Western Parkland City Authority

Bradfield City Centre
Master Plan Application

Pedestrian Wind Environment Review

Prepared by Windtech Consultants

October 2023 wpca.sydney

NSW GOVERNMENT

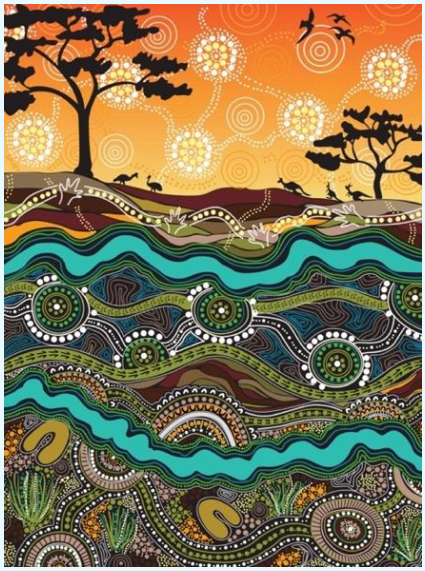
Acknowledgement of Country

Aboriginal people have had a continuous connection with the Country encompassed by the Western Parkland City (the Parkland City) from time immemorial. They have cared for Country and lived in deep alignment with this important landscape, sharing and practicing culture while using it as a space for movement and trade.

We Acknowledge that four groups have primary custodial care obligations for the area: Dharug/Darug, Dharawal/Tharawal, Gundungurra/Gundungara and Darkinjung. We also Acknowledge others who have passed through this Country for trade and care purposes: Coastal Sydney people, Wiradjuri and Yuin.

Western Sydney is home to the highest number of Aboriginal people in any region in Australia. Diverse, strong, and connected Aboriginal communities have established their families in this area over generations, even if their connection to Country exists elsewhere. This offers an important opportunity for the future of the Parkland City.

Ensuring that Aboriginal communities, their culture, and obligations for Country are considered and promoted will be vital for the future of the Parkland City. A unique opportunity exists to establish a platform for two-way knowledge sharing, to elevate Country and to learn from cultural practices that will create a truly unique and vibrant place for all.



Garungarung Murri Murri Nuru
(Beautiful Grass Country)
Artwork created by Dalmarri artists Jason Douglas and Trevor Eastwood for the Western Parkland City Authority

Version	Status	Date	Prepared By	Reviewer	Comments
1	Draft	9/03/2022	Thien Huynh	SWR	Draft technical report
2	Draft	11/11/2022	Thien Huynh	SWR	Updated study template and issue of final Master Plan requirements
3	Draft issue to TAP	22/11/2022	Thien Huynh	SWR	Reviewing comments from WPCA
4	Final	June 28 2023	Thien Huynh	SWR	Update report template. Final Master Plan footprint and associated updates
5	Final	1 August 2023	Hannah Gilvear	WPCA	Update report to reflect comments and Masterplan
6	Final	17 August 2023	Jason Azucena	WPCA	Minor update to images
7	For Publishing	13 September 2023	Jason Azucena	WPCA	Amendment to Table 1
8	For Publishing	19 October 2023	Hannah Gilvear	WPCA	Update Lot and DP

Executive Summary

This report is in relation to the proposed Bradfield City Centre Master Plan Site located at 215 Badgerys Creek Road, Bradfield, and presents an opinion on the likely wind conditions for consideration by the proposed masterplan design. The effect of wind activity is examined for the three (3) principal wind directions for the Badgerys Creek region; the south-westerly, easterly, and westerly winds. The analysis of the wind effects relating to the proposed site was 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 available precinct concept reports available at the time. No wind tunnel testing has been undertaken at the master planning stage. 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 the site benefits from the shielding provided by the indicative built-form of the various buildings within the development precinct. However, there are some areas that are likely to be exposed to stronger winds that can have an impact on the local wind amenity. It is expected that the wind effects identified in the report can be ameliorated and local wind conditions further enhanced with the consideration of the following treatment strategies into the design of the development precinct:

- Utilise extensive densely foliating vegetation (existing trees and strategic planting) along the various streetscapes and within and around the various open spaces, to mitigate approaching winds through larger open spaces and along building aspects. In particular around corners of buildings, within and around the open parkland and waterfront and areas intended for short duration stationary activities such as outdoor seating etc.
- The densely foliating vegetation is to be of an evergreen species to ensure their effectiveness in wind mitigation throughout the year. In particular along the western and southern boundaries as these areas are susceptible to the prevailing winds that frequently occur during the cooler winter periods of the year.
- Incorporating a podium component for taller buildings, with a setback of the tower component from the podium building edge.
- Utilise appropriate design measures such as awnings, canopies, streamlining building form with respect to the prevailing wind directions etc. to reduce the likelihood of adverse winds at ground level resultant from downwash effects. In particular along the building facades facing the proposed Sportsground and the southern open parkland areas of Moore Gully and City Parklands (East).
- Utilise architectural features at the ground level in conjunction with the densely foliating landscape vegetation such as localised vertical screening near high use areas intended for short duration stationary activities (outdoor seating, BBQ/communal areas etc.) to baffle approaching winds.
- Utilise vertical feature elements along building facades to reduce the ability of winds to side-stream long the various building facades.
- Utilise localised wind mitigating devices such as densely foliating vegetation in the form of trees or shrubs/hedge planting, localised vertical screens or seating with high backrests oriented perpendicular to the prevalent flow streams for areas intended for short duration stationary activities such as outdoor seating.
- Avoid placing high use pedestrian/patron areas in locations at risk of experiencing accelerated wind flow such as trafficable areas around the corners of buildings. This includes areas intended for short duration stationary activities where the expected activity time exceeds 1 hour (e.g., outdoor seating etc.).
- Avoid aligning wider building aspects perpendicular to the prevailing winds, where possible, to reduce the possibility for winds to be captured and down-washed from the façade towards the ground level, impacting pedestrians.

- Avoid aligning thoroughfares/roads parallel with the prevailing winds by integrating steps or changes in direction into the building massing.

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Glossary of Terms

AS	Australian Standard
Aerotropolis	Western Sydney Aerotropolis
BC Act	Biodiversity Conservation Act 2016
CIV	Capital Investment Value
DA	Development Application
DP	Deposited Plan
DPE	Department of Planning and Environment
EP&A Act	Environmental Planning and Assessment Act 1979
EP&A Regulation	Environmental Planning and Assessment Regulation 2000
LEP	Local Environmental Plan
LGA	Local Government Area
NSW Government	State Government for NSW
SEPP	State Environmental Planning Policy

References

Ref	Title	Author	Date
1	*Western Sydney Aerotropolis Development Control Plan Phase 2*	*Aerotropolis*	November 2022

1 Introduction

1.1 Purpose of this report

This report accompanies the Master Plan Application for the Bradfield City Centre submitted to the Department of Planning and Environment (DPE).

All matters were considered to have been adequately addressed within the Master Plan Application or in the accompanying appendices.

1.2 The Western Sydney Aerotropolis

The Western Sydney Aerotropolis is an 11,200-hectare region set to become Sydney's third city (the Western Parkland City), and the gateway and economic powerhouse of Western Sydney.

The Aerotropolis comprises of the new Western Sydney (Nancy-Bird Walton) International Airport surrounded by five initial precincts which include the Aerotropolis Core, Wianamatta– South Creek Northern Gateway, Agri-business and Badgerys Creek outlined in **Figure 1** below.

The final Aerotropolis planning package, including the Precinct Plan and State Environmental Planning Policy (SEPP) Amendment, was gazetted by DPE in March 2022 and the Development Control Plan Phase 2 was finalised in November 2022. These documents have been used to inform the preparation of the Bradfield City Centre Master Plan.

The proposed Master Plan Application for the site has also been prepared using the Western Sydney Aerotropolis Master Plan Guideline and Master Plan Requirements.

2 Bradfield City Centre

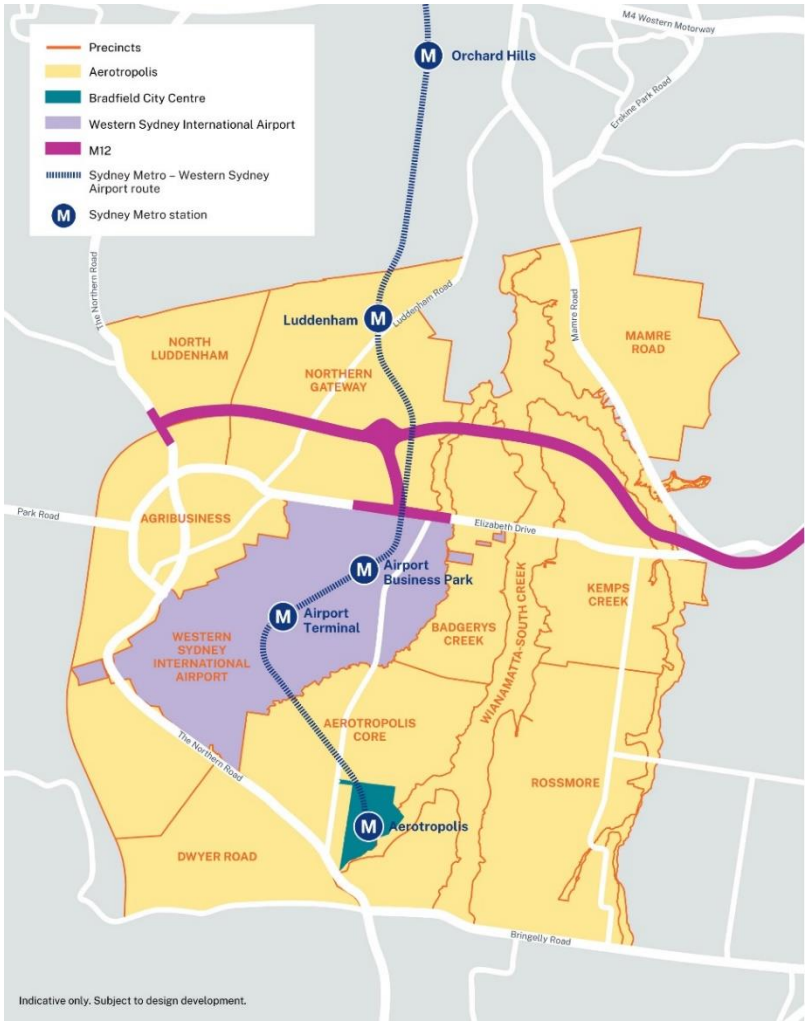
2.1 Strategic Context

The Bradfield City Centre is located to the south-east of the new Western Sydney International (Nancy-Bird Walton) Airport at the intersection of Badgerys Creek Road and The Northern Road (see **Figure 1** below).

The Sydney Metro Western Sydney Airport line runs through the site, providing connections from the key centre of St Marys through to stations at Orchard Hills, Luddenham, Airport Business Park, Airport Terminal and the Aerotropolis which is located within the site.

The site is surrounded by several key roads and infrastructure corridors including Bringelly Road, Badgerys Creek Road, Elizabeth Drive, M12 and The Northern Road.

Figure 1 Strategic Context



Set on natural waterways, Bradfield City Centre presents a rare opportunity to showcase the best urban design and to create a thriving, blue and green, connected City in which Australians will want to live, learn, and work. The Bradfield City Centre will be a beautiful and sustainable 22nd Century City. It will foster the innovation, industry and technology needed to sustain the broader Aerotropolis and fast track economic prosperity across the Western Parkland City.

2.2 The Master Plan Site

The street address for Bradfield City Centre is 215 Badgerys Creek Road, Bradfield (the Site) within the Liverpool Council Local Government Area (LGA). The site is legally described as Lot 3101 DP 1282964 and has an area of 114.6 hectares, with road access to Badgerys Creek Road located at the north-western corner. The site spans across the Aerotropolis Core and Wianamatta-South Creek Precinct, within Western Sydney Aerotropolis. The Site is outlined in **Figure 2** below.

The Site is predominantly zoned Mixed Use under the Western Parkland City SEPP, with a small portion of Enterprise zoned land located on the north-western corner of the site. The site also includes Environment and Recreation zoned land mostly along Thompsons Creek in the sites south-east.

Figure 2 Master Plan Site

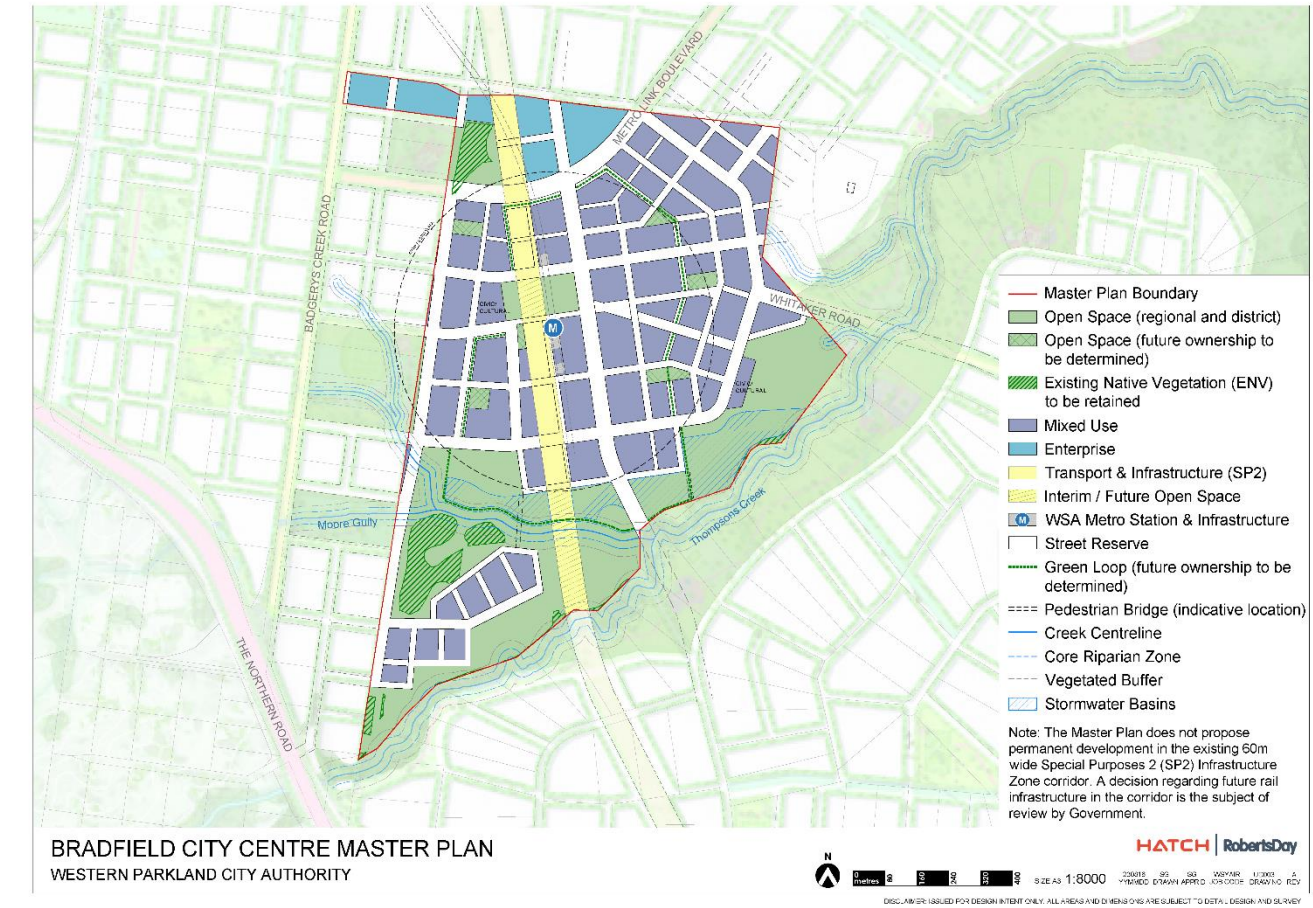
2.3 The Bradfield City Centre Master Plan

The Western Parkland City Authority has prepared a Master Plan (Figure 3 below) in accordance with the DPE Master Plan Requirements.

The Master Plan sets out a framework for future development within the Bradfield City Centre which includes:

- Road network, key connectors to adjoining land and the regional road network (existing and future)
- Block structure
- Indicative open space network
- Sustainability strategy
- Social and infrastructure strategy
- Arts and culture strategy
- Infrastructure servicing strategy

Figure 3 Master Plan



2.4 The Proposal

The Bradfield City Centre Master Plan is intended to facilitate the growth of the centre over time. The Master Plan has established the following three planning horizons for technical assessments.

Table 1 - Planning & Development Horizons

Phase	Indicative Timeframe	Estimated employment	Estimated residential population	Estimated Gross Floor Area (cumulative)
Immediate	2026	1,000 - 1,200 jobs	0 residents	48,500 sqm
Medium-term	2036	8,000 - 8,300 jobs	3,000 - 3,100 residents	341,000 sqm
Long-term	2056	20,000 – 24,000 jobs	15,000 – 15,200 residents	1,258,000 sqm

Note: The table above is an estimate of the population and employment forecast used for the purposes of modelling only.

The master plan has the capacity to accommodate ~10,000 residential dwellings. In accordance with NSW Government policy a proportion of the residential dwellings will be affordable housing. The timing and delivery of residential dwellings will be subject to market demand and future master plan reviews that consider the impact of additional population on the scope and timing of social and physical infrastructure.

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3 Baseline investigations

An examination of the existing site indicates it is comprised primarily of open field with clusters of dense vegetation located towards the south western aspect. Given the existing site receives minimal shielding from neighbouring sites, the wind conditions are expected to be directly comparable/similar to the wind speeds measured at the Badgerys Creek Automatic Wind Station (AWS). Therefore, it is expected that the site is generally exposed to the predominant south-westerly in all seasons, with the westerly and easterly winds being prominent, yet not as frequent as the south-westerly. The land topography generally slopes down from the highest point at the north-western corner towards the south-east boundary where the Thompsons Creek is situated.

3.1 Technical baseline site consideration

The analysis of the wind conditions within the development precinct is undertaken with the following baseline site considerations:

- The predominant wind directions for the Badgerys Creek region.
- The surrounding building morphology and local land topography.
- The indicative-built form of the various buildings within the development precinct.
- The acceptability of the conditions for outdoor areas are determined based on their intended use.

The conclusions of this report are drawn from our extensive experience in the field of wind engineering and studies of wind environment effect which have been applied to the subject site and assessed accordingly.

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, and any recommendations in this report are made only in-principle.

3.2 Area of Focus

The applicable areas of focus associated with the proposed development precinct with regards to the potential impact on local wind amenity, are listed as follows:

- The proposed building density and built form within the development precinct
- The proposed road alignment and design within and around the development precinct.
- The proposed outdoor areas intended for pedestrian use for short duration stationary activities such as the various open spaces within the development precinct.

4 Assessment Requirements and Policy Context

4.1 Master Plan Requirements

The DPE have issued Master Plan Requirements (MPRs) to the Authority for the preparation of a Master Plan for Bradfield City Centre. This report has been prepared to address the following MPRs.

Table 2 - Master Plan Requirements

Reference	Master Plan Requirement	Where addressed
3. Master plan	An analysis of the site opportunities and constraints, including wind	Section 7
3. Master plan	Demonstrate how the draft master plan meets the performance criteria and standards for the amenity of the public realm, including environmental wind comfort	Section 5.2/7

4.2 State Government Plans/Policies

The Phase 2 Western Sydney Aerotropolis Development Control Plan (DCP) does not include any specific requirements for pedestrian wind amenity. General wind effect provisions should be considered with respect to building heights and setbacks so to prevent building designs from creating unsafe and uncomfortable wind effects within public spaces. Conversely, wind effects within public spaces and along footpaths can assist in dispersing air pollution and vehicle emissions, as well as improve pedestrian comfort in warm climate areas.

In the absence of specific requirements for wind by the Planning Authority, the below criteria summarised in Tables 3 and 4 for pedestrian comfort and safety, respectively, is recommended to be considered for the Western Sydney Aerotropolis DCP Phase 2.

Table 3 – Pedestrian Comfort Criteria Standard

Classification	Description	Maximum 5% Exceedance GEM Wind Speed (m/s)
Sitting	Outdoor areas that involve long duration stationary activities, such as	4

	seating in parks, dining areas in restaurants, amphitheatres, etc.	
Standing	Short duration stationary activities (generally less than 1 hour), including window shopping, waiting areas, etc.	6
Walking	For pedestrian thoroughfares, private swimming pools, most communal areas, private balconies, and terraces, etc.	8

Table 4 – Pedestrian Safety Criteria Standard

Classification	Description	Maximum Exceedance Wind Speed (m/s)
Safety	Safety criterion applies to all trafficable areas.	23

For pedestrian comfort the hourly mean wind speed, or Gust-Equivalent Mean (GEM) wind speed (whichever is greater for each wind direction), must not exceed 8m/s for walking, 6m/s for standing, and 4m/s for sitting. These are based on a 5% probability of exceedance. For wind safety the annual maximum peak (3-second gust) wind speed must not exceed 23m/s.

The wind speed assessment for pedestrian comfort and safety is undertaken for winds occurring between 6am and 10pm (AEST).

The provisions should ensure that developments comply with the wind safety and wind comfort standards.

These have been adapted from the recommendations of the Australasian Wind Engineering Society and the most recent City of Sydney DCP.

4.3 Western Sydney Aerotropolis

A review of the documents available as part of the Phase 2 Western Sydney Aerotropolis Development Control Plan (DCP) package indicates that there are no specific requirements for pedestrian wind amenity. The review was based on the following documents:

- Western Sydney Aerotropolis Development Control Plan (DCP) - Phase 2
- Western Sydney Aerotropolis Precinct Plan
- Recognise Country: Guidelines for development in the Aerotropolis
- Aviation Safeguarding Guidelines – Western Sydney Aerotropolis

4.4 Other Relevant Technical Standards

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 5 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. It should be noted that wind speeds affecting this particular development can only be accurately quantified with a wind tunnel study.

Table 5 – Summary of Wind Effects on People

Type of Winds	Beaufort Number	Mean Wind Speeds (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.

4.5 Summary of Key Implications for Master Plan

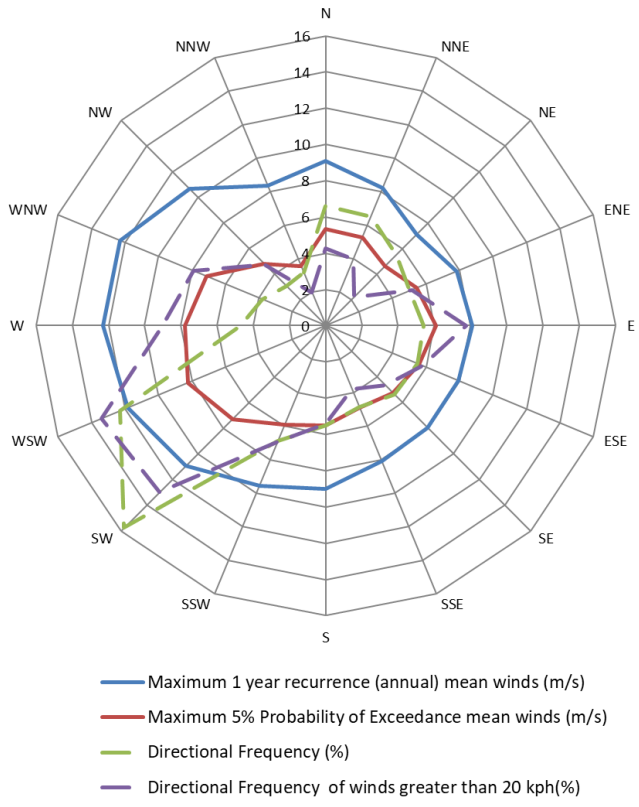
The key implications for the master plan in terms of wind conditions is the suitability of the critical outdoor trafficable areas within development precinct for its intended uses and the potential risk to pedestrian safety. A baseline investigation into the existing site conditions indicates the development precinct is generally exposed to the prevailing wind directions for the Badgerys Creek region given the context of the existing site and surrounding land topography and building morphology. The following sections of this report will investigate the impact on the local wind amenity due to the interaction between the prevailing winds directions for the Badgerys Creek region and the proposed built-form of the development precinct.

5 Technical Approach/ Framework

The assessment of the wind effects is based on a visual examination of the available precinct concept reports and in relation to the prevailing wind directions for the Badgerys Creek region. The Badgerys Creek region is governed by three principal wind directions, and these can potentially affect the subject development. The predominant winds occur from the south-west to west-south-west sector. The winds occurring from the east and west wind directions are predominant, however they are not as frequently occurring as the south-westerly sector winds.

These wind directions were determined from an analysis undertaken by Windtech Consultants of recorded directional wind speeds obtained at the meteorological station located at Badgers Creek Automatic Weather Station (AWS) by the Bureau of Meteorology. The data has been collected from this station from 2001 to 2020 and corrected so that it represents winds over standard open terrain at a height of 10m above ground level. **Figure 4** shows a summary of this analysis in the form of, a directional plot of the annual and 5% exceedance mean winds for the Bankstown region is also determined. The frequency of occurrence of these winds is also shown in **Figure 4**. **Figure 4** shows the 5% exceedance mean wind speeds for the Badgerys Creek region relative to the site.

Figure 4 Directional Hourly Mean Wind Speed and Frequencies of Occurrence Plots



6 Technical Assessment

The expected wind conditions affecting the development precinct are discussed in 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.

6.1 Building Density

An examination of the indicative-built form of the development precinct indicates the precinct is predominantly comprised of medium-rise buildings varying up to a height of 18 storeys. The proposed layout of buildings are expected to provide effective wind shielding to the direct wind effects from the prevailing wind directions for the region; in particular to the central outdoor trafficable areas such as the proposed Central Park and City Walk streetscapes that are expected to have a higher degree of pedestrian activity. The staggering of the overall building height within the various superblocks would also assist in ameliorating the potential reattachment flows over the buildings and minimise the impact of downwash effects off the taller building facades. Furthermore, the potential downwash wind effect is further mitigated through the proposed design of the taller buildings consisting of a tower component incorporating a setback from the building edge of the lower podium component. This setback design is effective in reducing the intensity of the potential downwash winds redirected off the tower building façade; with its effectiveness in wind mitigation increasing with the tower setback distance.

The superblocks along the southern boundary of the precinct will provide shielding of the prevailing south-westerly winds from the central areas of the precinct. However, the southern perimeter of these lots may be subject to potential wind impacts as they act as the first barrier against the prevailing south-westerly winds. These wind impacts can include direct and side-streaming wind effects along the building façade. An examination of the Master Plan Report indicates the inclusion of dense vegetation in the form of trees along the streetscapes of the superblocks. The dense vegetation are effective forms of wind mitigation, especially to the aforementioned wind effects. Furthermore, the local wind conditions can be enhanced with the inclusion of effective wind mitigation design elements such as impermeable awnings along the building façade.

This assessment is made on the assumption the surrounding precincts are not developed. Should the surrounding precincts be developed during a similar period then it would be expected that they would offer shielding benefits.

6.2 Road Alignment

The main arterial roads are positioned such that they generally do not align directly with the prevailing south-westerly sector winds. A majority of the roads consist of kinks as they travel across the precinct, therefore minimising the susceptibility of wind channelling. The introduction of additional kinks in main arterial roads that stretch for extended distances is expected to further disrupt channelling. Furthermore, the roads within the building lots also consist of a non-uniform layout which is beneficial in minimising wind channelling.

A wider transit road is proposed for the northern boundary of the precinct that will connect the existing Badgerys Creek Road to primary arterial road (rapid bus). The Transit Boulevard is located within the advanced manufacturing and commercial sectors to allow for transport and heavy vehicles. The proposed medium-rise buildings within this area combined with street trees is not expected to result in adverse funnelling wind effects. Similarly wider transit roads are proposed with north-south

corridor through the centre of the precinct and an east-west extension of the existing Whitaker Road respectively. These wider streets are beneficial in minimising the strength of funnelling effects through built-up areas.

Narrower city and local streets are proposed within the master plan. Combined with an increase in building density, building heights, the pedestrian footpaths along the street frontages are expected to have an increased susceptibility to funnelling wind effects. It should be noted the aforementioned kinks and non-uniform layout in the design of the precinct are expected to be effective in minimising the strength of these potential funnelling wind effects.

Note the inclusion of trees along the street frontages as intended in the Master Plan are expected to be effective in further enhancing the local wind conditions along the various streetscapes. Wider streets are also beneficial in minimising the strength of funnelling effects through built-up areas. Similarly, increasing the building gaps between adjacent buildings as well as varying building heights can assist in minimising wind speeds.

6.3 Open Spaces

A variety of open spaces are proposed within the development precinct. These include natural vegetation spaces such as the Parklands located along southern boundary of the precinct; including the proposed waterfront public spaces of Moore Gully and City Parklands (East). Open communal spaces such as the Central Park adjacent to the proposed Metro rail station, Ridge Park located at the north-western corner of the precinct and a communal sportsground located along the western boundary of the precinct. An analysis of the potential impact of the prevailing wind on the local wind amenity within these open spaces are detailed as follows:

- The Parklands benefits from the moderate shielding provided by the surrounding buildings within the most southern development lots (located in Moore Gully) to the prevailing south-westerly sector winds in the immediate surroundings of the parkland. However due to the size of the parkland there is susceptibility for the south-westerly winds to reform strength as they travel towards the central and south-eastern areas of the precinct.
- The Moore Gully and City Parklands (East) waterfront public spaces benefits from the shielding provided by the surrounding buildings within the lots (located along southern interface of city and Moore Gully) to the prevailing westerly winds. The Moore Gully waterfront public space also benefits from the shielding of the south-eastern lots along the Moore Gully (east of Transit Boulevard) to the prevailing easterly winds, however, the Thompsons Creek waterfront public space remains exposed to the prevailing easterly winds due to the lack of structures along the eastern boundary due to the proposed Whitaker Road extension. Both waterfront public spaces also susceptible to the prevailing south-westerly winds as it travels over the adjacent open waters and parkland of the precinct. This will be mitigated through detailed design at Development Application (DA) stage.
- The Central Park space benefits from the shielding provided by the surrounding buildings to the prevailing winds for the region. Due to the large footprint of the Central Park, it may be susceptible to reattachment flows as the prevailing winds travel over the buildings adjacent to the park.
- The Ridge Park benefits from the shielding provided by the surrounding buildings to the prevailing winds for the region. Due to the large footprint of Ridge Park and height of the surrounding buildings, it may be susceptible to reattachment flows as the prevailing winds travel over these buildings. Furthermore, Ridge Park is located along the boundary of the precinct allows for the reattachment flows to penetrate the more central areas of the precinct.
- The Sportsground earmarked by the Precinct Plan located outside of the subject site benefits from the moderate shielding provided by the surrounding buildings within the eastern superblock to the prevailing easterly winds. However, it is exposed to the prevailing westerly to south-westerly winds as it receives minimal shielding from the surrounding streetscape outside the precinct.

The following treatment strategies are expected to be effective in wind mitigation and enhancing the local wind conditions within the various open spaces to be suitable for its intended uses:

- The Parklands - Utilise extensive densely foliating vegetation within and around the parkland areas; in particular areas intended for short duration stationary activities such as outdoor seating etc.
- Moore Gully and City Parklands (East) waterfront public spaces – Utilise extensive densely foliating vegetation along the boundary edge of the public spaces; in particular along the bank areas of the Parklands and around areas intended for short duration stationary activities such as outdoor seating, pool deck areas etc.
- Central Park - Utilise extensive densely foliating vegetation within and around the Central Park; in particular areas intended for short duration stationary activities such as outdoor seating etc.
- Ridge Park - Utilise extensive densely foliating vegetation within and around the Ridge Park; in particular areas intended for short duration stationary activities such as outdoor seating etc.
- Sportsground - Utilise extensive densely foliating vegetation around the Sportsground; in particular along western, southern and eastern perimeter edge of the Sportsground. Furthermore, it is recommended that surrounding buildings to the east of the Sportsground incorporate an impermeable awning along the western aspect of the buildings to minimise the potential impact of the prevailing westerly winds being down-washed off the buildings onto ground level areas below.
- Note the aforementioned dense vegetation within the various open spaces is recommended is to be of an evergreen species to ensure their effectiveness in wind mitigation throughout the year. In particular along the western and southern boundaries as these areas are susceptible to the prevailing winds that frequently occur during the cooler winter periods of the year.

7 Recommendations

The following design advice should be considered in the design as a means of addressing the key wind impacts detailed in Section 7 to assist with wind mitigation and enhancing the local wind conditions to be suitable for its intended uses:

Table 6 - Recommendations

Ref	Recommendation	Timeframe	Responsible
Wind Treatment Strategies			
1	Utilise extensive densely foliating vegetation (existing trees and strategic planting) along the various streetscapes and proposed outdoor spaces, to mitigate approaching winds through larger open spaces and along building aspects. In particular around corners of buildings, within and around the open parkland and waterfront and areas intended for short duration stationary activities such as outdoor seating etc.	This has been considered during the design and development of the Master Plan.	Design Team
2	The densely foliating vegetation is to be of an evergreen species to ensure their effectiveness in wind mitigation throughout the year. In particular along the western and southern boundaries as these areas are susceptible to the prevailing winds that frequently occur during the cooler winter periods of the year.	This has been considered during the design and development of the Master Plan.	Design Team
3	Incorporating a podium component for taller buildings, with a setback of the tower component from the podium building edge. Increasing the tower setback will also increasing its effectiveness in wind mitigation.	This has been considered during the design and development of the Master Plan.	Design Team
4	Utilise appropriate design measures such as awnings, canopies, streamlining building form with respect to the prevailing wind directions etc. to reduce the likelihood of adverse winds at ground level resultant from downwash effects. In particular along the building facades facing the proposed Sportsground and the Parkland areas of Moore Gully and City Parklands (East).	This has been considered during the design and development of the Master Plan.	Design Team
5	Utilise architectural features at the ground level in conjunction with the densely foliating landscape vegetation such as localised vertical screening near high use areas intended for	This has been considered during the design and	Design Team

	short duration stationary activities (outdoor seating, BBQ/communal areas etc.) to baffle approaching winds.	development of the Master Plan.	
6	Utilise vertical feature elements along building facades to reduce the ability of winds to side-stream long the various building facades.	This has been considered during the design and development of the Master Plan.	Design Team
7	Utilise localised wind mitigating devices such as densely foliating vegetation in the form of trees or shrubs/hedge planting, localised vertical screens or seating with high backrests oriented perpendicular to the prevalent flow streams for areas intended for short duration stationary activities such as outdoor seating.	This has been considered during the design and development of the Master Plan.	Design Team
8	Avoid placing high use pedestrian/patron areas in locations at risk of experiencing accelerated wind flow such as trafficable areas around the corners of buildings. This includes areas intended for short duration stationary activities where the expected activity time exceeds 1 hour (e.g., outdoor seating etc.).	This has been considered during the design and development of the Master Plan.	Design Team
9	Utilise localised wind mitigating devices such as densely foliating vegetation in the form of trees or shrubs/hedge planting, localised vertical screens or seating with high backrests oriented perpendicular to the prevalent flow streams for areas intended for short duration stationary activities such as outdoor seating.	This has been considered during the design and development of the Master Plan.	Design Team
10	Avoid placing high use pedestrian/patron areas in locations at risk of experiencing accelerated wind flow such as trafficable areas around the corners of buildings. This includes areas intended for short duration stationary activities where the expected activity time exceeds 1 hour (e.g., outdoor seating etc.).	This has been considered during the design and development of the Master Plan.	Design Team

Note that detailed wind tunnel modelling can be undertaken as part of the detailed design phase to verify the wind conditions around the site and ensure suitable conditions are provided for pedestrians. This will provide a quantitative analysis of the wind conditions and determine the requirement for wind mitigation measures; including the optimisation of the size and extent of the treatments required to ensure suitable wind conditions are achieved at all outdoor pedestrian accessible locations within and around the development.

8 Conclusion

An analysis of the wind environment impact with respect to the three (3) principal wind directions for the Badgerys Creek region has been completed for the proposed Bradfield City Centre Master Plan Site located at 215 Badgerys Creek Road, Bringelly. The conclusions of this report are drawn from our extensive experience in this field and are based on an examination of the available precinct concept reports available at the time. No wind tunnel testing has been undertaken at this stage of the development. 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 the site benefits from the shielding provided by the indicative built-form of the various buildings within the development precinct. However, there are some areas that are likely to be exposed to stronger winds that can have an impact on the local wind amenity. It is expected that the wind effects identified in the report can be ameliorated and local wind conditions further enhanced with the consideration of the following treatment strategies into the design of the development precinct:

- Utilise extensive densely foliating vegetation (existing trees and strategic planting) along the various streetscapes and within and around the various open spaces, to mitigate approaching winds through larger open spaces and along building aspects. In particular around corners of buildings, within and around the open parkland and waterfront and areas intended for short duration stationary activities such as outdoor seating etc.
- The densely foliating vegetation is to be of an evergreen species to ensure their effectiveness in wind mitigation throughout the year. In particular along the western and southern boundaries as these areas are susceptible to the prevailing winds that frequently occur during the cooler winter periods of the year.
- Incorporating a podium component for taller buildings, with a setback of the tower component from the podium building edge.
- Utilise appropriate design measures such as awnings, canopies, streamlining building form with respect to the prevailing wind directions etc. to reduce the likelihood of adverse winds at ground level resultant from downwash effects. In particular along the building facades facing the proposed Sportsground and the southern open parkland areas of Moore Gully and City Parklands (East).
- Utilise architectural features at the ground level in conjunction with the densely foliating landscape vegetation such as localised vertical screening near high use areas intended for short duration stationary activities (outdoor seating, BBQ/communal areas etc.) to baffle approaching winds.
- Utilise vertical feature elements along building facades to reduce the ability of winds to side-stream long the various building facades.
- Utilise localised wind mitigating devices such as densely foliating vegetation in the form of trees or shrubs/hedge planting, localised vertical screens or seating with high backrests oriented perpendicular to the prevalent flow streams for areas intended for short duration stationary activities such as outdoor seating.
- Avoid placing high use pedestrian/patron areas in locations at risk of experiencing accelerated wind flow such as trafficable areas around the corners of buildings. This includes areas intended for short duration stationary activities where the expected activity time exceeds 1 hour (e.g., outdoor seating etc.).
- Avoid aligning wider building aspects perpendicular to the prevailing winds, where possible, to reduce the possibility for winds to be captured and down-washed from the façade towards the ground level, impacting pedestrians.
- Avoid aligning thoroughfares/roads parallel with the prevailing winds by integrating steps or changes in direction into the building massing.

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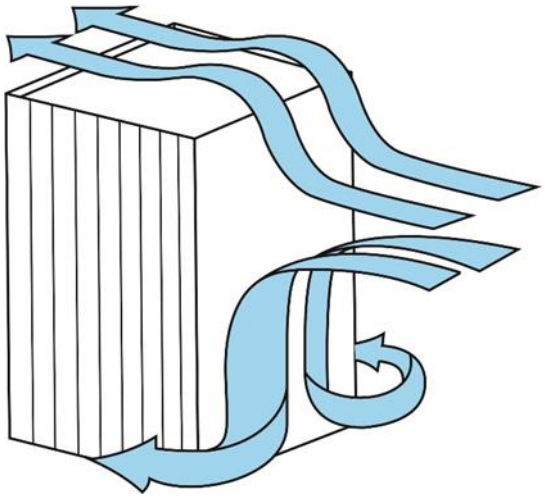
Appendix 1 – Wind Effects Glossary

Downwash and Upwash Effects

The downwash wind effect occurs when wind is deflected down the building's windward facade causing accelerated wind speeds 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 A1. This can also lead to recirculating flow in the presence of a shorter upstream building, causing the local ground level wind flow to move towards 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.

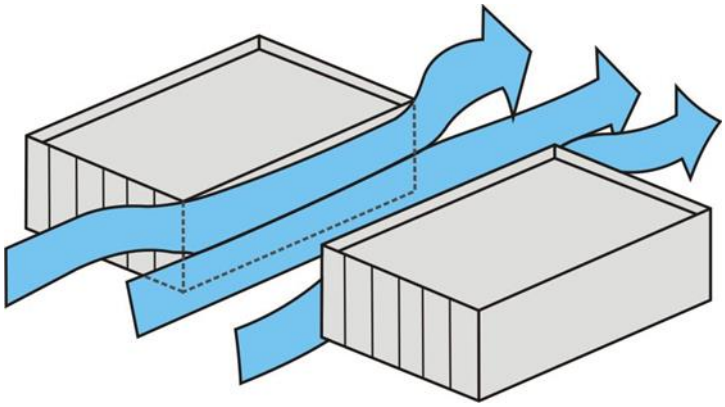
Figure A1: Downwash Leading to Corner Wind Effect, and Upwash Effects



Funnelling/Venturi Effect

Funnelling effects occur when the wind interacts with two or more buildings which are located adjacent to each other and the building form design results in a bottleneck, as shown in Figure A2. This can cause the wind to be forced 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.

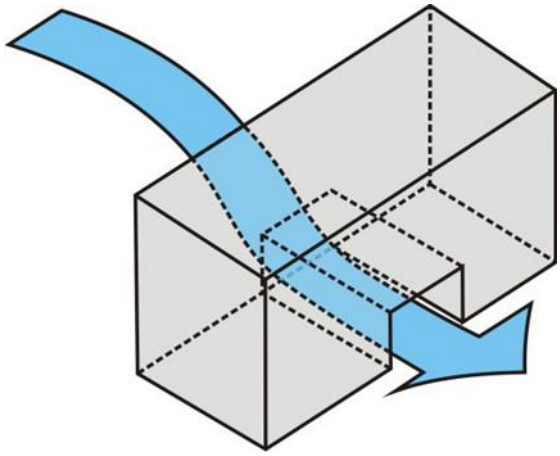
Figure A2: Funnelling/Venturi Wind Effect



Gap Effect

The gap effect occurs in small openings in the façade that are open to wind on opposite faces, as seen in Figure A3. 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 A3: Gap Wind Effect

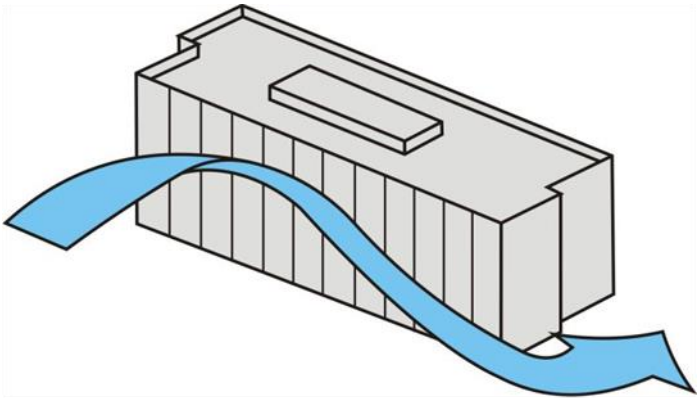


Sidestream and Corner Effects

The sidestream effect is due to a gradual accumulation of winds 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 A4

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 A4: Sidestream and Corner Wind Effect



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.

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