ARUP

NSW Department of Education

Bungendore High School

Environmental Wind Assessment

Reference: Wind

Revision 07 | 17 March 2025

Job number 304002-00

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Document Verification

Project title	Bungendore High School
Document title	Environmental Wind Assessment
Job number	304002-00
Document ref	Wind
File reference	

Revision	**Date**	**Filename**	Bungendore High School_ARUP wind REP_241129		
Initial release	29 Nov 2024	**Description**	Initial release		
			Prepared by	**Checked by**	**Approved by**
		Name	Lauren Boysen	Sina Hassanli	Lauren Boysen
		Signature			
Rev. 01	5 Dec 2024	**Filename**	Bungendore High School_ARUP wind REP_241205		
		Description	Minor updates as per planner comments.		
			Prepared by	**Checked by**	**Approved by**
		Name	Lauren Boysen	-	Lauren Boysen
		Signature			
Rev. 02	13 Feb 2025	**Filename**	Bungendore High School_ARUP wind REP_250213		
		Description	Updated site plan & landscape drawings		
			Prepared by	**Checked by**	**Approved by**
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		Signature			
Rev. 03	17 Feb 2025	**Filename**	Bungendore High School_ARUP wind REP_250217		
		Description	Minor updates as per Statutory Planning comments and latest floor plans included.		
			Prepared by	**Checked by**	**Approved by**
		Name	Lauren Boysen	-	Lauren Boysen
		Signature			
Rev. 04	20 Feb 2025	**Filename**	Bungendore High School_ARUP wind REP_250220		
		Description	Minor update (typographical error).		

			Prepared by	Checked by	Approved by
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Rev. 05	24 Feb 2025	**Filename**	Bungendore High School_ARUP wind REP_250224		
		Description	Minor updates to standard description.		
			Prepared by	**Checked by**	**Approved by**
		Name	Lauren Boysen	-	Lauren Boysen
		Signature			
Rev. 06	25 Feb 2025	**Filename**	Bungendore High School_ARUP wind REP_250225		
		Description	Minor updates to standard description.		
			Prepared by	**Checked by**	**Approved by**
		Name	Lauren Boysen	-	Lauren Boysen
		Signature			
Rev. 07	17 Mar 2025	**Filename**	Bungendore High School_ARUP wind REP_250317		
		Description	Minor updates to standard description.		
			Prepared by	**Checked by**	**Approved by**
		Name	Lauren Boysen	-	Lauren Boysen
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Issue Document Verification with Document ☑

Executive Summary

This Environmental Wind Assessment has been prepared to support a Review of Environmental Factors (REF) for the NSW Department of Education (DoE) for the construction and operation of the new Bungendore High School (the activity).

The purpose of the REF is to assess the potential environmental impacts of the activity prescribed by State Environmental Planning Policy (Transport and Infrastructure) 2021 (T&I SEPP) as “development permitted without consent” on land carried out by or on behalf of a public authority under Part 5 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The activity is to be undertaken pursuant to Chapter 3, Part 3.4, Section 3.37A of the T&I SEPP.

This document has been prepared in accordance with the Guidelines for Division 5.1 assessments (the Guidelines) by the Department of Planning, Housing and Infrastructure (DPHI). The purpose of this report is to provide an experienced-based wind impact assessment of the proposed Bungendore High School, on the pedestrian level wind conditions for comfort and safety in and around the site. The assessment is based on completion of the first stage of development, without the future expansion which forms part of the masterplan.

The site is located in a fairly open area with open farmland further afield and low-rise residential blocks immediately surrounding the site. The local wind climate is reasonably windy, particularly for winds from the north-west. The varied topography of the site additionally influences the local wind climate. It is expected that the proposed development will have an impact on the local wind environment, with some areas becoming calmer, and others becoming windier.

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that from a comfort perspective, the wind conditions at the majority of locations around the site would be classified as suitable for pedestrian walking or standing type activities at ground level. This would increase to suitable for walking and/or objective walking around some of the outer corners of the buildings, particularly the north-east corner of Block B and in between blocks. Areas in the lee of prevailing winds, such as the eastern area of the Lower Terrace and immediately adjacent to the northern embankment where the slope is steep (and flow has separated), would experience calmer conditions that would be likely suitable for sitting to standing type activities.

Seated areas on the Upper Terrace, south of the main entry on the southern perimeter and along the walkway north-east of the sports field will require local mitigation measures in the form of vertical barriers to render these areas suitable for sitting.

All areas around the development would be expected to meet the pedestrian safety criterion.

The proposed future expansion would likely improve wind comfort conditions, particularly for the Upper Terrace. The future expansion would ideally connect with Block B to avoid any accelerated flow through a narrow zone.

To quantify the qualitative advice provided in this report, numerical or physical modelling of the development would be required, which is best conducted during detailed design.

Contents

Tables

Figures

Appendices

Disclaimer

This assessment of the site environmental wind conditions is presented based on engineering judgement. In addition, experience from more detailed simulations have been used to refine recommendations. No detailed simulation, physical or computational study has been made to develop the recommendations presented in this report.

1. Introduction

This Environmental Wind Assessment has been prepared to support a Review of Environmental Factors (REF) for the NSW Department of Education (DoE) for the construction and operation of the new Bungendore High School (the activity).

The purpose of the REF is to assess the potential environmental impacts of the activity prescribed by *State Environmental Planning Policy (Transport and Infrastructure) 2021* (T&I SEPP) as “development permitted without consent” on land carried out by or on behalf of a public authority under Part 5 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The activity is to be undertaken pursuant to Chapter 3, Part 3.4, Section 3.37A of the T&I SEPP.

This document has been prepared in accordance with the *Guidelines for Division 5.1 assessments* (the Guidelines) by the Department of Planning, Housing and Infrastructure (DPHI) as well as the *Addendum Division 5.1 guidelines for schools and Addendum October 2024 (Consideration of environmental factors for health services facilities and schools)*.

The assessment is based on Stage 1 development completion, without future stages which form part of the masterplan; discussion regarding potential future development impacts is also included.

2. Site description

The current street address is part of 18 Harp Avenue, Bungendore, NSW, 2621 (the site), and is legally described as part Lot 125 in Deposited Plan 1297613. As shown at Figure 1, the proposed school site forms part of a larger lot which is the subject of a proposed residential subdivision.

The site is located within the North Bungendore Precinct (Elm Grove Estate) in Bungendore. As a result of precinct wide rezonings, the surrounding locality is currently transitioning from a semi-rural residential area to an urbanised area with new low density residential development.

The site is zoned R2 Low Density Residential, with all adjoining land also zoned R2 Low Density Residential.

The site has three frontages:

- Approx 500m southern frontage to Birchfield Drive.
- Approx 500m northern frontage to Bridget Avenue.
- Approx 100m eastern frontage to Winyu Rise.

The site is currently cleared of all vegetation and consists of grassland, having been prepared for the purposes of future low density residential development.

Figure 1: Aerial Photograph of the Site (Source: Urbis, 2024)

3. Proposed Activity Description

The proposed activity is for the construction and operation of a new high school in Bungendore at part 18 Harp Avenue, Bungendore (the **site**). The new high school will accommodate 600 students and 68 staff. The school will provide 26 general learning spaces, and three support learning spaces across two buildings. The buildings will be predominantly three-storeys in height and will include permanent and support teaching spaces, specialist learning hubs, a library, administrative areas and a staff hub.

Additional core facilities are also proposed including a standalone school hall with covered outdoor learning area (**COLA**), a car park, a kiss and drop zone along Birchfield Drive, sports courts and a sports field. The new school also features a single storey building with associated paddocks in the far western portion of the site designed for livestock management and hands-on agricultural learning.

Specifically, the proposal involves the following:

- Building A, a three-storey learning hub accommodating general learning spaces, a special education learning unit (SELU), a physical education centre, a performing arts space, and other core facilities including administrative areas, staff hub, library and end of trip facilities.
- Building B, a part three/part four storey learning hub accommodating general learning spaces, specialist workshops for food, textile, wood and metal workshops, as well as visual arts studios, science labs and staff areas.
- Building C, a standalone school hall with COLA.
- Building D, a single-storey agricultural block comprising an animal storage space, a COLA and internal workshop.
- On-site staff car park with 50 spaces with access via Bridget Avenue.
- Kiss and drop zones and bus bays along Birchfield Drive.

- Open play space including a sports courts and sports field.
- Associated utilities and services including a 1000kv padmount substation.
- Main pedestrian entrance to be located off Birchfield Drive.
- Secondary pedestrian access from Bridget Avenue.
- Public domain/off-site works including the removal of street trees.

The design has been masterplanned to allow for an additional future stage. The second stage does not form part of this proposal.

Figure 2 provides an extract of the proposed site plan.

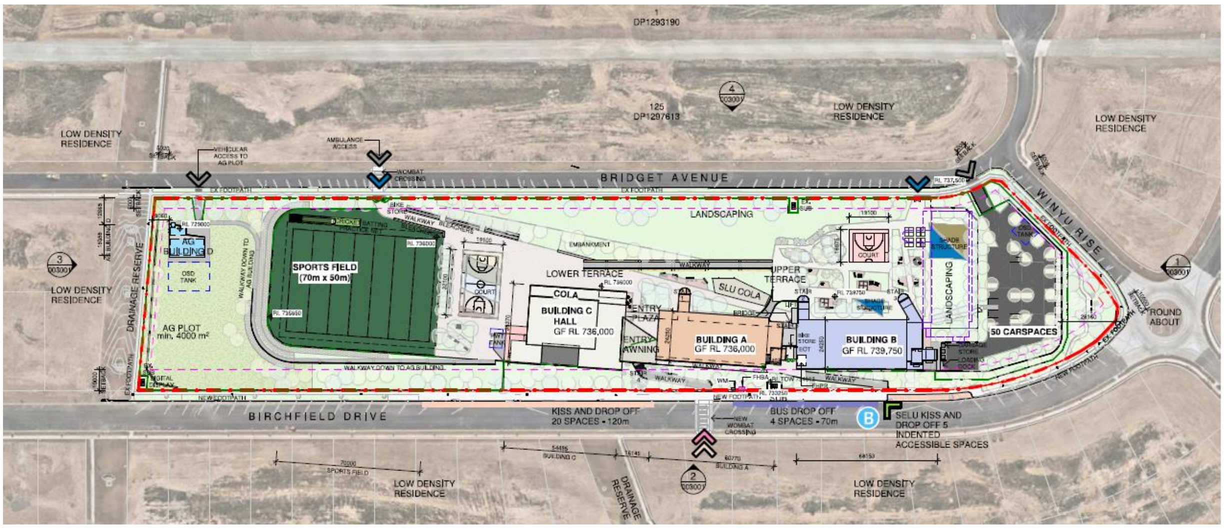

Figure 2: Site Plan (Source: NBRS, 2024)

4. Wind assessment

4.1 Site description relevant to the wind assessment

The proposed site is located to the north-east of Bungendore as part of a new residential estate, Figure 3. The site is presently surrounded by open terrain, and in future, by low-rise, low-density residential houses. The site is located on the western portion of the block bounded by Bridget Avenue, Winyu Rise, Birchfield Drive and Harp Avenue, Figure 4, with frontage to all streets/roads except Harp Avenue. Topography surrounding the site is relatively steep, rising to the north. The site drops towards the south between 15-27 m, Figure 5. Pedestrian traffic is expected to occur on all road and laneways in and around the site.

Figure 3: Site location (source: Google Earth 2024)

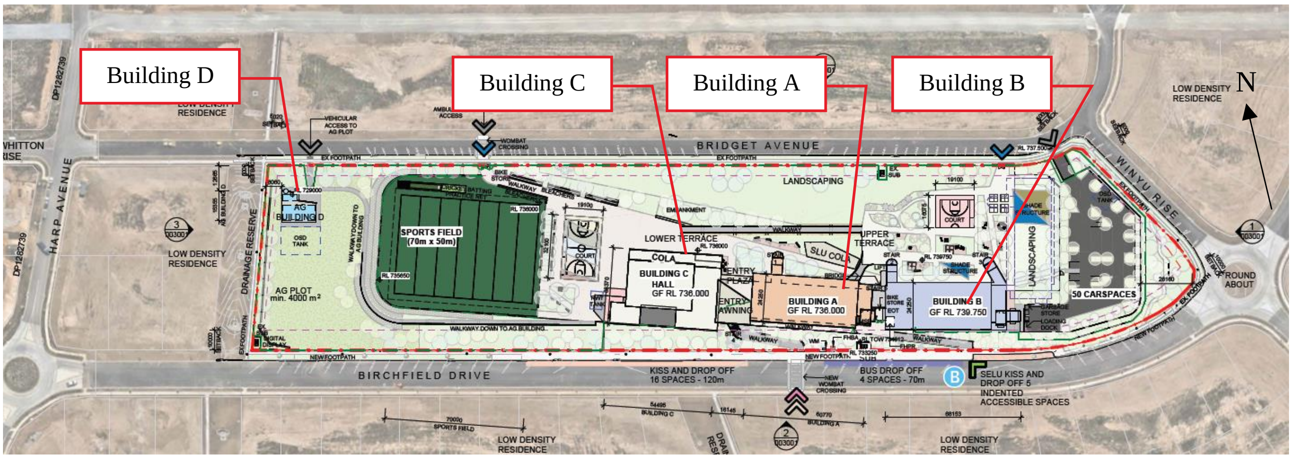

Figure 4: Site plan

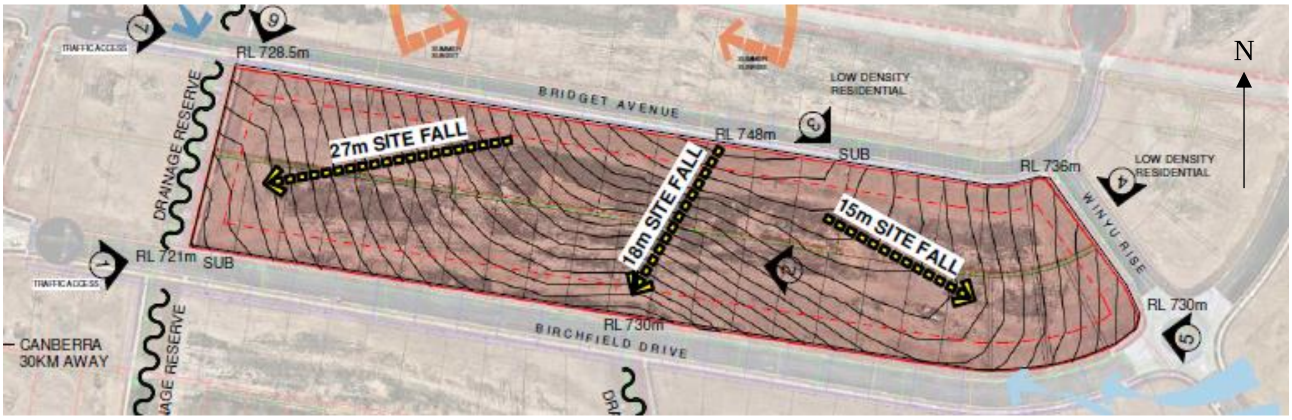

Figure 5: Site topography

The site is part of the initial stage of development forming part of the broader campus masterplan, with a future expansion wing planned on the east of the site, Figure 6. It is to be noted that given the staged development across the campus, pedestrian wind conditions will change over time which is discussed further in Section 4.4.

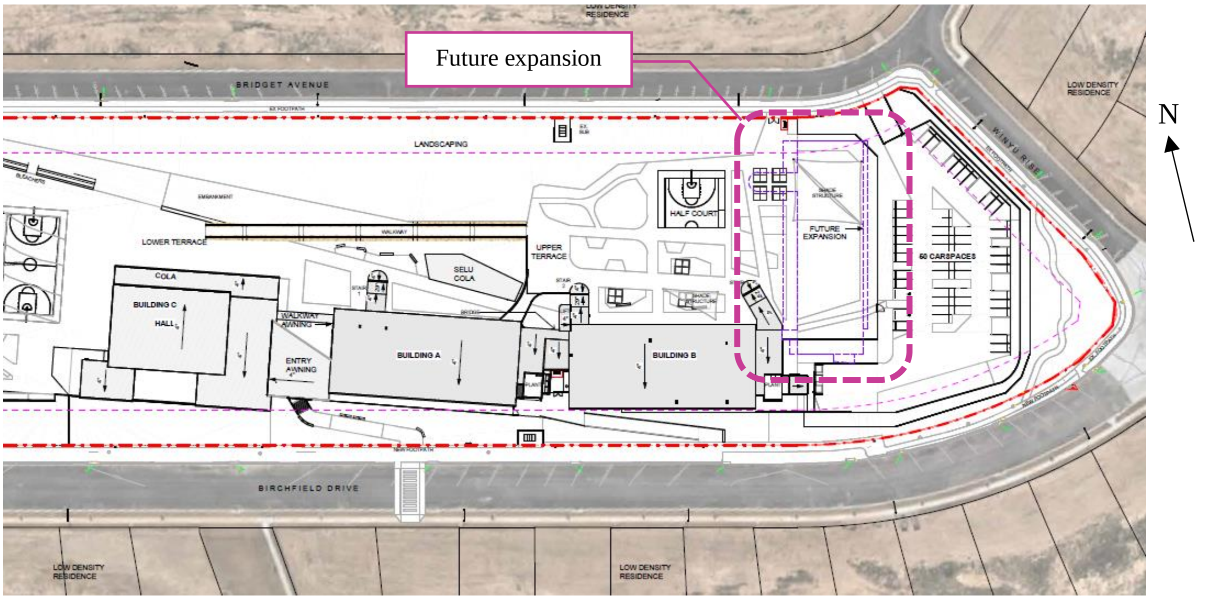

Figure 6: Future expansion

The proposed development includes four rectangular/prismatic buildings, sports facilities and landscaping, Figure 4 and Figure 7 - Figure 10:

- Block A (office, learning, library) – 3 storeys, maximum height above ground level (North elevation) of approximately 13.3 m
- Block B (learning, workshops, laboratories) – 3 storeys, maximum height above ground level (North elevation) of approximately 13.3 m
- Block C (gymnasium) – single storey, maximum height above ground level (North elevation) of approximately 10.1 m
- Block D (agricultural workshop) – single storey, maximum height above ground level (North elevation) of approximately 4.5 m

Key outdoor areas include the Upper Terrace (to the north of Building B), the Lower Terrace and walkway (to the north of Building A) and various sports facilities to the west of the site, Figure 12. There is a steep landscaped, embankment to the north of the site, Figure 8.

Figure 7: South elevation

Figure 8: East elevation

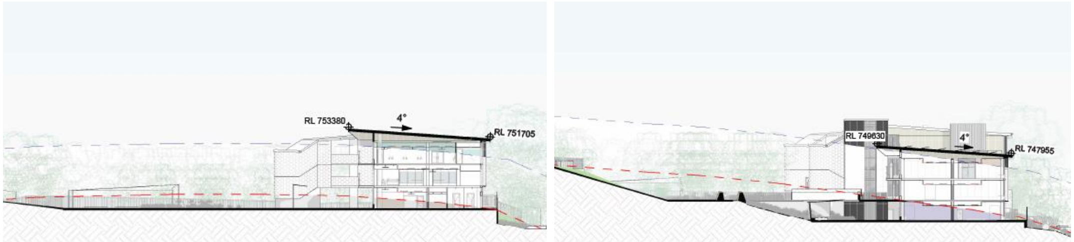

Figure 9: North-south sections looking east (Building B/Upper Terrace (L), Building A/Lower Terrace/walkway (R))

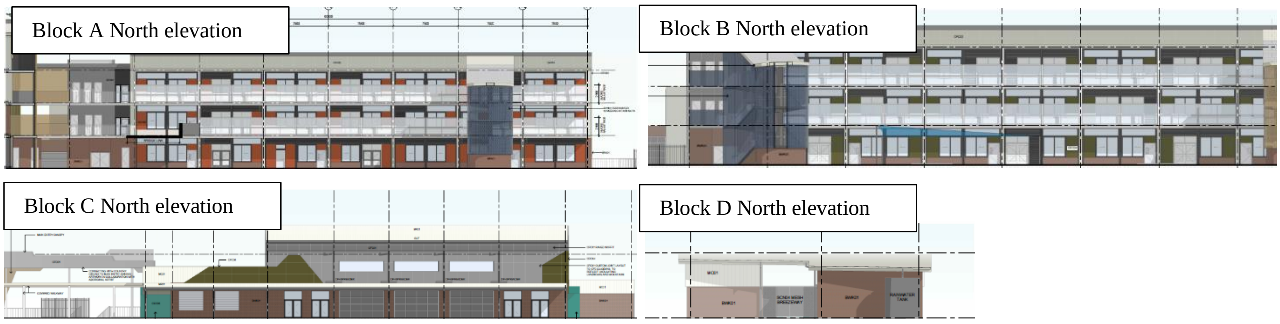

Figure 10: Various elevations

Seated areas are located at various locations across the site, Figure 12.

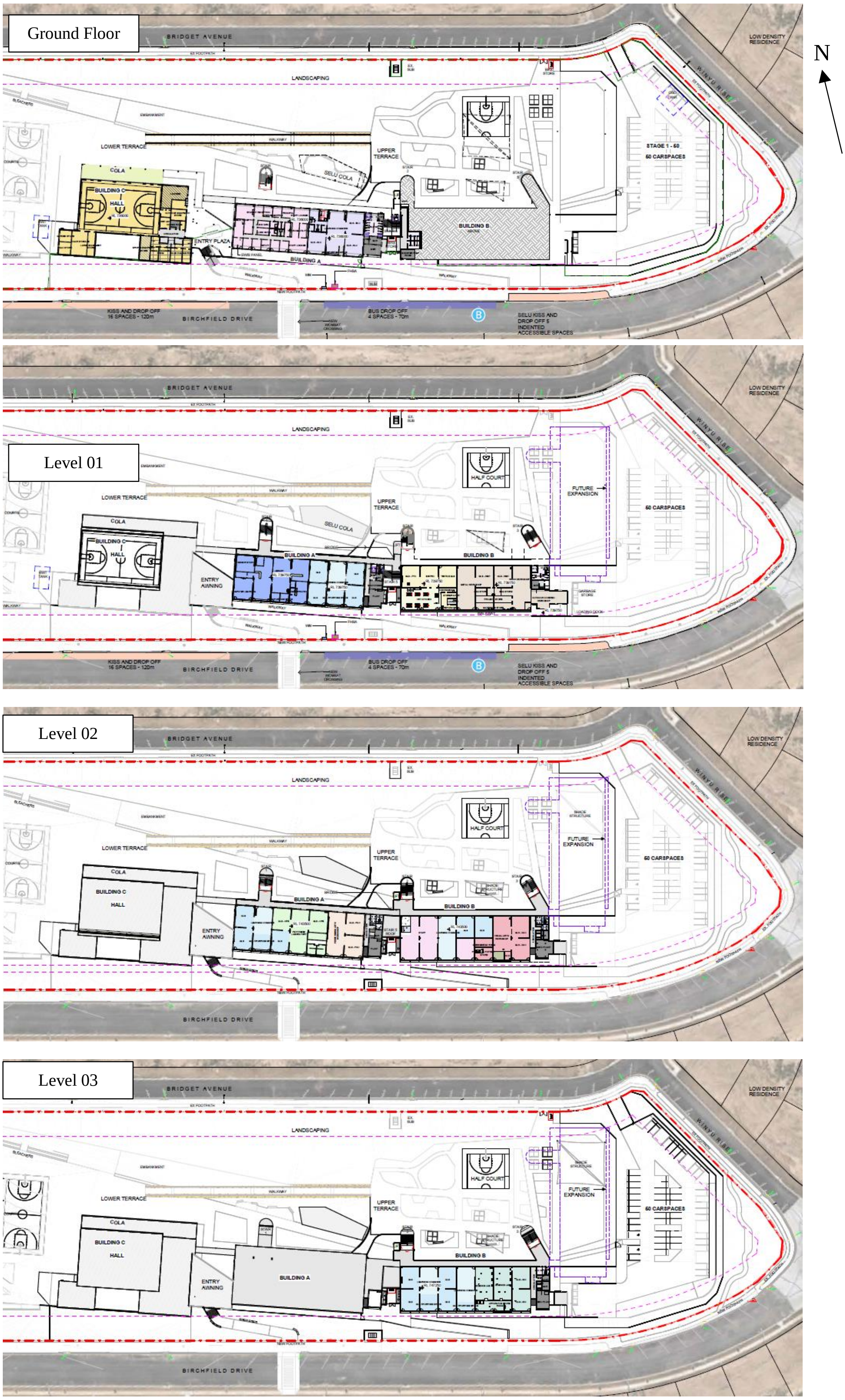

Figure 11: Various overall floor plans

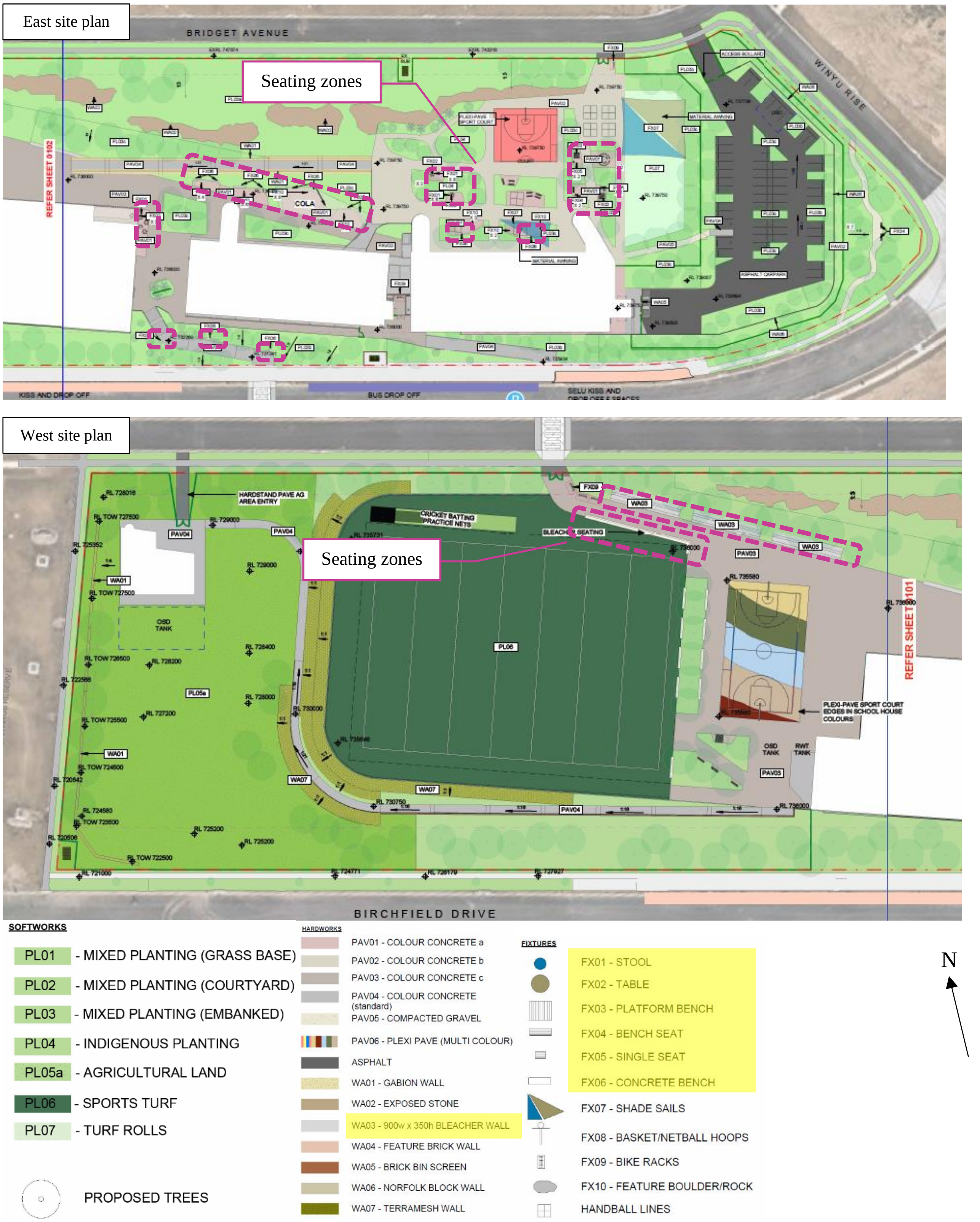

Figure 12: Landscape architecture site plan

4.2 Local wind climate

Weather data recorded at Canberra Airport by the Bureau of Meteorology has been analysed for this project. The site is located about 25 km to the north-east of the anemometer. The wind rose showing the probability of time winds with certain speed and direction are presented in Figure 13, where the arms of the wind rose point in the direction from where the wind is coming from.

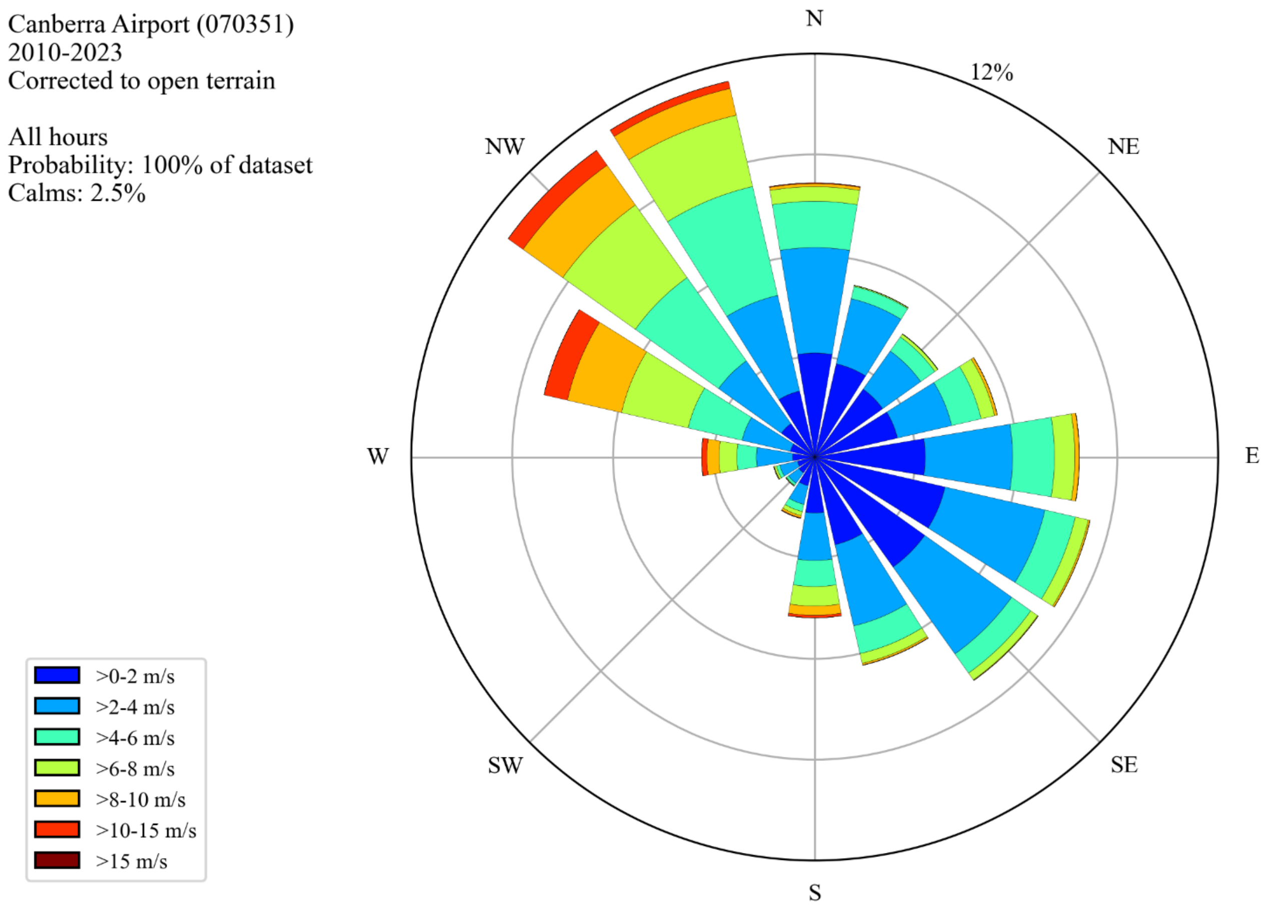

Figure 13: Wind rose showing probability of time of wind direction and speed

The measured mean (50th percentile) wind speed, converting the wind speeds at the anemometer to open terrain, is approximately 3.5 m/s, and the 5% exceedance mean wind speed, approximately 8.6 m/s (at 10m height). Converting the 5% of the time mean wind speed from 10 m height in exposed terrain to ground level in similar surrounds to the site would result in a wind speed of about 5.5-6.9 m/s, which is in the suitable for standing to walking type activities.

A general description on flow patterns around buildings is given in Appendix A.1.

4.3 Specific wind controls

Wind comfort is generally measured in terms of wind speed and rate of change of wind speed, where higher wind speeds and gradients are considered less comfortable. Air speed has a large impact on thermal comfort and are generally welcome during hot summer conditions. This assessment is focused on wind speed in terms of mechanical comfort.

There have been many wind comfort criteria proposed, and a general discussion is presented in Appendix A.2.

There are no specific wind controls for the site. The wind controls used in this wind assessment are based on the work of Lawson (1990), as defined in Table 1 and illustrated in Figure 27. The Lawson criteria are widely used in industry and are the basis for a number of councils' wind controls, including the Central Sydney Planning Strategy 2016-2036.

Table 1: Pedestrian comfort criteria for various activities

Comfort (max. of mean or GEM wind speed exceeded 5% of the time)	
<2 m/s	Dining
2-4 m/s	Sitting
4-6 m/s	Standing
6-8 m/s	Walking
8-10 m/s	Objective walking or cycling
>10 m/s	Uncomfortable
Safety (max. of mean or GEM wind speed exceeded 0.022% of the time)	
<15 m/s	General access
<20 m/s	Able-bodied people (less mobile or cyclists not expected)

4.4 Predicted wind conditions on ground plane

This section of the report outlines the predicted wind conditions in and around the site based on the local climate, topography, and building form. The assessment is based on completion of the first stage of development without the future expansion stage which forms part of the masterplan; discussion has been included regarding future development impacts.

Winds from the south-east

The site is exposed to prevailing winds from the south-east, Figure 14, which would approach the site fairly uninterrupted across open farmland, and subsequently two blocks of low-rise residential (once constructed) immediately upstream of the site. With rising topography from this direction, the prevailing winds would also accelerate on their approach to the site.

Winds from the south-east would impinge on the south-east corner of Block B and mostly pass horizontally around the building, along the southern perimeter of the site, and across the Upper Terrace. Flow would accelerate around the north-east corner of Block B, with the semi-open stairs diverting some flow at the upper levels, and some flow at ground level accelerating around the north-east corner and along the north façade, where the stairs are open. Pressure driven flow through the main entry between Blocks A and C is expected. This would be most felt along the east façade of Block C and at its north-east corner. There would be light recirculation at the west end of Block C as flow rounds this corner.

The Lower Terrace, immediately in front of Block A, will be in the lee of winds from the south-east, and therefore, reasonably well-protected. The sports field bleacher seating will experience less windy conditions towards its east because of protection from Block C building and at lower elevations, where the seating is more in the lee of winds from the south-east.

The proposed future expansion would likely improve conditions, particularly for the Upper Terrace, as the additional wing would shield for winds for the south-east in this area. The future expansion would ideally connect with Block B to avoid any accelerated flow through a narrow zone.

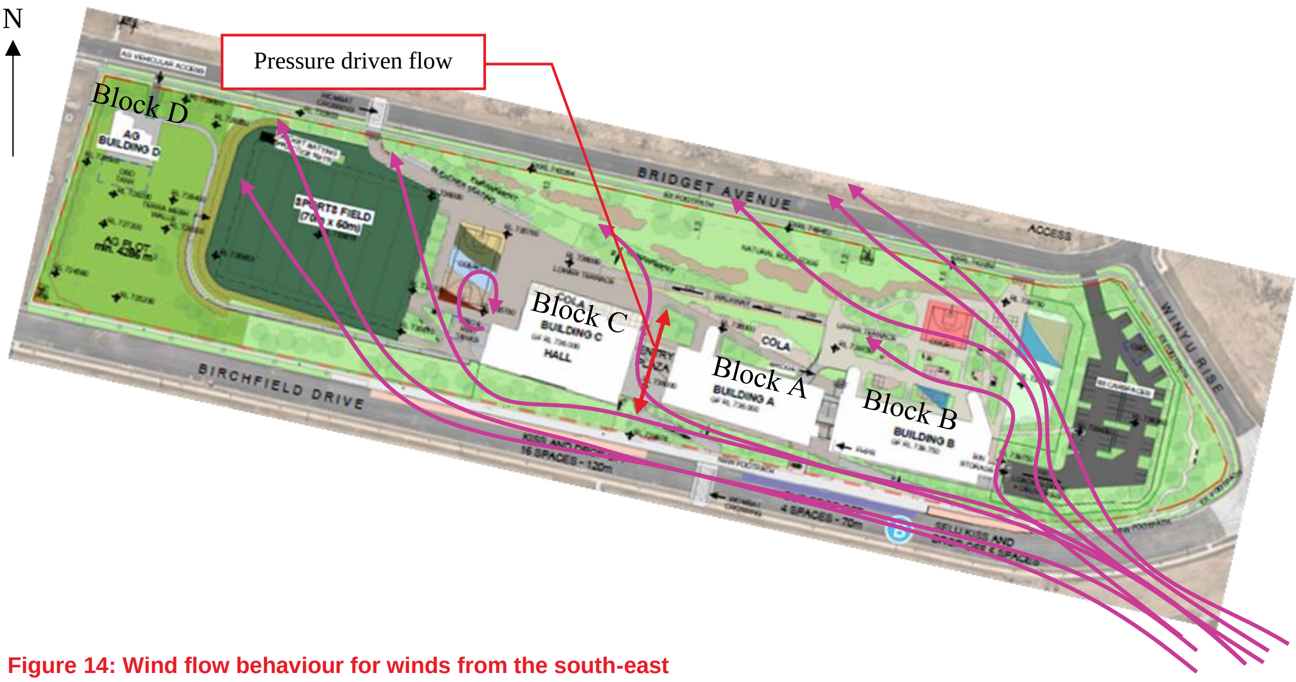

Figure 14: Wind flow behaviour for winds from the south-east

Winds from the north-west

Similar to winds from the south-east, the site is exposed to winds from the north-west, Figure 15, with winds from this direction approaching the site fairly uninterrupted across open farmland, and subsequently one block of low-rise residential (once constructed) immediately upstream of the site. With topography generally dropping from the north-west to the south-east, this would decelerate the flow to a degree, although with the strongest winds from the north-west, winds from this direction will still impact the site.

Winds from the north-west are generally aligned with the longitudinal aspects of the buildings so will impinge on the north facades at an oblique angle and slide along the facades, with any vertical barriers and/or articulated building massing/façade and/or semi-open stairs (at upper levels) reducing the speed of the flow. It is expected that the western corners of Block C and north-east corner of Block B will experience some accelerated flow at ground level. Pressure driven flow will exist through the main entry between Blocks A and C. Given the low-rise nature of the buildings, and the topography dropping to the south, some of the wind flow would go over and around the buildings.

The eastern end of the Lower Terrace will be calmer due to the sunken position. The Upper Terrace will be exposed to winds from the north-west, particularly to the east where the height of the northern landscaping/embankment is lower. Areas of calm will exist immediately adjacent to the northern embankment where the drop in elevation is steep and flow separates from the dropping topography.

The proposed future expansion would likely improve conditions, particularly for the Upper Terrace, as the additional wing would provide an area of calm in the elbow of the future expansion and Block B. The future expansion would ideally connect with Block B to avoid any accelerated flow through a narrow zone.

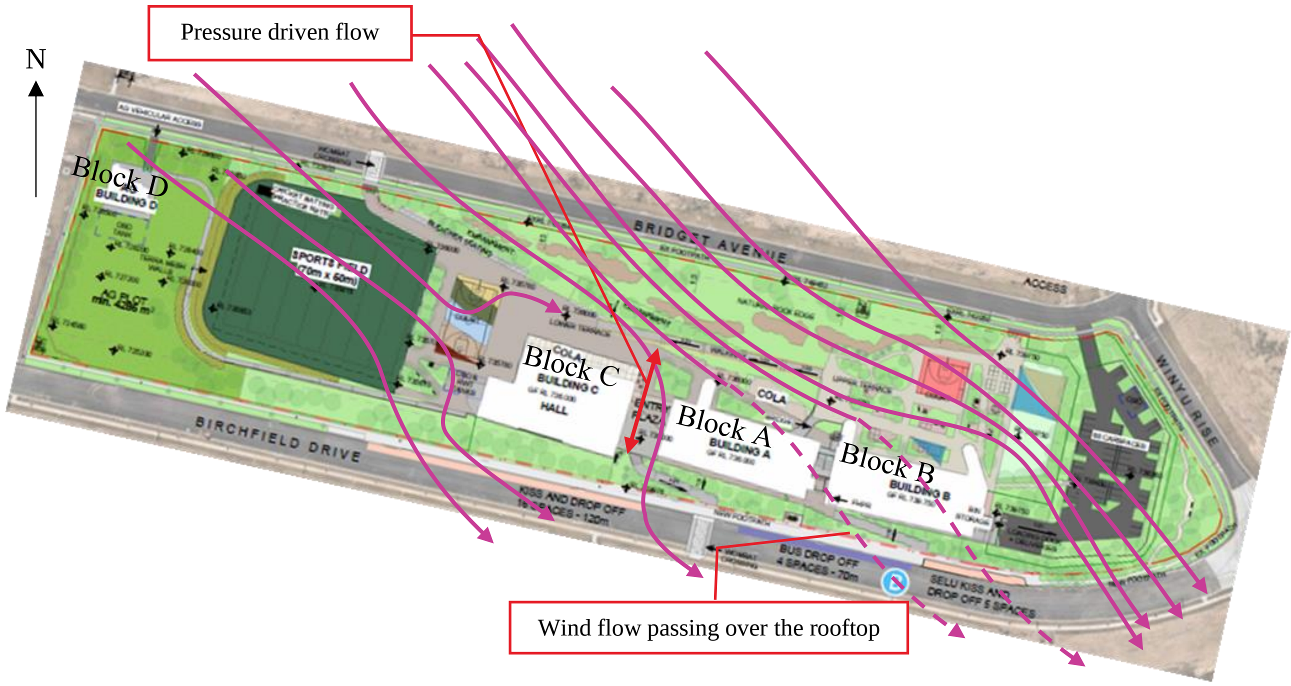

Figure 15: Wind flow behaviour for winds from the north-west

4.5 Conclusion

The site is located in a fairly open area with open farmland further afield and low-rise residential blocks immediately surrounding the site. The local wind climate is reasonably windy, particularly for winds from the north-west. The varied topography of the site additionally influences the local wind climate. It is expected that the proposed development will have an impact on the local wind environment, with some areas becoming calmer, and others becoming windier.

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that from a comfort perspective, the wind conditions at the majority of locations around the site would be classified as suitable for pedestrian walking or standing type activities at ground level. This would increase to suitable for walking and/or objective walking around some of the outer corners of the buildings, particularly the north-east corner of Block B and between the blocks. Areas in the lee of prevailing winds, such as the eastern area of the Lower Terrace and immediately adjacent to the northern embankment where the slope is steep (and flow has separated), would experience calmer conditions that would be likely suitable for sitting to standing type activities.

Seated areas on the Upper Terrace, south of the main entry on the southern perimeter and along the walkway north-east of the sports field, Figure 16, will require local mitigation measures in the form of vertical barriers to render these areas suitable for sitting; refer to Section 4.5.1 for further discussion.

All areas around the development would be expected to meet the pedestrian safety criterion.

The proposed future expansion would likely improve wind comfort conditions, particularly for the Upper Terrace. The future expansion would ideally connect with Block B to avoid any accelerated flow through a narrow zone.

4.5.1 Seating areas

There are several proposed seating areas in locations exposed to the prevailing winds, Figure 16. The flow in these areas will be predominantly horizontal and vertical barriers to sufficient height and density are recommended in these zones. L- and U-shaped sectioned/booth style seating areas are ideal to protect from multiple wind directions. The minimum recommended height for a vertical barrier for a small seating area is standing height (~1.5-2.0 m), given the effectiveness of protection diminishes with distance from the barrier. Refer to Section A.1 for further information.

Seating areas are ideally located away from corners and/or include options to switch to the other aspect of the corner for seating depending on the prevalent wind direction.

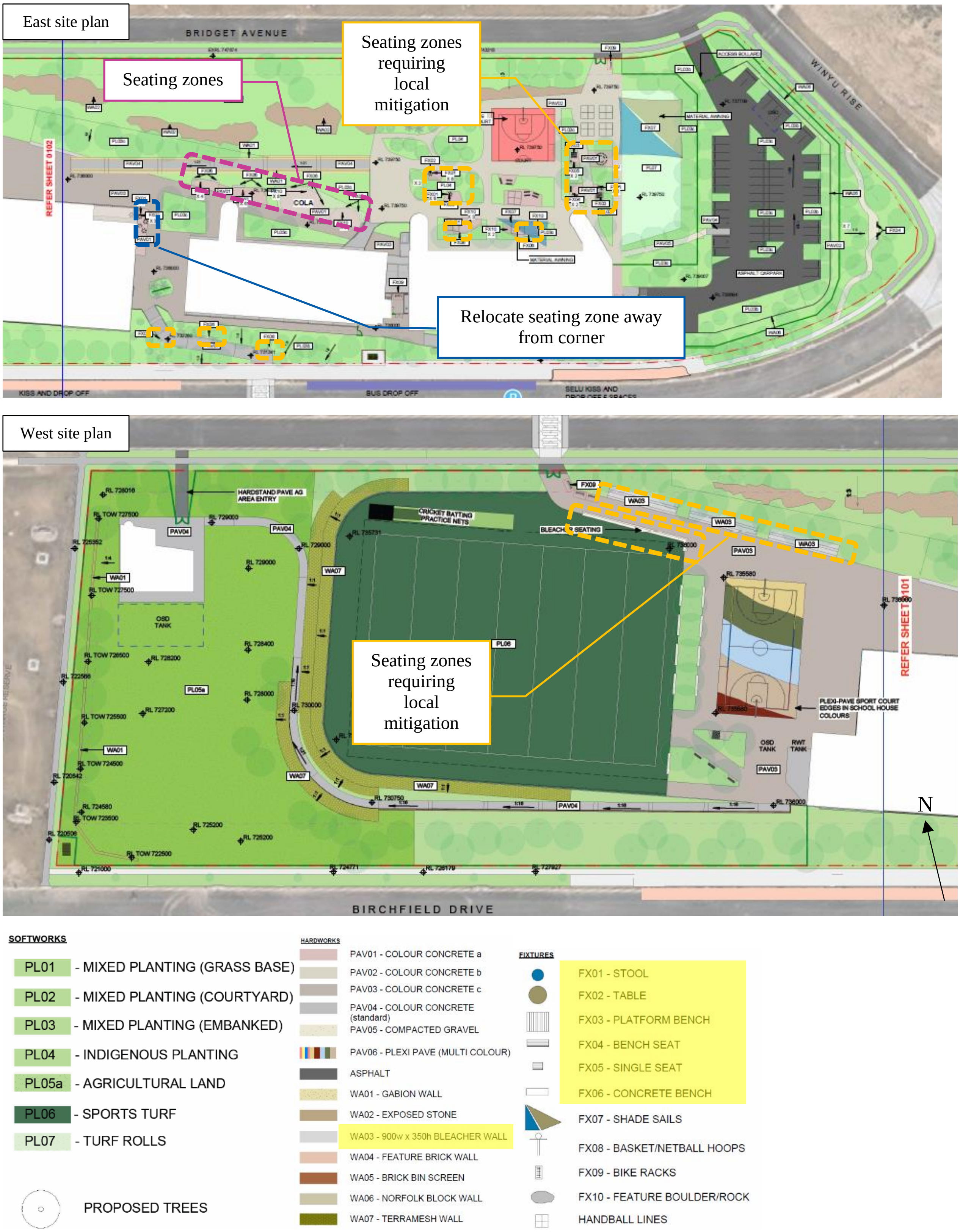

Figure 16: Seating areas requiring local mitigation measures

5. Mitigation

Based on the qualitative wind assessment undertaken, the proposed mitigation measures, which can be addressed during detailed design, are summarised in Table 2.

Table 2: Summary of mitigation measure

Mitigation Name	Aspect	Mitigation Measure	Reason for Mitigation Measures
Seated areas	Several proposed seating areas are located in areas exposed to prevailing winds that are more suitable for transitory activities. These areas include the Upper Terrace, south of the main entry on the southern perimeter and along the walkway north-east of the sports field.	Include vertical barriers (screens, booths, landscaping, etc) to sufficient height and density around the seating areas based on the desired area of protection/size of seating area. Recommended height is typically to standing height (~1.5-2 m) for a small, seated area. Locate seating areas away from corners and/or include options to switch to the other aspect of the corner for seating depending on the prevalent wind direction.	To ensure seating areas are suitable for their intended use based on the local wind conditions.

6. Evaluation of Environmental Impacts

The site is located in a fairly open area with open farmland further afield and low-rise residential blocks immediately surrounding the site. The local wind climate is reasonably windy, particularly for winds from the north-west. The varied topography of the site additionally influences the local wind climate. It is expected that the proposed development will have an impact on the local wind environment, with some areas becoming calmer, and others becoming windier. The level of impact of the proposed development on the local wind environment is not expected to be significant beyond the site boundary.

The extent and nature of potential impacts are low and will not have a significant impact on the locality, community and/or the environment. Potential impacts can be appropriately mitigated or managed to ensure that there is minimal impact on the locality, community and/or the environment.

7. References

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Appendix A

A.1 Wind flow mechanisms

An urban environment generates a complex wind flow pattern around closely spaced structures, hence it is exceptionally difficult to generalise the flow mechanisms and impact of specific buildings as the flow is generated by the entire surrounds. However, it is best to start with an understanding of the basic flow mechanisms around an isolated structure.

Isolated building

When the wind hits an isolated building, the wind is decelerated on the windward face generating an area of high pressure, Figure 17, with the highest pressure at the stagnation point at about two thirds of the height of the building. The higher pressure bubble extends a distance from the building face of about half the building height or width, whichever is lower. The flow is then accelerated down and around the windward corners to areas of lower pressure, Figure 17. This flow mechanism is called **downwash** and causes the windiest conditions at ground level on the windward corners and along the sides of the building.

Rounding the building corners or chamfering the edges reduces downwash by encouraging the flow to go around the building at higher levels. However, concave curving of the windward face can increase the amount of downwash. Depending on the orientation and isolation of the building, uncomfortable downwash can be experienced on buildings of greater than about 6 storeys.

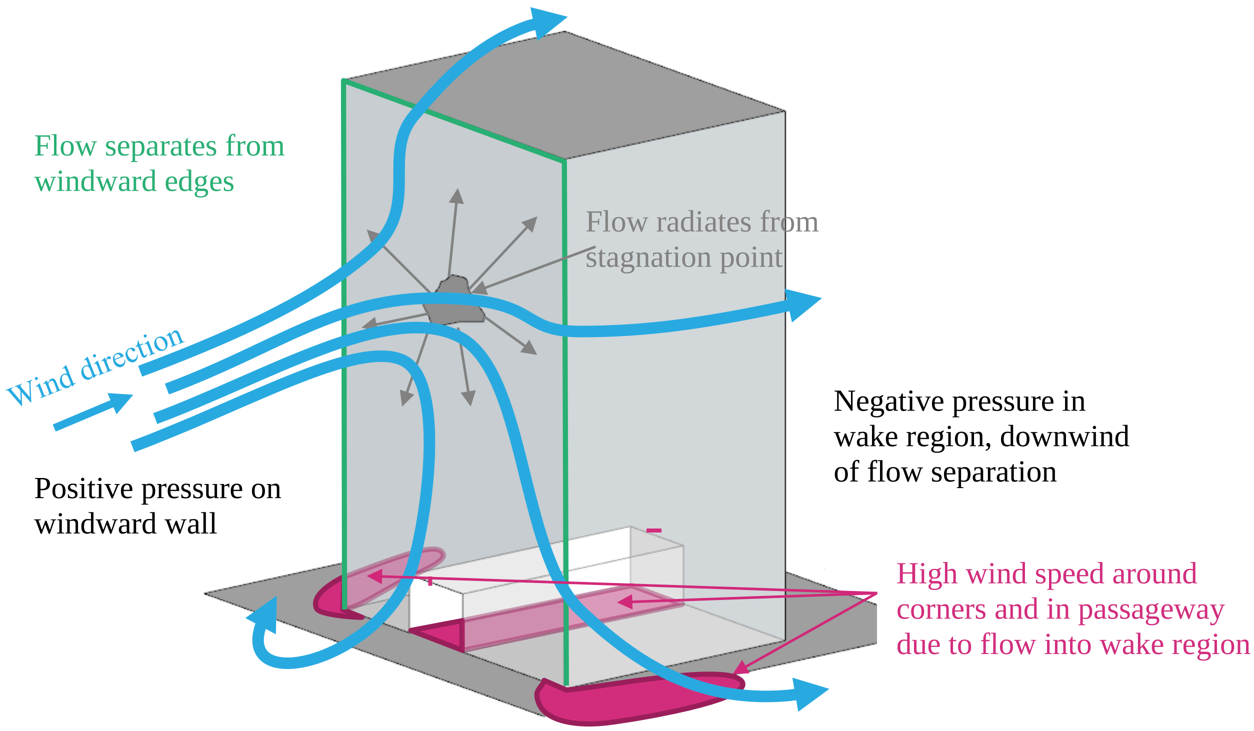

Figure 17: Schematic wind flow around tall isolated building

Techniques to mitigate the effects of downwash winds at ground level include the provision of horizontal elements, the most effective being a podium to divert the downward flow away from pavements and building entrances, but this will generate windy conditions on the podium roof, Figure 11. Generally, the lower the podium roof and deeper the setback from the podium edge to the tower improves the ground level wind conditions. The provision of an 8 m setback on an isolated building is generally sufficient to improve ground level conditions, but is highly dependent on the building isolation, orientation to prevailing wind directions, shape and width of the building, and any plan form changes at higher level.

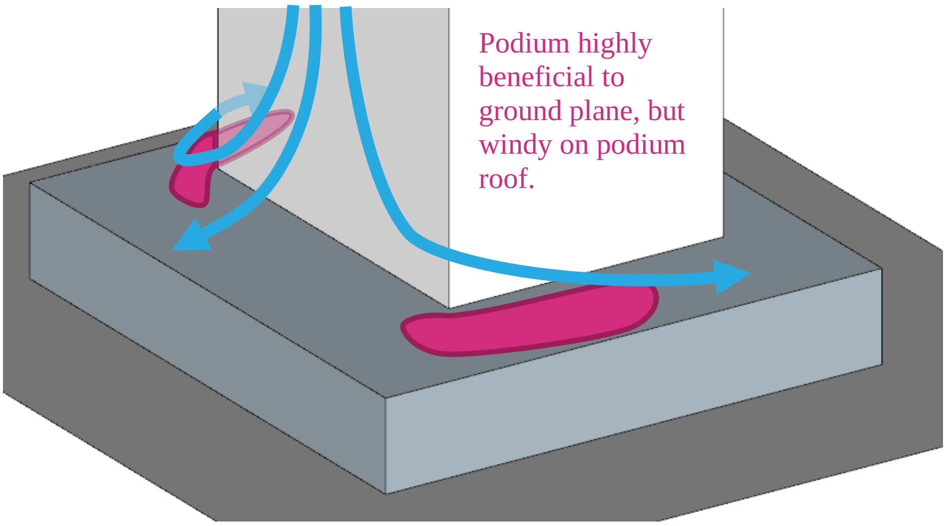

Figure 18: Schematic flow pattern around building with podium

Awnings along street frontages perform a similar function as a podium, and generally the larger the horizontal projection from the façade, the more effective it will be in diverting downwash flow, Figure 19. Awnings become less effective if they are not continuous along the entire façade, or on wide buildings as the positive pressure bubble extends beyond the awning resulting in horizontal flow under the awning.

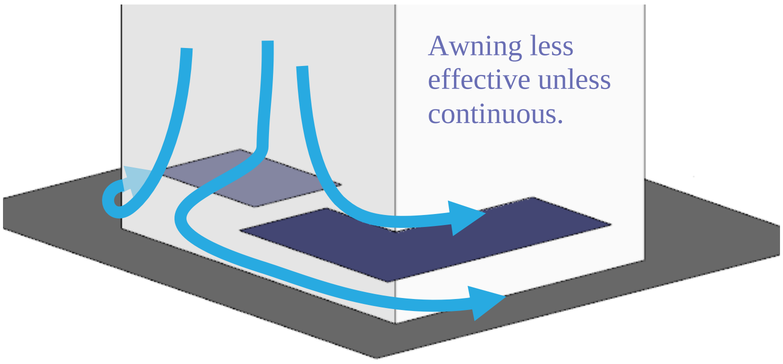

Figure 19: Schematic flow pattern around building with awning

It should be noted that colonnades at the base of a building with no podium generally create augmented windy conditions at the corners due to an increase in the pressure differential, Figure 20. Similarly, open through-site links through a building cause wind issues as the environment tries to equilibrate the pressure generated at the entrances to the link, Figure 17. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 21. This area is in a region of high pressure and therefore the is the potential for internal flow issues. A ground level recessed corner has a similar effect as an undercroft, resulting in windier conditions, Figure 21.

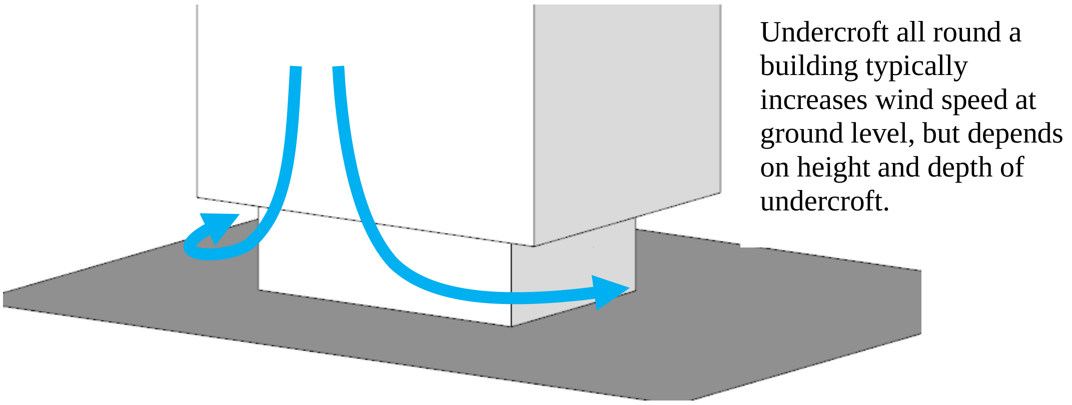

Figure 20 Schematic of flow patterns around isolated building with undercroft

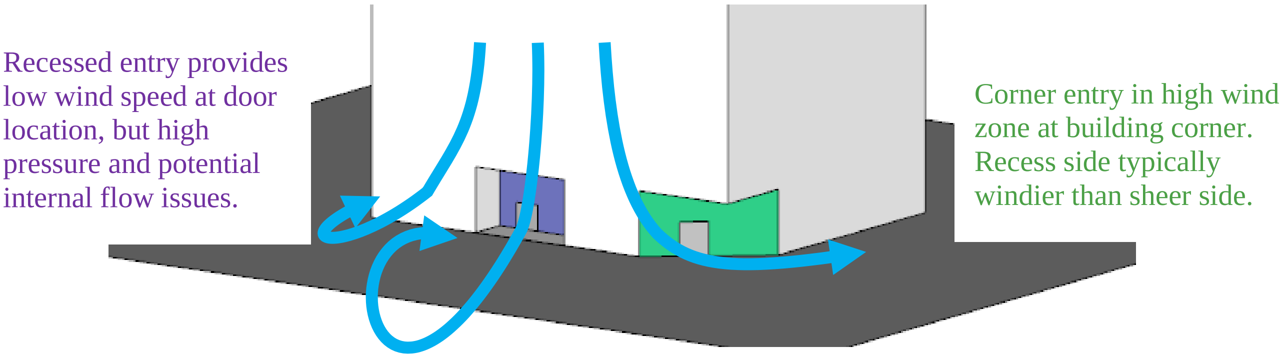

Figure 21: Schematic of flow patterns around isolated building with ground articulation

Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 22. If the building is taller, more of the wind impacting on the exposed section of the building is likely to be drawn to ground level by the increase in height of the stagnation point, and the additional negative pressure induced at the base. If the upwind buildings are of similar height then the pressure around the building will be more uniform hence downwash is typically reduced with the flow passing over the buildings.

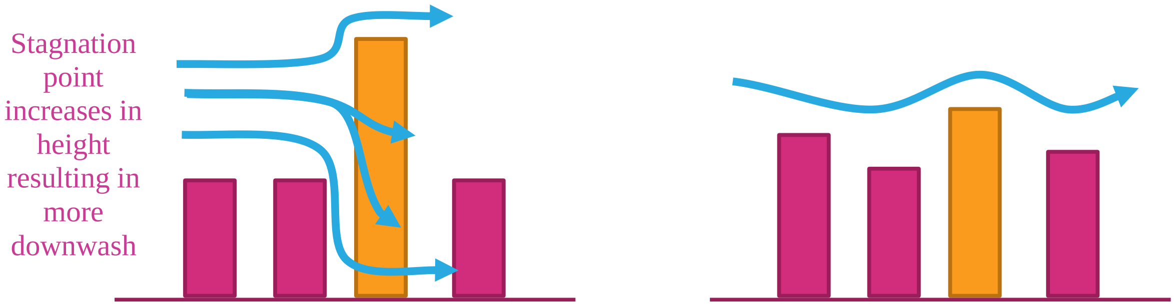

Figure 22: Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 23.

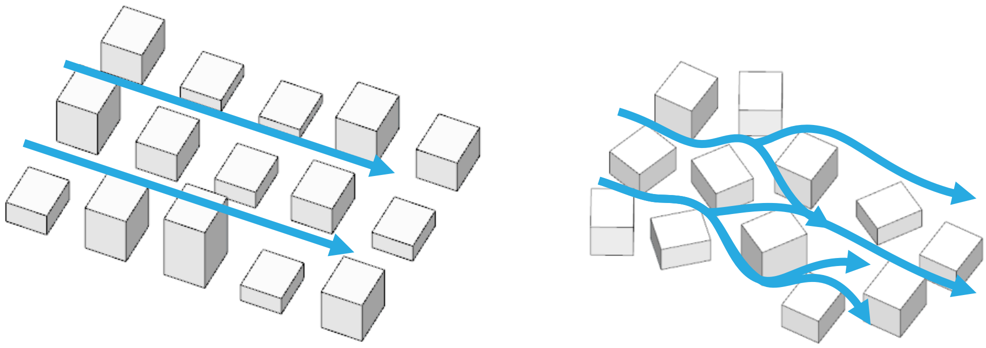

Figure 23: Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 23(L), particularly on the edge of built-up areas where the approaching flow is diverted around the city massing and channelled along the fringe by a relatively continuous wall of building facades. This is generally the primary mechanism driving the wind conditions for this perimeter of a built-up area, particularly on corners, which are exposed to multiple wind directions. The perimeter edge zone in a built-up area is typically about two blocks deep. Downwash is more important flow mechanism for the edge zone of a built-up area with buildings of similar height.

As the city expands, the central section of the city typically becomes calmer, particularly if the grid pattern of the streets is discontinued, Figure 23(R). When buildings are located on the corner of a central city block, the geometry becomes slightly more important with respect to the local wind environment.

Single barriers and screens

The wind flow pattern over a vertical barrier is illustrated in Figure 24, showing there will be recirculation zones near the windward wall and in the immediate lee of the barrier. The typical extent of these recirculation zones relative to the height of the barrier, h, is illustrated in Figure 24. These regions are not fixed but fluctuate in time. The mean wind speed in the wake areas drops significantly compared with the incident flow. With increasing distance from the barrier the flow pattern will resort to the undisturbed state. Typically the mean velocity and turbulence intensity at barrier height would be expected to be within 10% of the free stream conditions at 10 times the height of the structure downwind from the barrier.

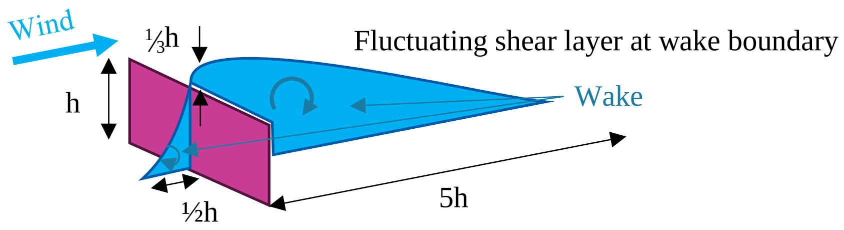

Figure 24: Sketch of the flow pattern over an isolated structure

A.2 Wind speed criteria

General discussion

Primary controls that are used in the assessment of how wind affects pedestrians are the wind speed, and rate of change of wind speed. A description of the effect of a specific wind speed on pedestrians is provided in Table 3. It should be noted that the turbulence, or rate of change of wind speed, will affect human response to wind and the descriptions are more associated with response to mean wind speed.

Table 3: Summary of wind effects on pedestrians

Description	Speed (m/s)	Effects
Calm, light air	0–2	Human perception to wind speed at about 0.2 m/s. Napkins blown away and newspapers flutter at about 1 m/s.
Light breeze	2–3	Wind felt on face. Light clothing disturbed. Cappuccino froth blown off at about 2.5 m/s.
Gentle breeze	3–5	Wind extends light flag. Hair is disturbed. Clothing flaps.
Moderate breeze	5–8	Raises dust, dry soil. Hair disarranged. Sand on beach saltates at about 5 m/s. Full paper coffee cup blown over at about 5.5 m/s.
Fresh breeze	8–11	Force felt on body. Limit of agreeable wind on land. Umbrellas used with difficulty. Wind sock fully extended at about 8 m/s.
Strong breeze	11–14	Hair blown straight. Difficult to walk steadily. Wind noise on ears unpleasant. Windborne snow above head height (blizzard).
Near gale	14–17	Inconvenience felt when walking.
Gale	17–21	Generally impedes progress. Difficulty with balance in gusts.
Strong gale	21–24	People blown over by gusts.

Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. These have all generally been developed around a 3 s gust, or 1 hour mean wind speed. During strong events, a pedestrian would react to a significantly shorter duration gust than a 3 s, and historic weather data is normally presented as a 10 minute mean.

Despite the apparent differences in numerical values and assumptions made in their development, it has been found that when these are compared on a probabilistic basis, there is some agreement between the various criteria. However, a number of studies have shown that over a wider range of flow conditions, such as smooth flow across water bodies, to turbulent flow in city centres, there is less general agreement among. The downside of these criteria is that they have seldom been benchmarked, or confirmed through long-term measurements in the field, particularly for comfort conditions. The wind criteria were all developed in temperate climates and are unfortunately not the only environmental factor that affects pedestrian comfort.

For assessing the effects of wind on pedestrians, neither the random peak gust wind speed (3 s or otherwise), nor the mean wind speed in isolation are adequate. The gust wind speed gives a measure of the extreme nature of the wind, but the mean wind speed indicates the longer duration impact on pedestrians. The extreme gust wind speed is considered to be suitable for safety considerations, but not necessarily for serviceability comfort issues such as outdoor dining. This is because the instantaneous gust velocity does not always correlate well with mean wind speed, and is not necessarily representative of the parent distribution. Hence, the perceived ‘windiness’ of a location can either be dictated by strong steady flows, or gusty turbulent flow with a smaller mean wind speed.

To measure the effect of turbulent wind conditions on pedestrians, a statistical procedure is required to combine the effects of both mean and gust. This has been conducted by various researchers to develop an equivalent mean wind speed to represent the perceived effect of a gust event. This is called the ‘gust equivalent mean’ or ‘effective wind speed’ and the relationship between the mean and 3 s gust wind speed is defined within the criteria, but two typical conversions are:

$$\mathrm{U_{GEM}} = \frac{(\mathrm{U_{1\,hour\,mean}} + 3 \cdot \sigma_u)}{1.85} \text{ and } \mathrm{U_{GEM}} = \frac{1.3 \cdot (\mathrm{U_{1\,hour\,mean}} + 2 \cdot \sigma_u)}{1.85}$$

It is evident that a standard description of the relationship between the mean and impact of the gust would vary considerably depending on the approach turbulence, and use of the space.

A comparison between the mean and 3 s gust wind speed criteria from a probabilistic basis are presented in Figure 25 and Figure 27. The grey lines are typical results from modelling and show how the various criteria would classify a single location. City of Auckland has control mechanisms for accessing usability of spaces from a wind perspective as illustrated in Figure 25 with definitions of the intended use of the space categories defined in Figure 26.

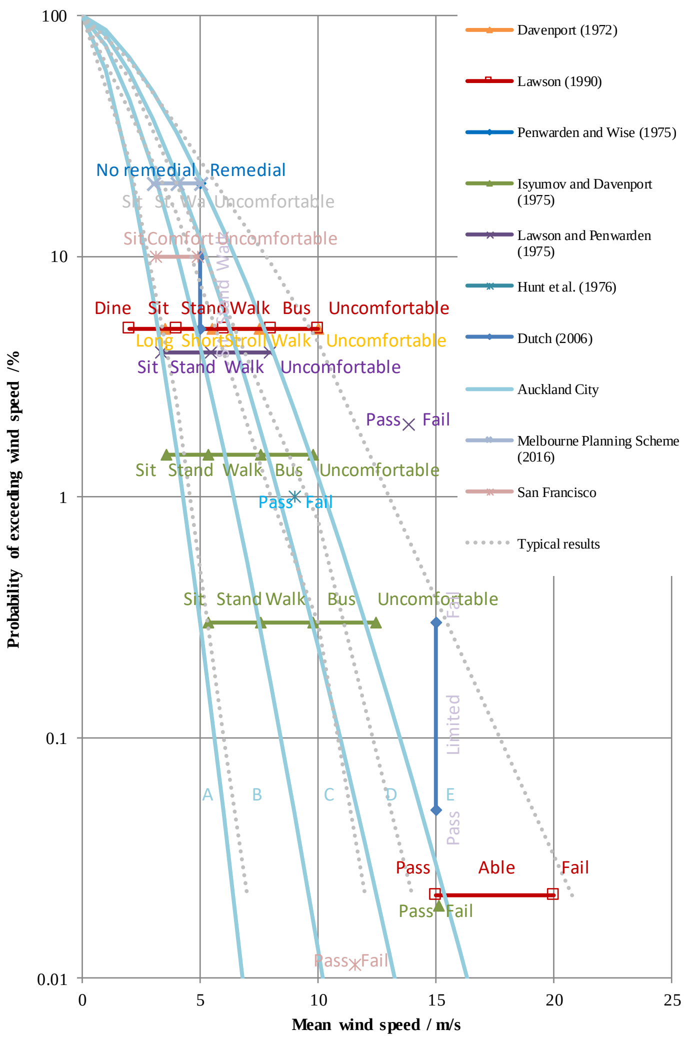

Figure 25: Probabilistic comparison between wind criteria based on mean wind speed

Category A	Areas of pedestrian use or adjacent dwellings containing significant formal elements and features intended to encourage longer term recreational or relaxation use i.e. public open space and adjacent outdoor living space
Category B	Areas of pedestrian use or adjacent dwellings containing minor elements and features intended to encourage short term recreation or relaxation, including adjacent private residential properties
Category C	Areas of formed footpath or open space pedestrian linkages, used primarily for pedestrian transit and devoid of significant or repeated recreational or relaxational features, such as footpaths not covered in categories A or B above
Category D	Areas of road, carriage way, or vehicular routes, used primarily for vehicular transit and open storage, such as roads generally where devoid of any features or form which would include the spaces in categories A - C above.
Category E	Category E represents conditions which are dangerous to the elderly and infants and of considerable cumulative discomfort to others, including residents in adjacent sites. Category E

Figure 26: Auckland Utility Plan (2016) wind categories

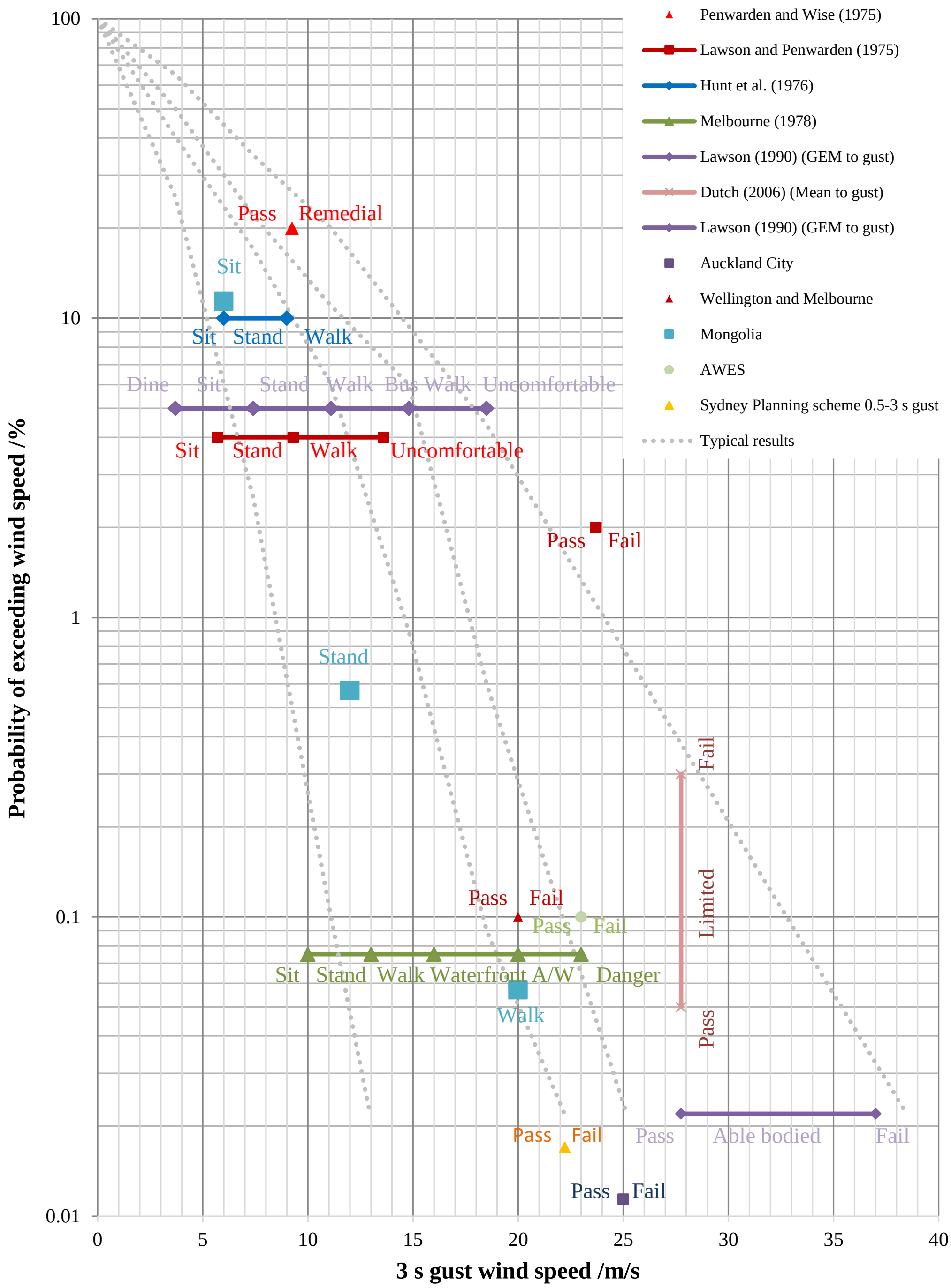

Figure 27: Probabilistic comparison between wind criteria based on 3 s gust wind speed

A.3 Reference documents

In preparing the assessment, the following documents have been referenced to understand the building massing and features:

- Architectural Drawings, dated 19 December 2024 (Issue C, Ref Issue)
- Landscape Architecture Drawings, dated 19 December 2024 (Ref Issue for Review)