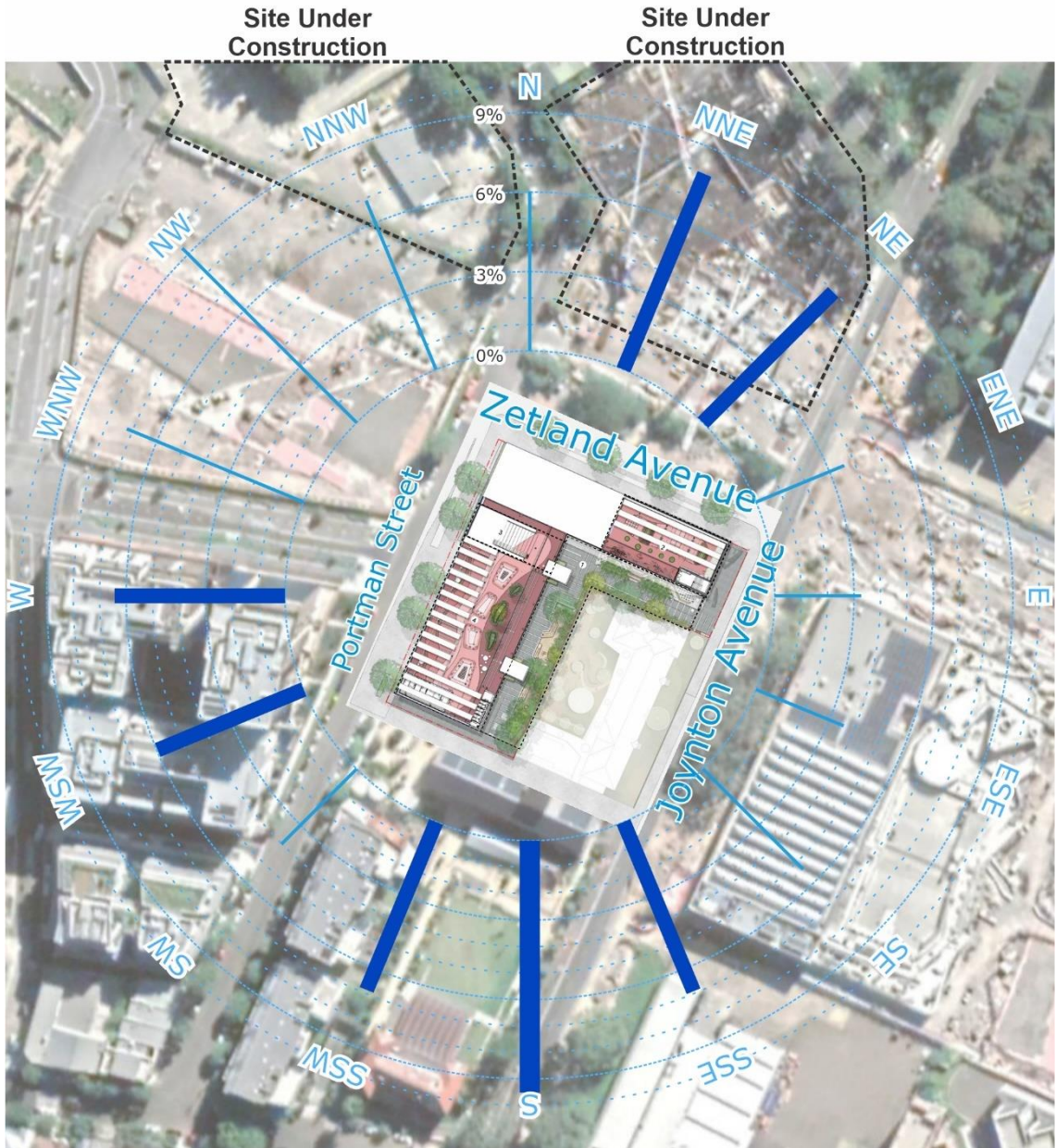


Figure 1: Aerial Image of the Site Location and Prevailing Wind Directions

### 3 REGIONAL WIND

The Sydney region is governed by three principal wind directions that can potentially affect the subject development. These winds prevail from the north-east, south, and west. These wind directions were determined from an analysis undertaken by Windtech Consultants of recorded directional wind speeds obtained from the meteorological station located at Kingsford Smith Airport by the Bureau of Meteorology (recorded from 1995 to 2016). The data has been corrected to represent winds over standard open terrain at a height of 10m above ground level. The results of this analysis are presented in Figure 2 in the form of a directional plot of the annual and 5% exceedance mean winds for the region. The frequency of occurrence of these winds is also shown in Figure 2.

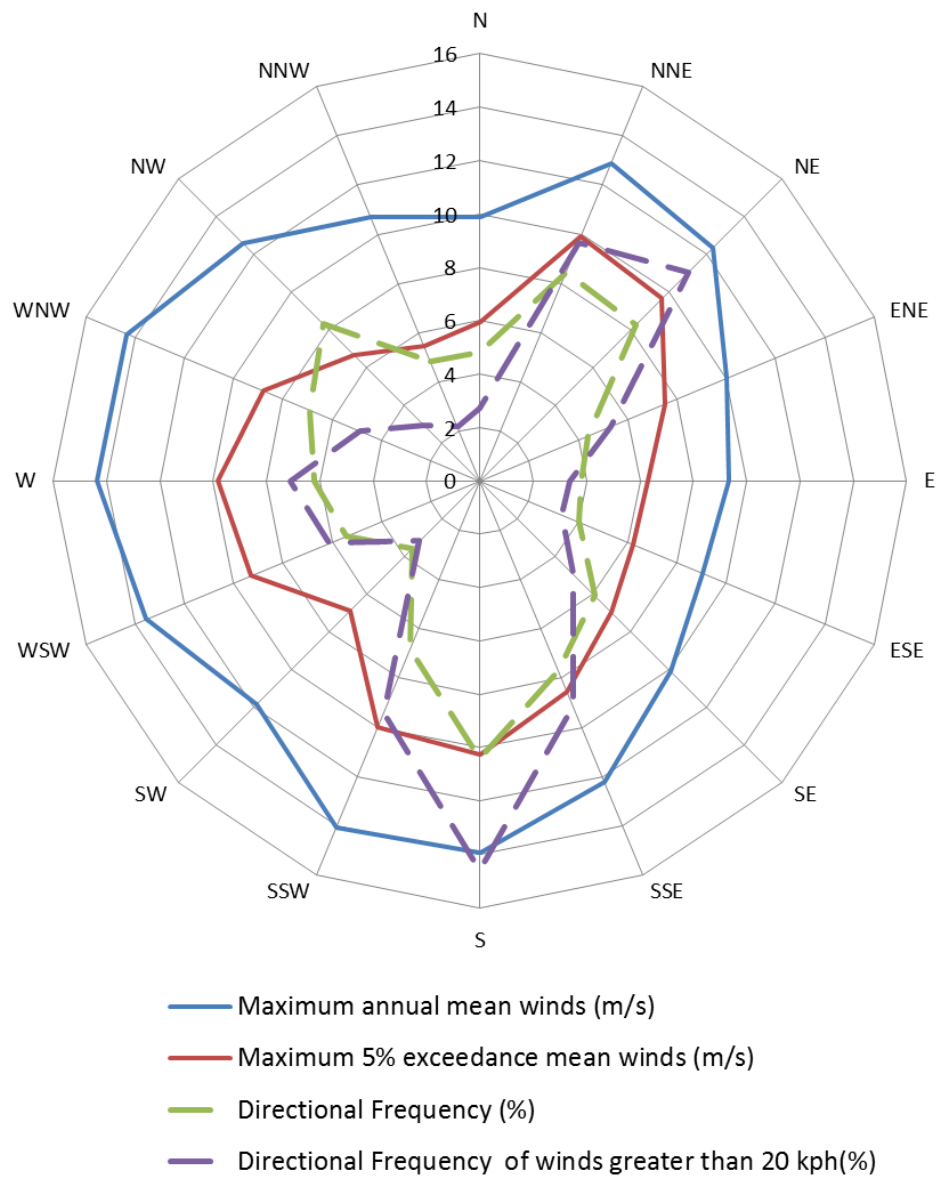


Figure 2: Directional Annual and 5% Exceedance Hourly Mean Wind Speeds (referenced to 10m height in standard open terrain), and Frequencies of Occurrence, for the Sydney Region

## 4 WIND EFFECTS ON PEOPLE

The acceptability of wind in any area is dependent upon its use. For example, people walking, or window-shopping will tolerate higher wind speeds than those seated at an outdoor restaurant. Various other researchers, such as A.G. Davenport, T.V. Lawson, W.H. Melbourne, and A.D. Penwarden, have published criteria for pedestrian comfort for pedestrians in outdoor spaces for various types of activities. Some Councils and Local Government Authorities have adopted elements of some of these into their planning control requirements.

For example, A.D. Penwarden (1973) developed a modified version of the Beaufort scale which describes the effects of various wind intensities on people. Table 1 presents the modified Beaufort scale. Note that the effects listed in this table refers to wind conditions occurring frequently over the averaging time (a probability of occurrence exceeding 5%). Higher ranges of wind speeds can be tolerated for rarer events.

Table 1: Summary of Wind Effects on People (A.D. Penwarden, 1973)

Type of Winds	Beaufort Number	Mean Wind Speed (m/s)	Effects
Calm	0	Less than 0.3	Negligible.
Calm, light air	1	0.3 – 1.6	No noticeable wind.
Light breeze	2	1.6 – 3.4	Wind felt on face.
Gentle breeze	3	3.4 – 5.5	Hair is disturbed, clothing flaps, newspapers difficult to read.
Moderate breeze	4	5.5 – 8.0	Raises dust, dry soil and loose paper, hair disarranged.
Fresh breeze	5	8.0 – 10.8	Force of wind felt on body, danger of stumbling
Strong breeze	6	10.8 – 13.9	Umbrellas used with difficulty, hair blown straight, difficult to walk steadily, wind noise on ears unpleasant.
Near gale	7	13.9 – 17.2	Inconvenience felt when walking.
Gale	8	17.2 – 20.8	Generally impedes progress, difficulty balancing in gusts.
Strong gale	9	Greater than 20.8	People blown over.

It should be noted that wind speeds affecting this particular development can only be accurately quantified with a wind tunnel study. This assessment addresses only the general wind effects and any localised effects that are identifiable by visual inspection and the acceptability of the conditions for outdoor areas are determined based on their intended use. Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind environment effects.

## RESULTS AND DISCUSSION

The wind impacts within and around the site due to the subject development are discussed within the following sub-sections of this report. The interaction between the wind and the building morphology in the area is considered and important features taken into account including the distances between the surrounding buildings and the proposed building form, as well as the surrounding landform. Note that only the potentially critical wind effects are discussed in this report. A glossary of the different wind effects described in this report included in Appendix A.

For this assessment, the wind speed criteria for pedestrian comfort that are considered are listed as follows:

- Walking Criterion (8m/s with a 5% probability of exceedance)  
for general circulation and pedestrian thoroughfares, e.g. footpaths, private balconies/terraces, through-site links etc.
- Standing Criterion (6m/s with a 5% probability of exceedance)  
for stationary activities generally less than an hour, e.g. waiting areas, communal terraces, main entries, café seating etc.
- Sitting Criterion (4m/s with a 5% probability of exceedance)  
for stationary activities longer than an hour, e.g. outdoor cinemas, outdoor fine dining etc.

Although this assessment is qualitative in nature, the abovementioned criteria for pedestrian comfort are considered when assessing the wind environment impacts. However, all areas are also assessed with consideration to a pedestrian safety criterion of 24m/s for the annual maximum gust.

### 5.1 Ground Level Pedestrian Areas

The prevailing winds for the Sydney region are the north-easterly, southerly and westerly winds. The site is generally shielded from the prevailing winds approaching from the north-east and south due to the surrounding mid-rise buildings. The westerly winds have the potential to travel along Geddes Avenue and The Drying Green Public Park and directly impact the western aspect of the development. The mid-rise buildings to the south-west are expected to provide partial shielding of the westerly winds to the south-western aspect of the school.

The wind conditions of the pedestrian footpath along Portman Street is primarily exposed to the prevailing north-easterly, westerly and southerly winds. The westerly winds are expected to directly impact the pedestrian footpath due to the limited shielding to the west of the proposed site.

The north-easterly prevailing winds are expected to be relatively shielded from the development at 811 Elizabeth Street, however recirculating wind has the potential to side stream along the northern facade and accelerate around the north-western recessed building corner, adjacent the games court. The inclusion of the proposed densely foliating trees and vegetation along Zetland Avenue is expected to filter the side streaming and corner accelerating wind conditions. The perimeter of the games court proposes to utilise full height cables with the potential for planting to climb. This feature is only expected to provide wind benefits once the vegetation interlocks, covers the full height of the cables and has fully matured.

The games court is recessed within the building footprint and is open to the northern and western aspects. Openings on the eastern aspect leading to the outdoor learning area has the potential to allow the westerly winds to flow across the games court resulting in localised adverse winds due to funnelling. The western building façade directly above the games court is not relatively tall therefore, is not expected to capture large volumes of the westerly winds which may downwash into the games court. Similarly, the porous façade element is expected to assist in minimising wind shear and any potential downwash.

The proposed tree layout as shown in the landscape plan along Portman Street and Zetland Avenue are recommended to be retained in the final design. All vegetation should be densely foliating, evergreen and have interlocking canopies where possible, particularly for the westerly winter winds. The trees should be capable of growing to a minimum height of 3-4m with a canopy diameter of 3-4m. The trees selected to be included within the final design scheme are recommended to be of a sturdy densely foliating variety. These plants should also be installed in a semi-mature to mature state as early as possible into the site works to allow these trees to become sufficiently established before the completion of the development.


The southerly winds have the potential to accelerate about the south-western corner of the school onto the pedestrian footpath along Portman Street. The neighbouring building to the south is expected to provide shielding and reduce the potential of adverse winds, as well as the proposed tree planting along Portman Street. It is recommended that the proposed tree planting along Portman Street be retained and consist of dense evergreen trees.

The north-easterly winds have the potential to impact the eastern entry at Joynton Avenue as they are expected to interact with the south-eastern building corner and accelerate around the corner. It is recommended to retain the porous screening along the northern and eastern building façade as this will assist in disrupting potential side stream wind effects. Similarly, the ground level tree planting and planter box vegetation adjacent the south-eastern corner is recommended to be retained to assist in filtering the corner accelerating winds at the entry. The pedestrian footpath along Joynton Avenue is primarily exposed to the north easterly and southerly prevailing winds.

The outdoor learning area is relatively shielded from the prevailing winds from the development itself as well as the neighbouring education centre and mid-rise building to the south. It is recommended to retain the proposed vegetation and tree planting to further assist the wind conditions through this area. All vegetation should be densely foliating, evergreen and have interlocking canopies where possible.

Wind tunnel testing is recommended to be conducted during the detailed design stage to verify the wind conditions within and around the proposed development. Testing will allow for the optimisation of potential treatment strategies required within the games court and along the pedestrian footpaths.

### Treatments Legend

 Retention of densely foliating evergreen hedges capable of growing to a height of 1.0m above ground.


 Retention of densely foliating, evergreen trees, capable of growing to a height of 3-4m, with a canopy diameter of 3-4m.



Figure 3: Recommended Treatments – Ground Floor

## 5.2 Terraces and Outdoor Learning Areas (Level 1 - Level 2)

The Level 1 terrace along the southern and eastern aspects are relatively shielded from the prevailing winds. The length of these terraces has the potential to allow winds to propagate however with the retention of the proposed porous balustrading and façade panels it is expected that wind conditions will be suitable for their use.


The Level 1 terrace located along the western aspect benefits from the setback design within the building floorplan. However, the terrace area is exposed to the direct westerly winds due to limited shielding from this aspect, which has the potential to result in adverse wind conditions locally at the northern and southern ends of the terrace due to corner acceleration. The terrace benefits from the retention of the proposed porous balustrading and façade panels, however full height porous end screens are recommended to assist in minimising the adverse corner acceleration.

The Level 2 terrace area is exposed to the direct westerly winds due to limited shielding from this aspect, which has the potential to result in adverse wind conditions locally at the northern and southern corners of the terrace due to corner acceleration. The northern corner of the terrace benefits from the retention of the proposed full height porous façade panels, however a full height porous end screen is recommended along the southern aspect to assist in minimising the adverse corner acceleration.

The Level 2 terrace shares a similar layout to Level 1, however the inclusion of the amphitheatre will allow the southerly and westerly winds to propagate into this area. The amphitheatre which spans across Levels 2 and 3 is exposed to the prevailing westerly winds, which are expected to directly impact the area as they receive limited shielding. As such there is the potential for the westerly winds to propagate upstream and directly impact the amphitheatre.

The amphitheatre is to be assessed under the seating comfort criteria, hence patrons will be more sensitive to adverse wind conditions. The proposed screening along the western aspect will assist in minimising the impact of the westerly winds, however additional treatment is to be investigated. The proposed canopies situated over the amphitheatre are recommended to be retained to assist in mitigating the direct westerly winds that will freely travel across The Drying Green Public Park and any upwash winds that may be generated from the westerly winds interacting with the western façade. The implementation of strategic landscaping within the amphitheatre will assist in mitigating adverse winds. Wind tunnel testing is recommended to be conducted during the detailed design stage to verify the wind conditions within the amphitheatre.

## Treatments Legend

 Full height porous end screens

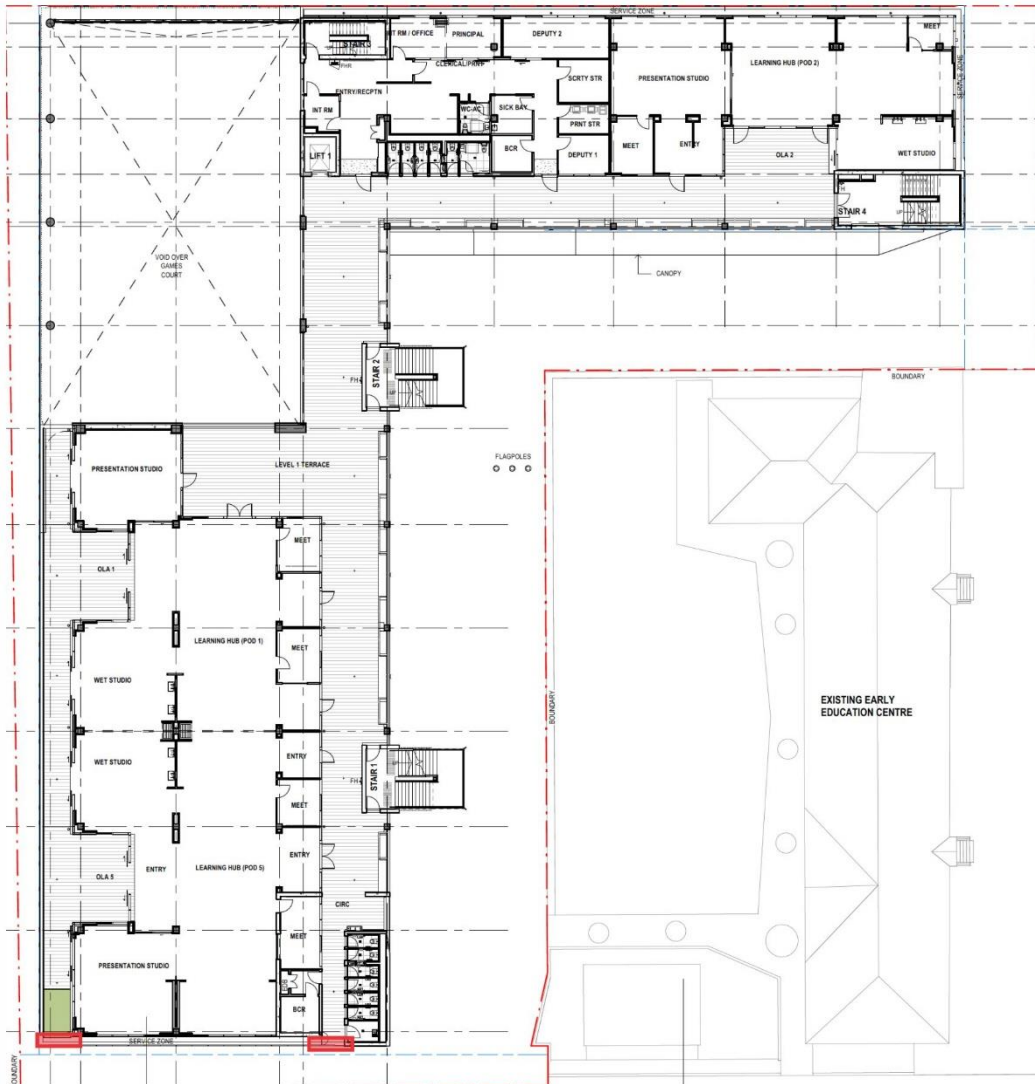


Figure 4: Recommended Treatments – Level 1

### Treatments Legend

 Full height porous end screens

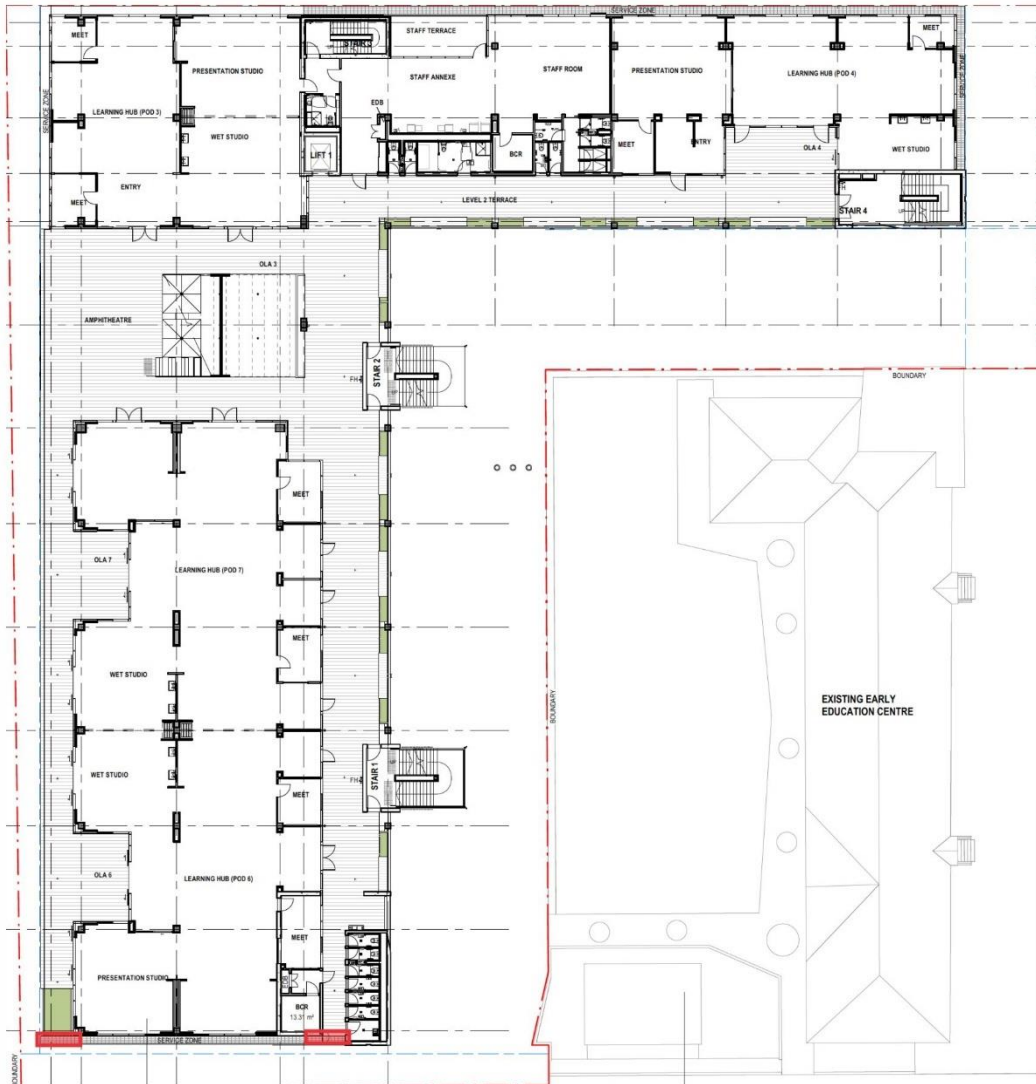


Figure 5: Recommended Treatments – Level 2

### 5.3 Rooftop Terrace

The Library Learning Space located at the north-eastern aspect of the Roof Terrace is exposed to the prevailing north-easterly and the direct southerly winds. The north-easterly prevailing winds will be relatively shielded from the development at 811 Elizabeth Street, however recirculating wind has the potential to impact localised areas on the terrace. There is the potential for these prevailing winds to interact with the building façade and upwash into the space. However, the proposed porous façade design along the northern perimeter is expected to assist in disrupting the wind flow as it attempts to side streams and up-wash.

The terrace is encompassed by 3.6m high porous screening along the northern and eastern aspects and 2.0m high porous screening along the southern aspect. The retention of these screen elements are expected to assist in filtering the direct winds, minimising the adverse conditions within the Library Learning Space. The space also consists of PV panels located over the northern half of the terrace, which will assist in providing protection to any upwash winds from the north-easterly winds.

Further inclusion of densely foliating evergreen planting in strategic locations within the southern aspect of the terrace is expected to further improve wind conditions.

The Mound Play Space located at the southern aspect of the Roof terrace shares similar architectural design elements as the Library Learning Space. The area is directly exposed to the prevailing westerly and southerly winds. The building design provides shielding of the prevailing north-easterly winds. The terrace is encompassed by 3.6m high porous screening along the northern, southern and western perimeter and 2.0m high porous screening along the eastern perimeter. The inclusion of these screen elements are expected to assist in filtering the direct winds, minimising the adverse conditions within the Mound Play Space. PV panels are located over the space along the western and southern aspects. The inclusion of the PV structure is expected to provide protection to upwash winds from the prevailing southerly and westerly directions.

The space proposes tree planting and vegetation along the eastern aspect, which is recommended to be retained. Note that for the trees and landscaping to be effective in wind mitigation throughout the year, they are recommended to be of a densely foliating evergreen species. The inclusion of additional trees and landscaping is expected to further improve wind conditions.

## IMPACT OF CLIMATE CHANGE

We have undertaken a review of the potential impact of climate change on the wind climate for the Sydney Region as it would affect the wind comfort for this development. When assessing these comfort conditions, wind speeds which have a daily, weekly, up to annual recurrence interval are normally considered and these frequent non-extreme events are the focus of the study.

We have reviewed several publications prepared by the BoM and CSIRO (BoM, 2016, Bom 2020, CSIRO, 2015a, CSIRO, 2015b). In particular the CSIRO publication "Climate change in Australia - Projections for Selected Australian Cities" (CSIRO, 2015b) provides projected changes for various climatic variables under three climate change scenarios and a table from the publication is reproduced in Figure 6. Under the strongest climate change scenario (2090 RCP9.5) it is projected that the 10th and 90th percentile range of change in wind speed is -6.9% to +4.2%.

A further consideration is that within the 50 to 100 year lifetime of the current development it is very likely the local and regional site context will change as a result of further building developments. This will also have an impact on the local wind speeds that maybe larger than the suggested climate change variations.

Should you wish to consider the impact of climate change on the present studies we recommend considering a 5% variation in wind speed which may be implemented by:

- Positive variation in the wind speeds for studies where increased wind speeds cause discomfort, e.g. pedestrian wind comfort studies

The effect of these variations on the recommendations and conclusions of the various report can then be discussed compared with current conditions.

**TABLE A: PROJECTED CHANGES FOR 2030 AND 2090 FOR AVERAGE TEMPERATURE, RAINFALL, EVAPOTRANSPIRATION, WIND SPEED, SOLAR RADIATION, RELATIVE HUMIDITY AND SEA LEVEL RISE FOR THE SUB-CLUSTER IN WHICH SYDNEY IS LOCATED, RELATIVE TO THE 1986-2005 AVERAGE. THE PROJECTIONS HAVE BEEN DERIVED FROM THE AVAILABLE GLOBAL CLIMATE MODEL SIMULATIONS IN THE CMIP5 ARCHIVE (UP TO 40 MODELS) DRIVEN BY RCP4.5 AND RCP8.5 (INTERMEDIATE AND HIGH EMISSION SCENARIOS FOR GREENHOUSE GASES AND AEROSOLS). FOR 2030, RESULTS FOR ALL RCP'S ARE SIMILAR SO ONLY RCP4.5 VALUES ARE SHOWN. THE MEDIAN PROJECTION IS SHOWN WITH THE 10TH TO 90TH PERCENTILE RANGE IN BRACKETS (\*5TH TO 95TH FOR SEA LEVEL RISE PROJECTIONS).**

VARIABLE	SEASON	2030 RCP4.5	2090 RCP4.5	2090 RCP8.5
Temperature (°C)	Annual	0.9 (0.6 to 1.1)	1.8 (1.3 to 2.5)	3.7 (2.9 to 4.6)
Rainfall (%)	Annual	-3 (-10 to +6)	-2 (-16 to +9)	-3 (-20 to +16)
	Summer	+1 (-10 to +15)	0 (-15 to +19)	+11 (-12 to +27)
	Autumn	-3 (-22 to +15)	-1 (-22 to +18)	-2 (-28 to +20)
	Winter	-5 (-18 to +14)	-8 (-24 to +7)	-17 (-31 to +1)
	Spring	-1 (-19 to +12)	-6 (-23 to +9)	-8 (-30 to +14)
Evapotranspiration (%)	Annual	3.4 (2.3 to 4.4)	7.8 (5.3 to 9.5)	14.3 (10.1 to 18.1)
Wind speed (%)	Annual	-1.1 (-2.9 to +0.5)	-1 (-4.2 to +0.2)	-1.1 (-6.9 to +4.2)
Solar radiation (%)	Annual	+0.5 (-0.5 to +1.9)	+1.5 (-0.3 to +3.7)	+1.3 (-1.2 to +3.4)
Relative humidity (%) (absolute)	Annual	-0.5 (-1.6 to +0.8)	-1 (-3.1 to +0.3)	-1.5 (-3.8 to +1.3)
Sea level rise (m)* (Sydney)	Annual	0.13 (0.09 to 0.18)	0.47 (0.30 to 0.65)	0.66 (0.45 to 0.88)

Figure 6: Table A Reproduced for Sydney from CSIRO(2015b)

## CONCLUSION

The conclusions of this report are drawn from our extensive experience in this field and are based on an examination of the latest architectural drawings. No wind tunnel testing has been undertaken for the subject development, and hence this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection of the architectural drawing (Architectural Design Report, Issue B, dated: 08.04.2021, received April 14, 2021). Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind environment effects.

The results of this assessment indicate that the development receives moderate shielding of the prevailing north-easterly and southerly winds due to the neighbouring mid-rise surrounding developments. However, the site remains relatively exposed to the prevailing westerly winds due to the potential for the winds to travel along Geddes Avenue and The Drying Green Public Park. The development will incorporate several design features and wind mitigating strategies and is expected to be suitable for the intended use for the majority of the outdoor trafficable areas.

Wind tunnel testing is recommended to be undertaken at a more detailed design to quantitatively assess the wind conditions within and around the development site to ensure a suitable level of amenity is achieved. Wind tunnel testing will allow for the required treatment size, screen porosity and extents to be optimised to ensure wind conditions are safe and suitable for patrons.

BoM (2016) State of the Climate 2016. Bureau of Meteorology..

BoM (2020) State of the Climate 2020. Bureau of Meteorology.

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# APPENDIX A WIND EFFECTS GLOSSARY

## A.1 Downwash and Upwash Effects

The downwash wind effect occurs when wind is deflected down the windward face of a building, causing accelerated winds at pedestrian level. This can lead to other adverse effects as corner acceleration as the wind attempts to flow around the building, as seen in Figure A.1.

This can also lead to recirculating flow in the presence of a shorter upstream building, causing local ground level winds to move back into the prevailing wind.

The upwash effect occurs near upper level edge of a building form as the wind flows over the top of the building. This has the potential to cause acceleration of winds near the leading edge, as well as potentially reattaching onto the roof area. This effect causes wind issues particularly near the leading edges of tall building and on the rooftop areas if there is sufficient depth along the wind direction. Upwash is more apparent in taller towers and podia.

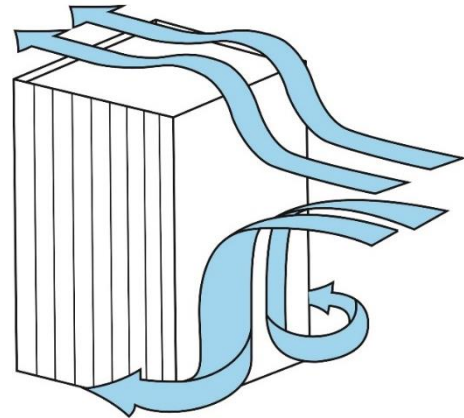


Figure A.1: Downwash Leading to Corner Wind Effect, and Upwash Effects

## A.2 Funnelling/Venturi Effect

Funnelling occurs when the wind interacts with two or more buildings which are located adjacent to each other, which results in a bottleneck, as shown in Figure A.2. This causes the wind to be accelerated through the gap between the buildings, resulting in adverse wind conditions and pedestrian discomfort within the constricted space. Funnelling effects are common along pedestrian links and thoroughfares generally located between neighbouring buildings that have moderate gaps between them.

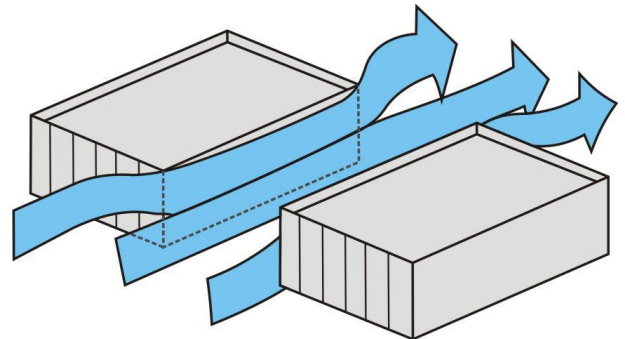


Figure A.2: Funnelling/Venturi Wind Effect

## A.3 Gap Effect

The gap effect occurs in small openings in the façade that are open to wind on opposite faces, as seen in Figure A.3. This can involve a combination of funnelling and downwash effects. Presenting a small gap in the façade on the windward aspect as the easiest means through which the wind can flow through can result in wind acceleration through this gap. The pressure difference between the windward façade and the leeward façade also tends to exacerbate the wind flow through this gap.

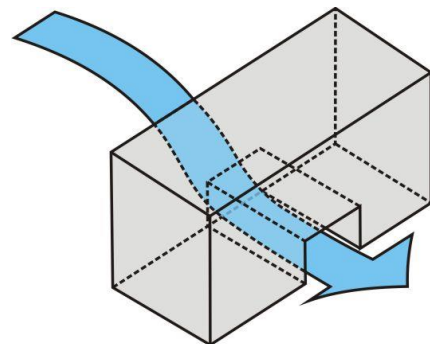


Figure A.3: Gap Wind Effect

## A.4 Sidestream and Corner Effects

The sidestream effect is due to a gradual accumulation of wind shearing along the building façade that eventuates in an acceleration corner effect. The flow is parallel to the façade and can be exacerbated by downwash effects as well, or due to corner effect winds reattaching on the façade.

This is shown in Figure A.4. The corner refers to the acceleration of wind at the exterior vertical edge of a building, caused by the interaction of a large building massing with the incident wind, with the flow at the corner being accelerated due to high pressure differentials sets up between the windward façade and the orthogonal aspects. It can be further exacerbated by downwash effects that build up as the flow shears down the façade.

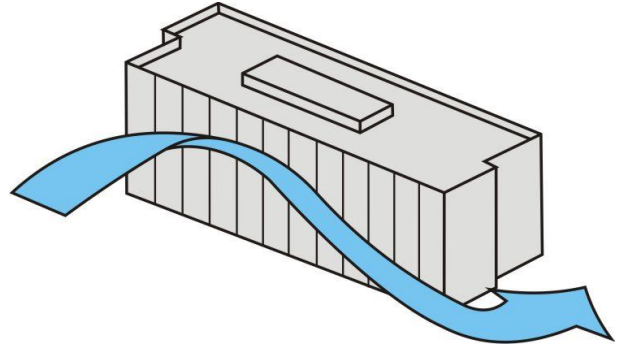


Figure A.4: Sidestream and Corner Wind Effect

## A.5 Stagnation

Stagnation in a region refers to an area where the wind velocity is significantly reduced due to the effect of the flow being impeded by the bluff body. For a particular prevailing wind direction, this is typically located near the middle of the windward face of the building form or over a short distance in front of the windward face of a screen or fence. Concave building shapes tend to create an area of stagnation within the cavity, and wind speeds are generally low in these areas.