WINDTECH

PEDESTRIAN WIND ENVIRONMENT STATEMENT

LIVERPOOL BOYS AND GIRLS HIGH SCHOOL UPGRADE PROJECT

WJ008-01F02(REV3)- WS REPORT
FEBRUARY 13, 2025

Prepared for:

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DOCUMENT CONTROL

Date	Revision History	Issued Revision	Prepared By (initials)	Instructed By (initials)	Reviewed & Authorised by (initials)
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November 19, 2024	Updated treatments.	1	AFM	MM	AFM/MM
February 3, 2025	Updated treatments.	2	AFM	MM	AFM/MM
February 13, 2025	Added Mitigations Table.	3	AFM	MM	AFM

EXECUTIVE SUMMARY

This report presents an opinion on the likely impact of the Liverpool Boys and Girls High School (LBGHS), located at Lachlan & Forbes Street, in Liverpool, on the local wind environment at the 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, south-easterly, 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 dated October 24, 2024 (received October 25, 2024). 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 has incorporated 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. However, there are some areas that are likely to be exposed to stronger winds. It is expected that the wind effects identified in the report can be ameliorated with the consideration of the following treatment strategies into the design of the development:

Mitigation Measures for the Lower Ground Level and The Ground Level:

- Retention of the proposed trees throughout the development (north, west and central courtyards), ensuring that the trees are of an evergreen and densely foliating species capable of growing to a height of at least 3-5m, with 3-5m wide canopies.
- Retention of the proposed 1.3m high porous screens (max. porosity = 30%) along the exposed edges of the walkways.
- Retention of the proposed porous fencing (max. porosity = 30%) along the north facing entrance at the Lower Ground Level.
- Stairwells: Retention of the proposed full-height 30% porous screens on the southern/eastern aspects of the stairwells, and 60% porous balustrades, (OR),

  Inclusion of full-height 30% porous screening within the first 2.4m height above the FFL, and 60% porous screening within the upper 1.1m of the floor height.

Mitigation Measures for Level 1 to Level 4:

- Retention of the proposed full-height porous screens (max. porosity = 30%) around the stairwells.
- Retention of the proposed 1.3m high porous screens (max. porosity = 30%) along the exposed edges of the walkways.
- Inclusion of full-height wind barriers on the open façade areas on the northern and western aspects of the floor plans. The wind barriers may consist of full-height 30% porous screening, or, 1m high planter boxes with 0.5-1m high hedges/shrubs that overlap with the proposed roller blinds/screens.
- Stairwells: Retention of the proposed full-height 30% porous screens on the southern/eastern aspects of the stairwells, and 60% porous balustrades, (OR),

Inclusion of full-height 30% porous screening within the first 2.4m height above the FFL, and 60% porous screening within the upper 1.1m of the floor height.

With the inclusion of the abovementioned recommendations in the final design, it is expected that wind conditions for the various trafficable outdoor areas within and around the development will be suitable for their intended uses, and that the wind speeds will satisfy the applicable criteria for pedestrian comfort and safety. The wind conditions occurring within and around the proposed school development can be quantified via a wind tunnel test undertaken at a more details design stage if required, which can also assist with the optimisation of the size and extent of the treatments required.

CONTENTS

1 INTRODUCTION

This desktop pedestrian wind comfort assessment report has been prepared by Windtech Consultants on behalf the NSW Department of Education (the Applicant) to assess the potential environmental impacts that could arise from the redevelopment of the Liverpool Boys High School and Liverpool Girls High School, at 18 Forbes Street, Liverpool NSW, 2170 (the site).

This report has been prepared to present an opinion on the likely impact of the proposed design on the local wind environment affecting pedestrians within the critical outdoor areas within and around the subject development. 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. No wind tunnel testing has been undertaken for this assessment. Hence this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection of the drawings provided (as referenced in Appendix B), and any recommendations in this report are made only in-principle.

This report accompanies a Review of Environment Factors (REF) that seeks approval for redeveloping the Liverpool Boys and Liverpool Girls High Schools into a single co-educational school, including:

[redacted]

- Construction and operation of a six-storey school building, including school hall and gymnasium;
- Associated parking and building services;
- Tree removal;
- Associated landscaping and play spaces;
- Augmentation of service infrastructure; and
- Associated off-site infrastructure works to support the school, including (but not limited to) services, kiss and drop point and pedestrian crossings.

For reference, the following REF requirement is addressed in this report:

Table A: REF Requirement

Item	REF Requirement	Relevant Section of Report
1	Desktop Pedestrian Wind Comfort Assessment	Section 5 – Results, Discussion and Mitigation Measures

Statement of Significance

Based on the identification of potential issues, and an assessment of the nature and extent of the impacts of the proposed development, it is determined that the extent and nature of potential impacts are moderate, which can be appropriately mitigated or managed to ensure that there is minimal effect on the locality, community and the environment.

2 SITE DESCRIPTION

The site is located at 18 Forbes Street, Liverpool, within the Liverpool Local Government Area (LGA). The site is legally described as Lot 1 DP1137425 and has a total area of approximately 74,973m^2, and is bounded by Lachlan Street to the north, Forbes Street to the west, 1-2 storey school buildings and grass areas to the south. The buildings surrounding the subject development are predominately low-rise residential and commercial buildings, with a train rail line to the east and the Georges River to the south.

The site itself comprises a broadly rectangular portion of land which currently contains the existing Liverpool Boys High School, Liverpool Girls High School, and the Gulyangarri Public School, which commenced operations in January 2024 and is located to the east of the wider site. The site's western portion contains Liverpool Boys High School and Liverpool Girls High School. Liverpool Girls High School in the site's southwest comprises three, two-storey buildings. Liverpool Boys High School in the site's northwest, comprises approximately four, two-storey buildings, with adjacent at-grade carparking and various sports courts.

A survey of the land topography indicates a gradual upward slope towards the north-west, causing some topographical effects in the area immediately surrounding 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 is superimposed for each wind direction. The existing site consists of 1-2 storey school buildings. The proposed building is 6 storeys high.

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 trafficable areas and surrounding pedestrian footpaths.
- The various elevated open areas, including the open walkways and the adjoining stairwells (Lower Ground Level to Level 4).

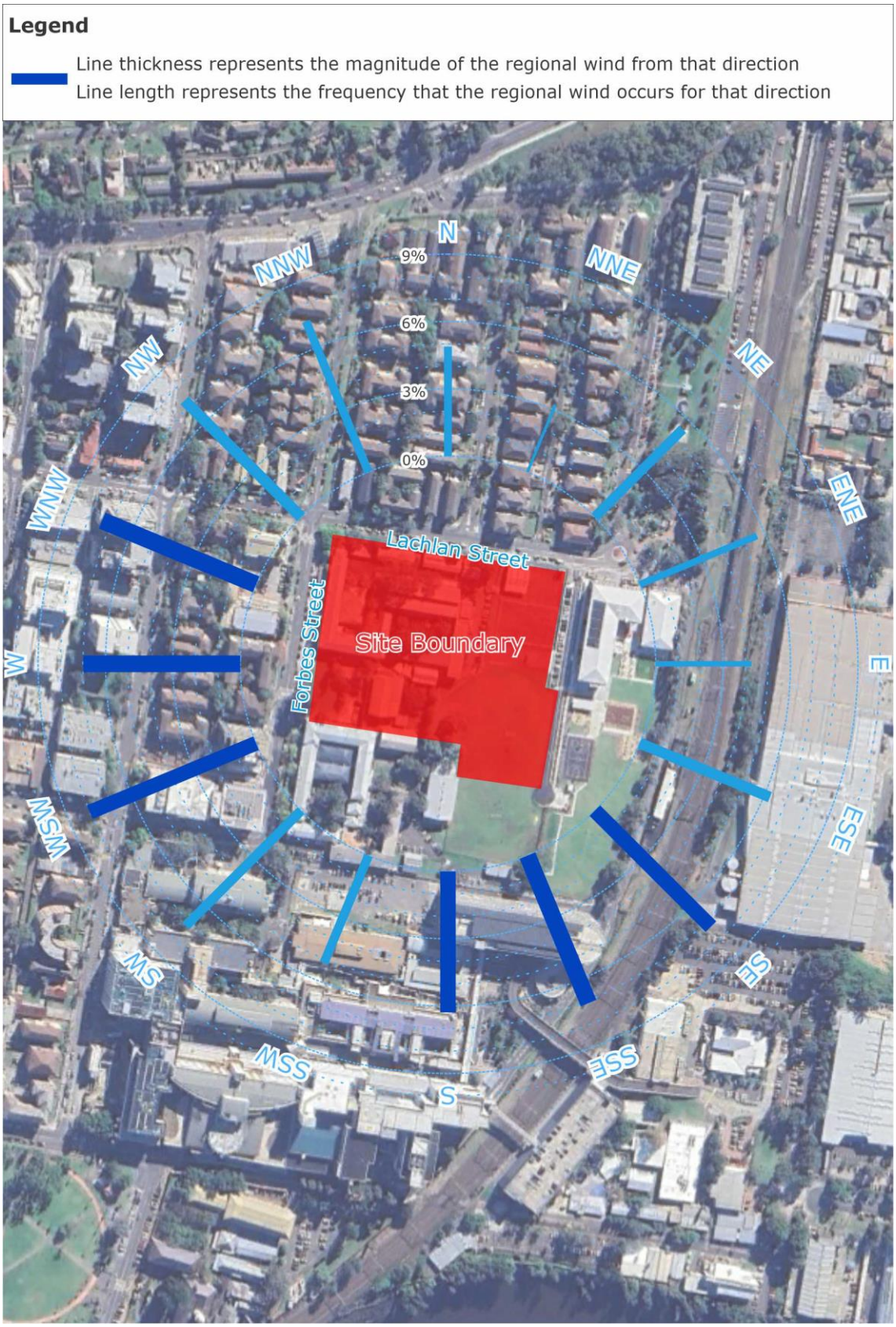

Figure 1: Aerial Image of the Site Location and Prevailing Wind Directions

3 REGIONAL WIND

The Liverpool region is governed by three principal wind directions that can potentially affect the subject development. These winds prevail from the north-east, south-east, 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 Bankstown Airport by the Bureau of Meteorology (recorded from 1993 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.

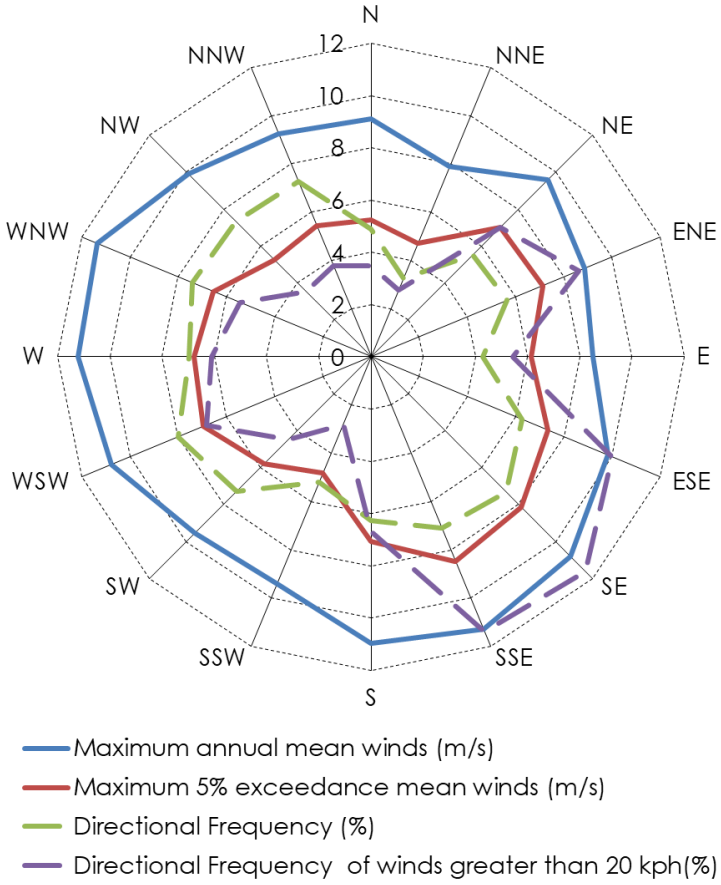

Figure 2: Directional Annual and 5% Exceedance Hourly Mean Wind Speeds (referenced to 10m height in standard open terrain), and Frequencies of Occurrence, for the Liverpool Region

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.

5 RESULTS, DISCUSSION AND MITIGATION MEASURES

The expected wind conditions affecting the development are discussed in the following sub-sections of this report for the various outdoor areas within and around the subject development. 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 (Short Exposure) 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 (Long Exposure) (4m/s with a 5% probability of exceedance)
  for stationary activities longer than an hour, e.g. outdoor cinemas, outdoor fine dining etc.

Note that the above wind comfort levels are derived from the Lawson (1975) criteria. 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 23m/s for the annual maximum gust.

5.1 Ground Level Trafficable Areas and Pedestrian Footpaths

The pedestrian footpath along Lachlan Street is exposed to the north-easterly prevailing winds. Given the set-back of the proposed building massing from the site boundary (and hence the adjacent footpath), the effects of these prevailing winds on the footpath areas with the inclusion of the subject development are expected to be marginally higher than the existing wind conditions. In the event the northern façade of the northern façade of the massing results in side-streaming of the north-easterly winds, the existing row of trees along the Lachlan Street is recommended to be retained to ameliorate these wind effects. Given the alignment of Lachlan Street footpath with the westerly winds, the effects of these winds on the footpath with the inclusion of the proposed building massing are expected to be comparable to the existing conditions. The pedestrian footpath along Forbes Street is exposed to the prevailing westerly winds, and in addition to direct effects, these winds can also down-wash off the western façade on to the Ground Level areas underneath. However, given the set-back of the building massing from the footpath, and with the inclusion of proposed row of trees along the street, the Forbes Street footpath is expected to be suitable for circulation activities even with the inclusion of the subject development.

The entrances located to the north (Lower Ground) and west (Ground) of the development are exposed to the prevailing north-easterly and westerly prevailing winds, respectively. These winds can also generate funnelling

effects as the winds travel through the entrances, which are expected to be ameliorated with strategic use of tree planting and screening. The various courtyard areas located to the south of the building massing will receive direct south-easterly and westerly winds. While these winds are not expected to cause safety concerns within the courtyard areas, the required comfort levels within these areas can be achieved with the retention of the proposed trees.

The open walkways (along the side of the building) and the adjoining stairwells are exposed to direct south-easterly prevailing winds, which may cause undesirable effects on the patrons using these areas. These walkways and open stairwells can be treated with strategic inclusion of porous screening.

The following treatment measures are recommended to be included in the design to ensure safe and comfortable wind conditions within and around the ground plane of the proposed development. These measures are also shown in Figures 3a and 3b:

Mitigation Measures (Lower Ground Level and Ground Level):

- Retention of the proposed trees throughout the development (north, west and central courtyards), ensuring that the trees are of an evergreen and densely foliating species capable of growing to a height of at least 3-5m, with 3-5m wide canopies.
- Retention of the proposed 1.3m high porous screens (max. porosity = 30%) along the exposed edges of the walkways.
- Retention of the proposed porous fencing (max. porosity = 30%) along the north facing entrance at the Lower Ground Level.
- Stairwells: Retention of the proposed full-height 30% porous screen on the southern/eastern aspects of the stairwells, and 60% porous balustrades, (OR),

  Inclusion of full-height 30% porous screening within the first 2.4m height above the FFL, and 60% porous screening within the upper 1.1m of the floor height.

5.2 Elevated Open Spaces (Level 1 to Level 4)

The open walkways (along the side of the building) and the adjoining stairwells are exposed to direct south-easterly prevailing winds, which may cause undesirable effects on the patrons using these areas. Furthermore, the open façade areas on the northern and western aspects of the development at Levels 1-4 have the potential to capture and funnel the prevailing north-easterly and westerly winds though these spaces, which can result in safety and comfort exceedances within these spaces.

The following treatment measures are recommended to be included in the design to ensure safe and comfortable wind conditions elevated open spaces within the proposed development. These measures are also shown in Figures 4, 5, 6 and 7:

Mitigation Measures (Level 1 to Level 4):

- Retention of the proposed 1.3m high porous screens (max. porosity = 30%) along the exposed edges of the walkways.
- Inclusion of full-height wind barriers on the open façade areas on the northern and western aspects of the floor plans. The wind barriers may consist of full-height 30% porous screening, or, 1m high planter boxes with 0.5-1m high hedges/shrubs that overlap with the proposed roller blinds/screens.

- Stairwells: Retention of the proposed full-height 30% porous screens on the southern/eastern aspects of the stairwells, and 60% porous balustrades, (OR),

  Inclusion of full-height 30% porous screening within the first 2.4m height above the FFL, and 60% porous screening within the upper 1.1m of the floor height.

5.3 Concluding Remarks and Summary of Recommendations

With the inclusion of the abovementioned recommendations in the final design, it is expected that wind conditions for the various trafficable outdoor areas within and around the development will be suitable for their intended uses, and that the wind speeds will satisfy the applicable criteria for pedestrian comfort and safety. The recommendations are summarised in Table 2 below. The wind conditions occurring within and around the proposed school development can be quantified via a wind tunnel test undertaken at a more details design stage if required, which can also assist with the optimisation of the size and extent of the treatments required.

Table 2: Mitigati

Project Stage Design (D) Construction (C) Operation (O)	Mitigation Measures	Relevant Section of Report
	Lower Ground Level and Ground Level	
D	Retention of the proposed trees throughout the development (north, west and central courtyards), ensuring that the trees are of an evergreen and densely foliating species capable of growing to a height of at least 3-5m, with 3-5m wide canopies.	Section 5
D	Retention of the proposed 1.3m high porous screens (max. porosity = 30%) along the exposed edges of the walkways.	Section 5
D	Retention of the proposed porous fencing (max. porosity = 30%) along the north facing entrance at the Lower Ground Level.	Section 5
D	Stairwells: Retention of the proposed full-height 30% porous screen on the southern/eastern aspects of the stairwells, and 60% porous balustrades, (OR), Inclusion of full-height 30% porous screening within the first 2.4m height above the FFL, and 60% porous screening within the upper 1.1m of the floor height	Section 5
	Elevated Open Spaces (Level 1 to Level 4)	
D	Retention of the proposed 1.3m high porous screens (max. porosity = 30%) along the exposed edges of the walkways.	Section 5
D	Inclusion of full-height wind barriers on the open façade areas on the northern and western aspects of the floor plans. The wind barriers may consist of full-height 30% porous screening, or, 1m high planter boxes with 0.5-1m high hedges/shrubs that overlap with the proposed roller blinds/screens.	Section 5
D	Stairwells: Retention of the proposed full-height 30% porous screens on the southern/eastern aspects of the stairwells, and 60% porous balustrades, (OR), Inclusion of full-height 30% porous screening within the first 2.4m height above the FFL, and 60% porous screening within the upper 1.1m of the floor height	Section 5

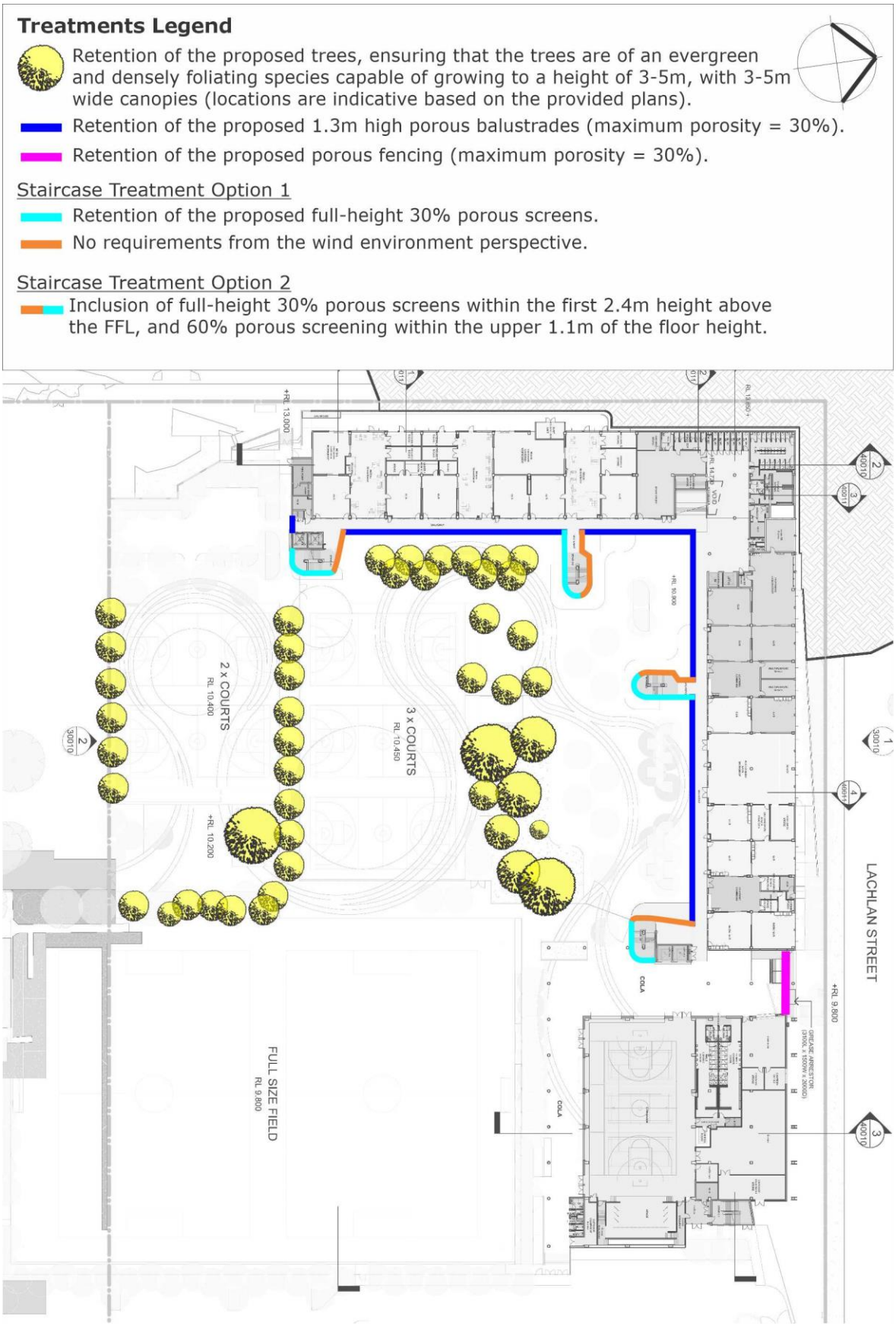

Figure 3a: Recommended Treatments (Lower Ground Level)

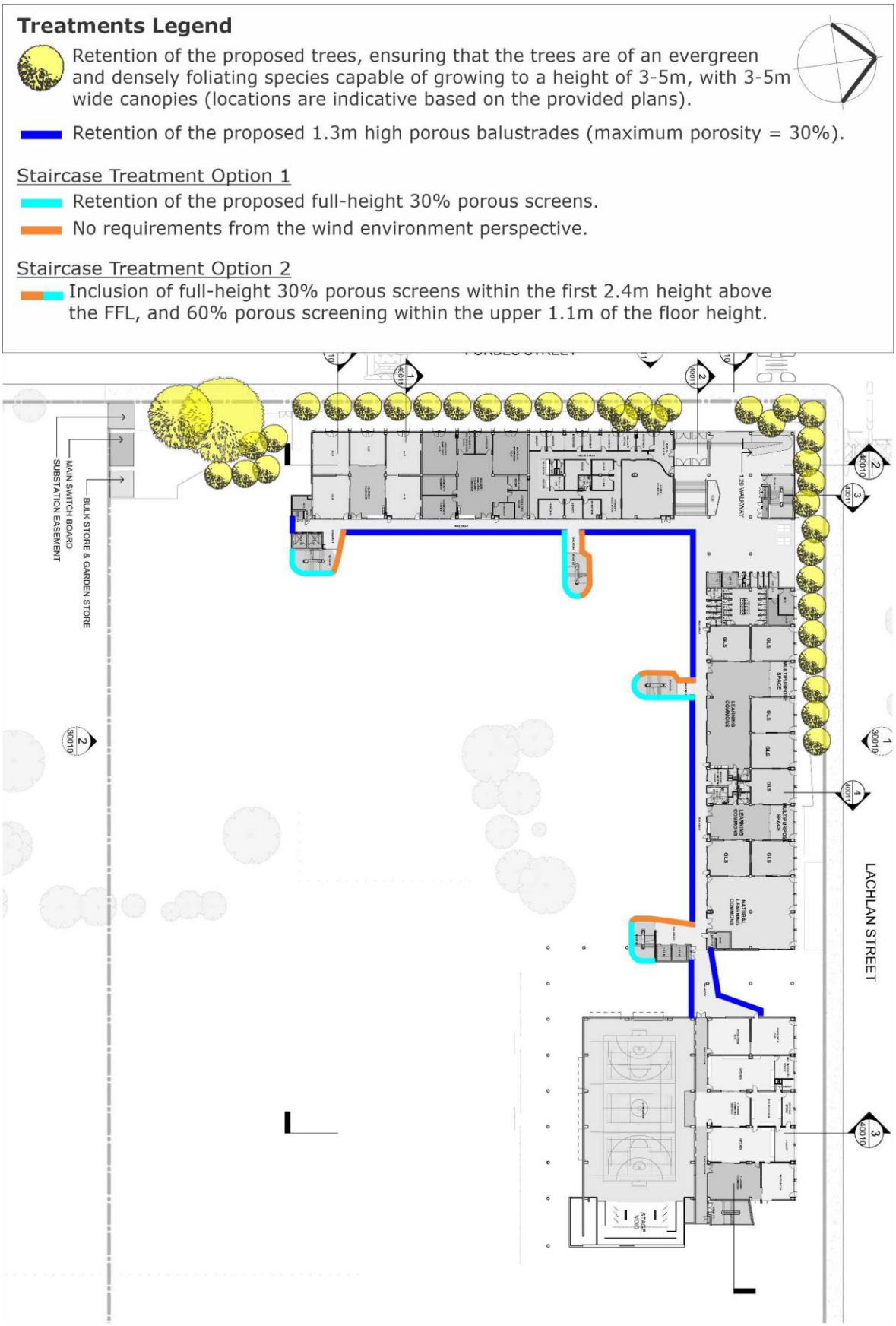

Figure 3b: Recommended Treatments (Ground Level)

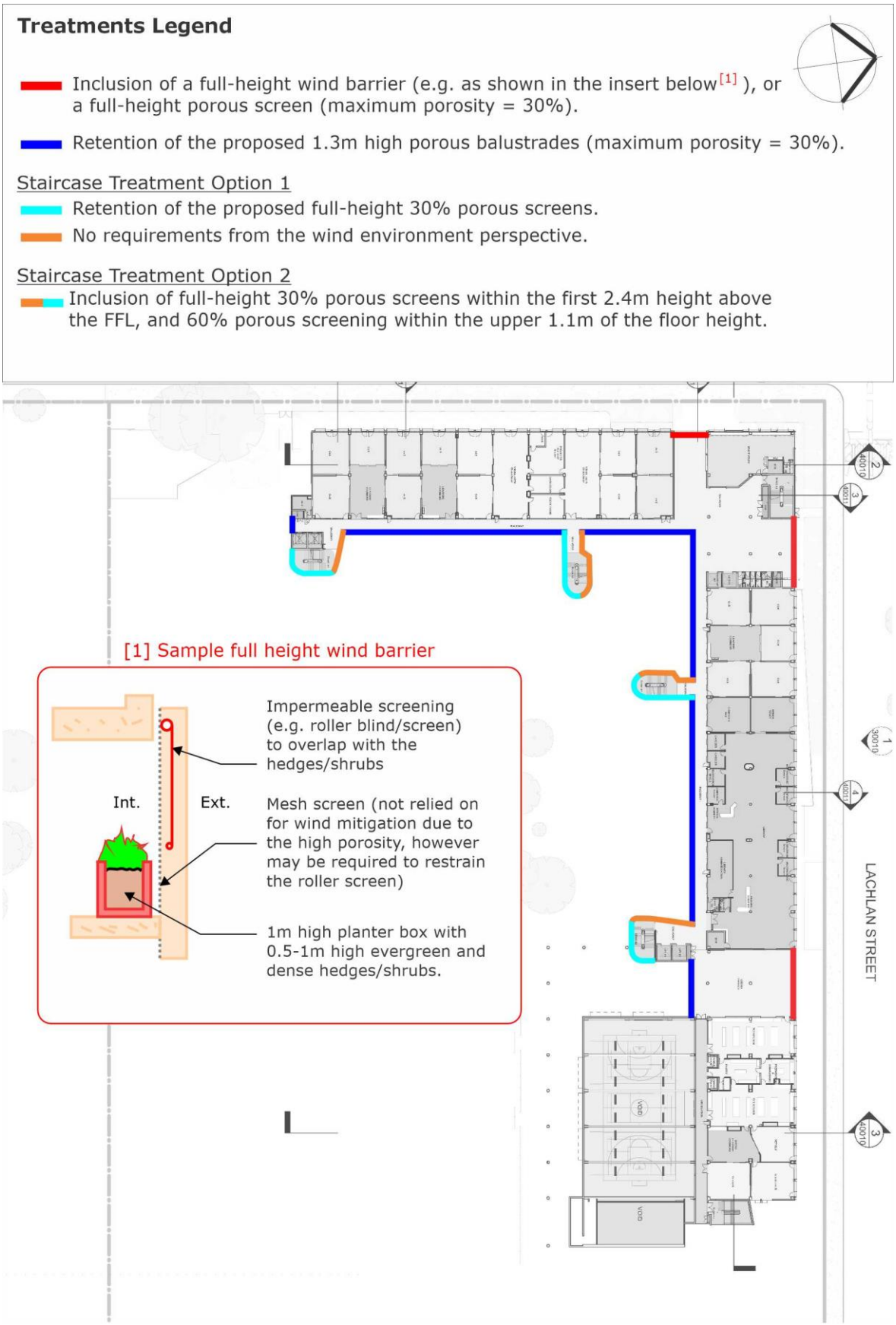

Figure 4: Recommended Treatments (Level 1)

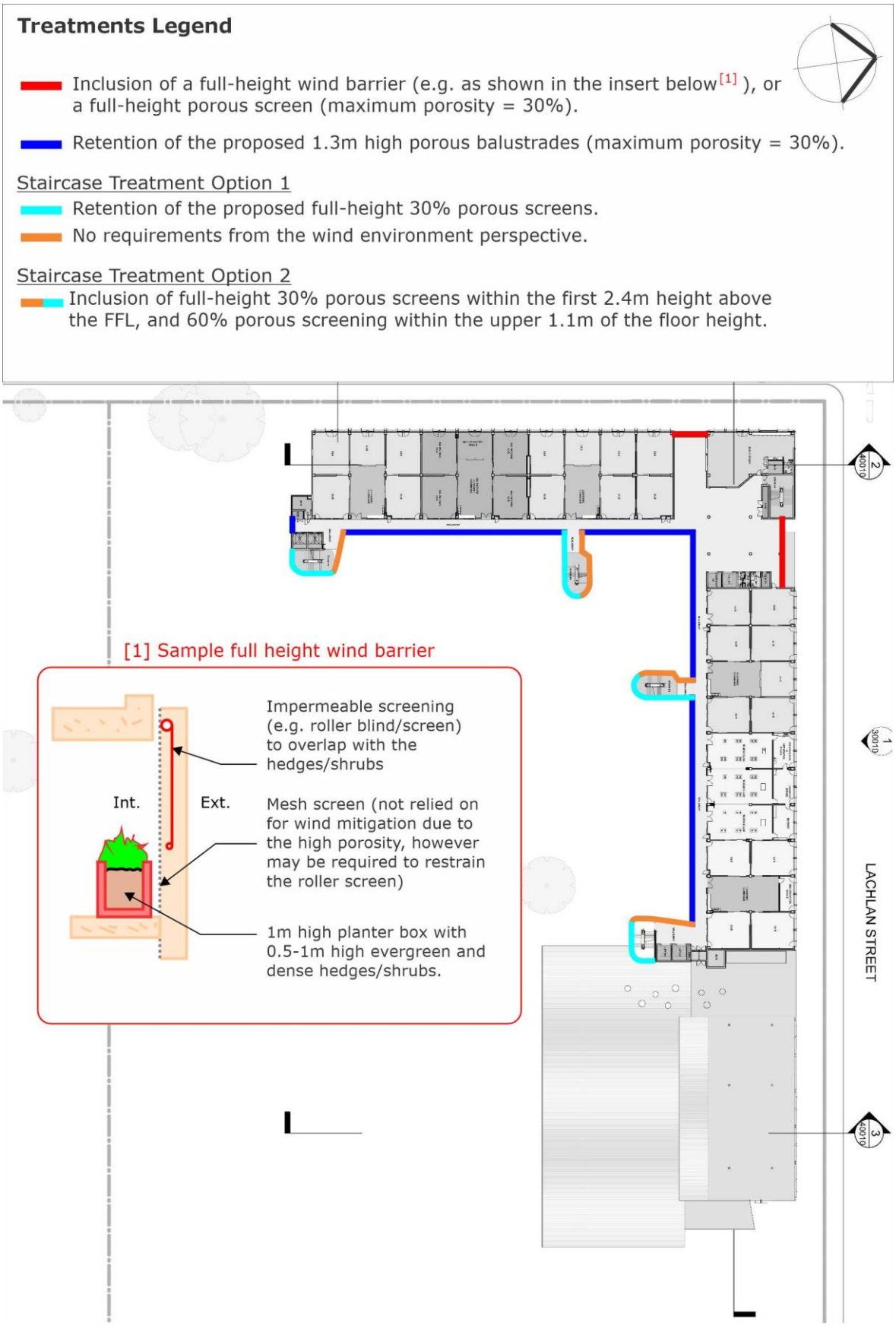

Figure 5: Recommended Treatments (Level 2)

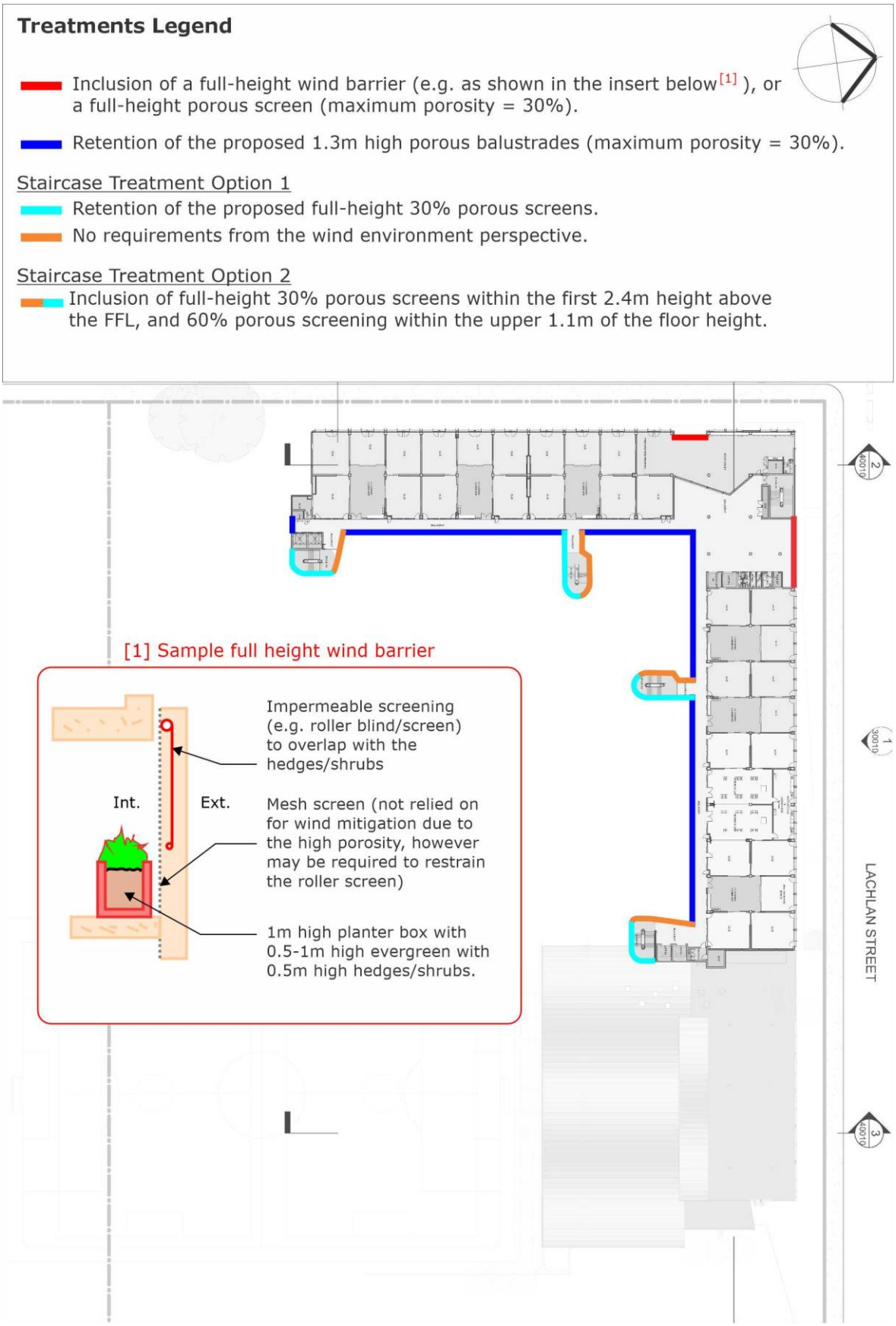

Figure 6: Recommended Treatments (Level 3)

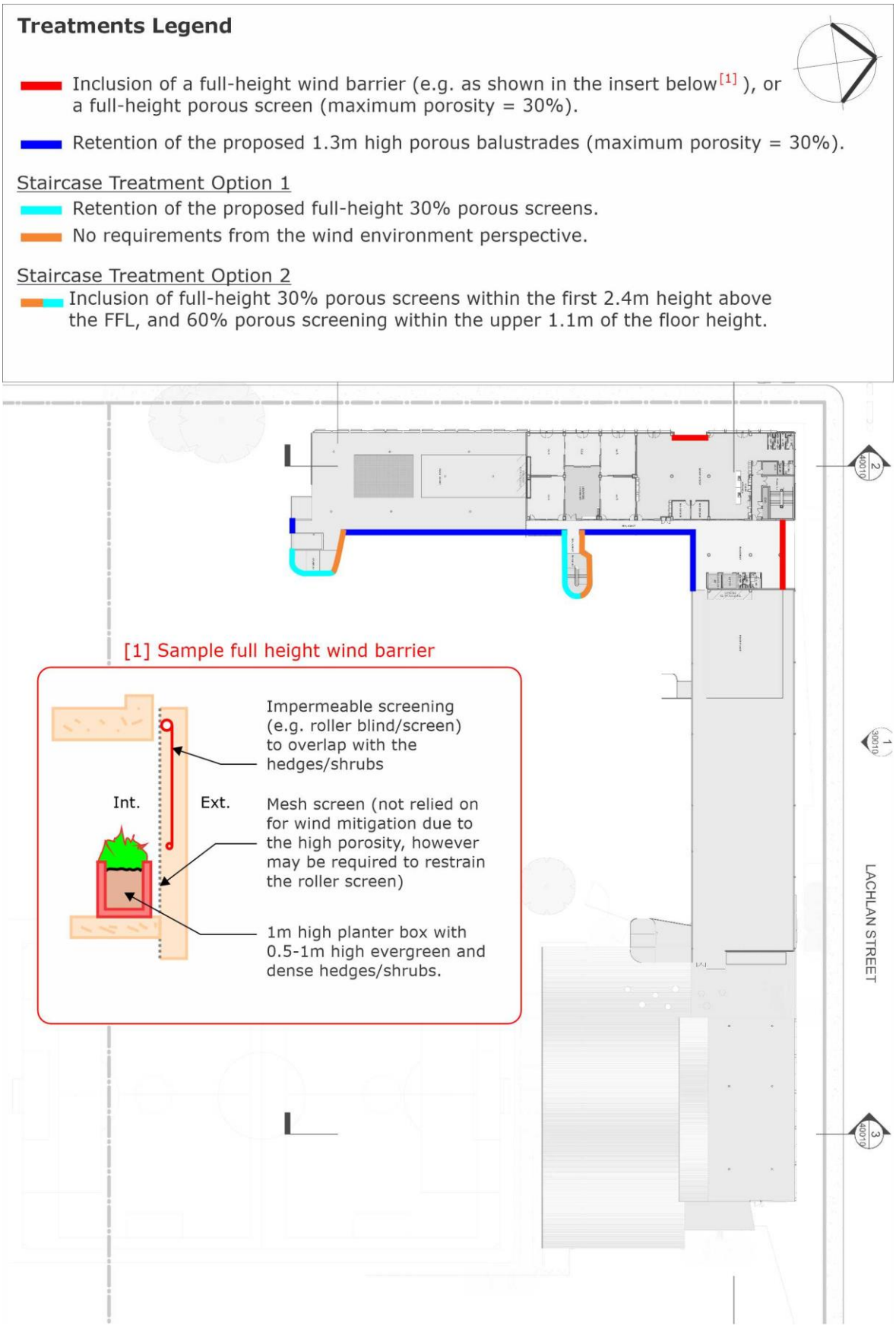

Figure 7: Recommended Treatments (Level 4)

6 REFERENCES

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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.

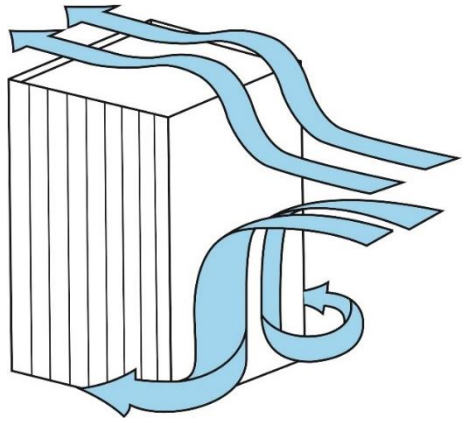

Figure A.1: Downwash Leading to Corner Wind Effect, and Upwash Effects

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.

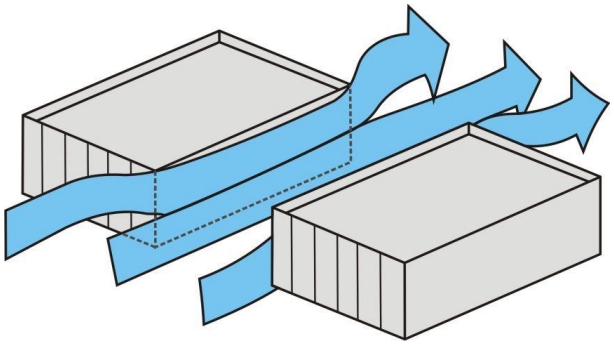

Figure A.2: Funnelling/Venturi Wind Effect

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.

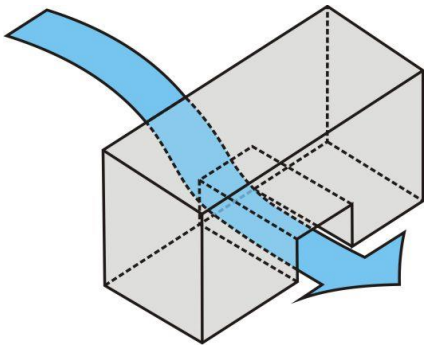

Figure A.3: Gap Wind Effect

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.

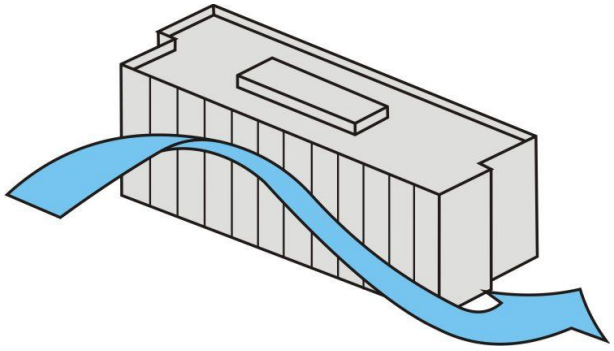

Figure A.4: Sidestream and Corner Wind Effect

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.

APPENDIX B LIST OF ARCHITECTURAL DRAWINGS

Table B1: List of Architectural Drawings Referenced

Drawing No. and Title	Revision number	Date
Overall Lower Ground Floor Plan LBGHS-NBRS-00-ZZ-DR-A-01200	10	Oct 24, 2024
Overall Ground Floor Plan LBGHS-NBRS-00-ZZ-DR-A-01200	10	Oct 24, 2024
Overall Level 1 Floor Plan LBGHS-NBRS-00-ZZ-DR-A-01202	10	Oct 24, 2024
Overall Level 2 Floor Plan LBGHS-NBRS-00-ZZ-DR-A-01203	10	Oct 24, 2024
Overall Level 3 Floor Plan LBGHS-NBRS-00-ZZ-DR-A-01204	10	Oct 24, 2024
Overall Level 4 Floor Plan LBGHS-NBRS-00-ZZ-DR-A-01205	10	Oct 24, 2024
Overall Roof Plan LBGHS-NBRS-00-ZZ-DR-A-01206	10	Oct 24, 2024
Site Elevation Steet 1	8	Oct 24, 2024
Site Elevation Steet 2	8	Oct 24, 2024