Appendix 5 – Wind Impact Assessment

PEDESTRIAN WIND ENVIRONMENT STATEMENT

263-281 PENNANT HILLS ROAD, CARLINGFORD, CARLINGFORD APARTMENTS (MASTERPLAN)

WH942-01F02(REV2)- MASTERPLAN WS

SEPTEMBER 1, 2023

Prepared for:

MERITON APARTMENTS PTY LTD

LEVEL 11, 528 KENT STREET, SYDNEY NSW 2000

WINDTECH Consultants

Head Office: 607 Forest Road, Bexley NSW 2207, Australia
ABN: 72 050 574 037

P +61 2 9503 0300 **E** reception@windtechglobal.com **W** www.windtechconsult.com

DOCUMENT CONTROL

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EXECUTIVE SUMMARY

This report presents an assessment of the likely impact of the future built massing at the Carlingford Apartments located at 263-281 Pennant Hills Road, Carlingford, on the local wind environment at the critical outdoor trafficable 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 to 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. 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 is relatively exposed to the three prevailing wind directions affecting the site. The development incorporates several design features which are effective in wind mitigation and suitable wind conditions are expected to be experienced for the majority of the outdoor trafficable areas within and around the development. However, there are some areas that are likely to be exposed to stronger winds. These areas are discussed below.

Stage 01

The orientation of Buildings A to D along Pennant Hills Road leads to exposure to the prevailing SSE and NE winds along the wider aspects facing SE. In turn, these side-streaming effects and funnelling will occur in gaps between Buildings A and B, C and D, and primarily Buildings B and C. Depending on the designated use of the area, there are differing mitigation options in the form of landscaping for non-trafficable areas, and hard architectural features for trafficable areas (e.g., screens, awnings, etc.). The developments to the immediate west of the site are expected to alleviate some of the harsher westerly winds. It is expected that these stronger wind effects can be ameliorated with the consideration of the following treatment strategies into the design of the development:

- If the area along the base of the SE aspects of the towers fronting Pennant Hills Road are not intended to be trafficable and will serve as deep soil planters, we recommend 3m high screens, approximately 30% porous and 3m deep at the two southern corners of each of the towers. These are expected to bring wind conditions to within the safety limit and with the proposed tree planning in the gaps between these towers it is expected that the comfort criterion will also be met.
- If the area along the base of the SE aspects of the towers fronting Pennant Hills Road are intended to be trafficable, we recommend a 3m deep continuous awning along the entire SE aspect, which will need to return around the two southern corners of each of the towers. These are expected to bring wind conditions to within the safety limit and with the proposed tree planning in the gaps between these towers it is expected that the comfort criterion will also be met.
- It is recommended to cover the outdoor area belonging to the Child Care Centre. This will help mitigate the effect of the NE and W winds. In the case of the SE winds, we recommend a full-height impermeable screen along the southern edge of the outdoor area facing the internal site connections to deflect the side-streaming winds off the base of Building G.

- Utilise strategic landscaping (tree planting, planter boxes, shrubs, or hedges), where possible, to slow winds through larger open space and along building aspects where the prevailing winds may be side-streaming or directly impacting an active area of the site. Particularly along Pennant Hills Road and through the internal pedestrian and vehicle access areas.

- Retain any significant trees to the northern, western, and southern perimeters of the proposed development site.

- Provide exclusion zones in the form of dense vegetation and tree planting, particularly at the eastern corners of Buildings A, B, C and D and at the western boundary of Building G. These can be provided within the designated deep soil zones.

- Either 1800m high vegetation and/or hedging or impermeable screens along the perimeter of elevated communal areas situated on the building podium or rooftop areas.

- Provide 3m high x 4m wide porous screens at the southern corners where the towers meet the elevated podium area, if intended for pedestrian/communal use. Alternatively, provide semi-enclosed gazebos within these zones.

- Utilise more localised impermeable screening around areas where longer duration stationary activities are expected to help satisfy the more stringent comfort criterion for these types of activities.

Stage 02

The substantial shielding provided by existing building to the NE and W as well as partial shielding of the SSE winds by Stage 01 of the subject development, is expected to provide some protection from adverse wind impacts at the ground level. Nevertheless, the proposed tree planting along the site perimeter is important in enabling the wind conditions in these areas to satisfy the pedestrian comfort criterion. Some sections of the elevated terraces will require some form of wind mitigation if they are to be accessible by the occupants. It is expected that these stronger wind effects can be ameliorated with the consideration of the following treatment strategies into the design of the development:

- Utilise design measures such as awnings and canopies, with some screening in key locations, to achieve acceptable wind conditions on the podium, particularly along Shirley Street and eastern aspect of Building F. Awnings are also beneficial in reducing the impact of winds spilling off the podium onto lower lever areas.

- Utilise strategic landscaping (additional tree planting, planter boxes, shrubs, or hedges), where possible, to slow winds through larger open spaces and along building aspects where the prevailing winds may be side-streaming or directly impacting an active area of the site.

- Retain any significant trees to the northern, western, and southern perimeters of the proposed development site.

- Taller than standard height perimeter balustrades are recommended around the perimeter of the elevated podium area, if intended for pedestrian/communal use. This is to trip direct prevailing winds impacting the large open podium areas.

Along with the above mitigation and hard architectural treatments, landscaping in the form of dense hedging and or vegetation should be utilised where appropriate in combination with tree planting along aspects experiencing severe wind conditions.

In addition to the above, retention of the proposed trees located to the north, west and south of the development is expected to further enhance the wind conditions within and around the subject site.

Note: For tree planting/landscaping to be effective as a wind mitigation device, the species should be of a densely foliating variety. It is recommended that evergreen species are selected to ensure year-round effectiveness. Trees should also be planted in clusters with interlocking canopies where possible to effectively absorb incident winds.

CONTENTS

1 INTRODUCTION

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

2 DESCRIPTION OF DEVELOPMENT AND SURROUNDINGS

The site is located at lot 263-281 Pennant Hills Road and is bounded by the Cumberland Highway along the south-eastern boundary and the accompanying Shirley Street to the west and north. It is situated near the corner of the Marsden Road and Pennant Hills Road turn off to the Cumberland Highway. It is in immediate proximity to a collection of three 18-20 storey apartment block buildings to the west, two of which are direct neighbours of the site, with a further two 9-10 storey building approved and under-construction. Similarly, to the north there are four mid-rise residential buildings varying from 6-9 storeys.

Significant features of the area include James Rous Agricultural High School to the west with Cox Park and Galaringi Park to the south-east.

A survey of the land topography in the vicinity of the subject site indicates that there is a decrease in elevation of approximately 20m across the site from the North-East down Pennant Hills Road and Shirley Street with a further approximate 1:10 gradient.

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 is predominantly vacant with the two aforementioned buildings currently under construction of heights 30m and 27m. The future building form within the subject site consists of three significant Build Zone areas which highlight the respective stages of the project. These are as follows:

- **Stage 01** - Five future building forms are expected to be developed in Stage 01 and are positioned towards the south and eastern ends, as well centre of the development site.
    - **Building A** 18 Storeys (*12 Storeys above 'Ground Level'*)
    - **Building B** 29 Storeys (*24 Storeys above 'Ground Level'*)
    - **Building C** 28 Storeys (*25 Storeys above 'Ground Level'*)
    - **Building D** 12 Storeys (*11 Storeys above 'Ground Level'*)
    - **Building G** 8 Storeys (*4 Storeys above 'Ground Level'*)
- **Stage 02** - Two future building forms are expected to be developed in Build Zone 2 and are positioned towards the northern to north-eastern ends of the development site.
    - **Building E** 13 Storeys (*8 Storeys above 'Ground Level'*)
    - **Building F** 13 Storeys (*9 Storeys above 'Ground Level'*)

The various stage of the subject site and the corresponding critical outdoor trafficable areas with regards to wind impact which are the focus of this assessment, are listed as follows:

- Wind conditions within the Existing Site. The Existing Site refers to the existing buildings, currently present within the western sector of the subject site.

- Inclusion of the future built form in Stage 01. The impact on the wind conditions due to the inclusion of the future built form in Stage 01, is assessed for the following areas:
    - Building A Ground Level and Podium Level Areas.
    - Building B Ground Level and Podium Level Areas.
    - Building C Ground Level and Podium Level Areas.
    - Building D Ground Level and Podium Level Areas.
    - Building G Ground Level and Podium Level Areas.
- Inclusion of the future built form in Stage 02. The impact on the wind conditions due to the inclusion of the future built form in Stage 02, is assessed for the following areas:
    - Building E Ground Level and Podium Level Areas.
    - Building F Ground Level and Podium Level Areas.

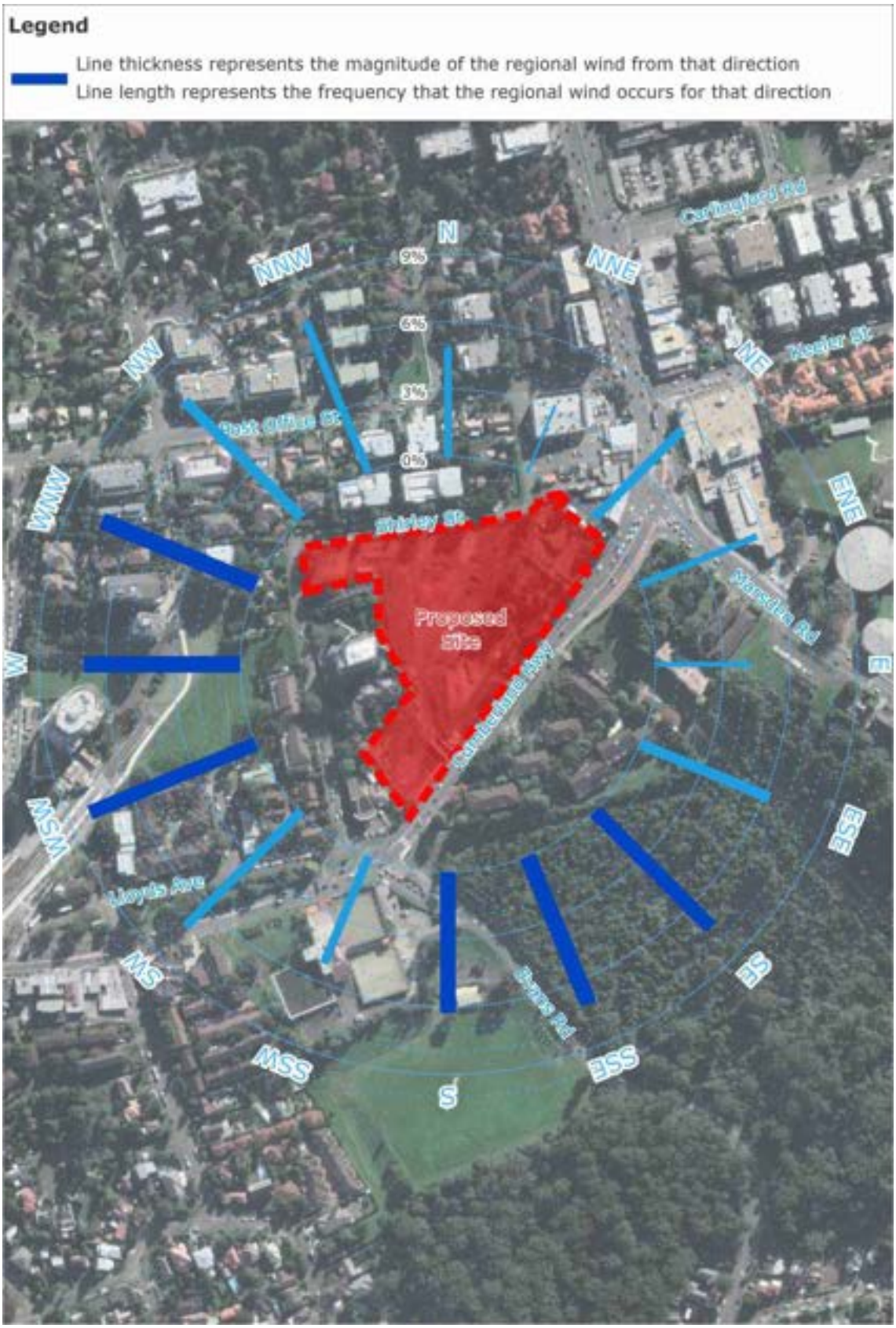

Figure 1: Aerial Image of the Site Location and Prevailing Wind Directions

Figure 2: Site Layout and Staging Locations

3 REGIONAL WIND

The Carlingford region is governed by three principal wind directions that can potentially affect the subject development. These winds prevail from the north-east, south-east to south, and west. These wind directions were determined from an analysis undertaken by Windtech Consultants of recorded directional wind speeds obtained from the meteorological station located at 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 3 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 3.

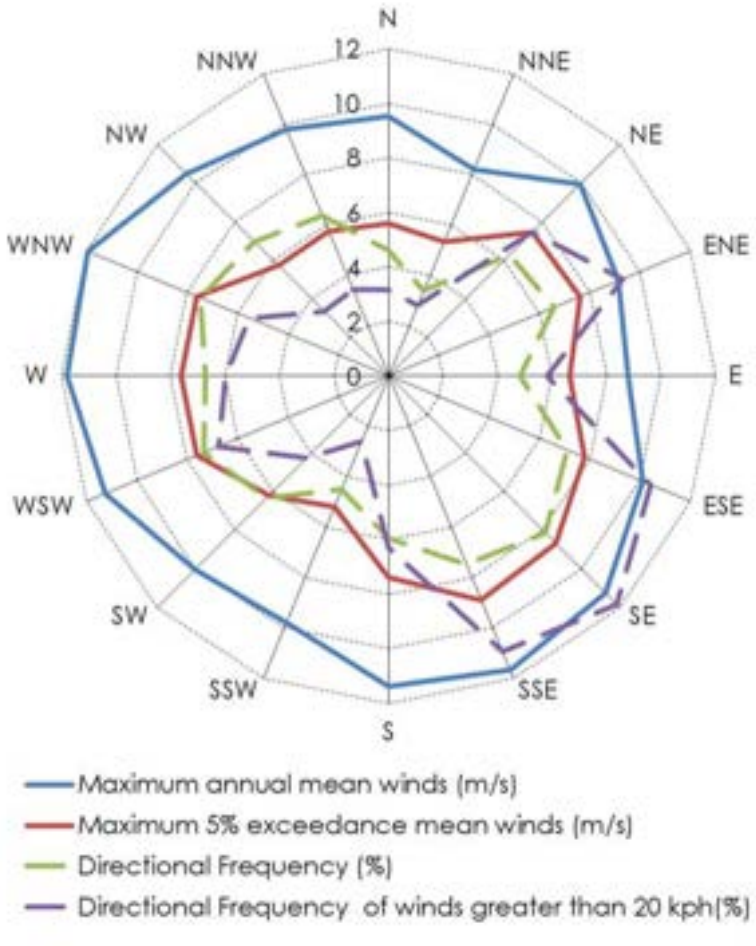

Figure 3: Directional Annual and 5% Exceedance Hourly Mean Wind Speeds (referenced to 10m height in standard open terrain), and Frequencies of Occurrence, for the Carlingford Region

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 AND DISCUSSION

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:

- Comfortable 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.

- 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.

- Long Exposure Criterion (4m/s with a 5% probability of exceedance)
  for stationary activities longer than an hour, e.g. outdoor cinemas, outdoor fine dining etc.

Although this assessment is qualitative in nature, the abovementioned criteria for pedestrian comfort are considered when assessing the wind environment impacts. However, all areas are also assessed with consideration to a pedestrian safety criterion of 23m/s for the annual maximum gust.

5.1 Existing Site

5.1.1 Site Conditions

The existing site is surrounded in all directions by predominantly low-rise residential, commercial, and industrial buildings, with the exception of several mid-rise residential buildings and developments located along Shirley Street immediately to the North and West. The mid-rise buildings directly adjacent to the west of the development site and the building masses to the north provide some shielding from the prevailing westerly and north-westerly winds. However, these winds are still expected to directly impact the site, due to the overall large area of the site relative to the effective area of shielding provided by the neighbouring buildings. These close proximity buildings will exert a significant influence on wind arriving at the site and are expected to generate adverse wind conditions such as side-streaming, corner accelerating and funnelling flows at the existing site location.

The further surrounding built environment comprises of a mixture of mostly low to medium rise residential and low-rise industrial buildings, with Galaringi Park to the southeast. There is a sizable incline along Pennant Hills Road towards the northeast. The existing site is predominantly vacant with two buildings currently under construction to the west. The future built form within the subject site consists of seven individual building masses, in two separate stages.

5.1.2 Mitigations

To reduce the impact of the prevailing winds on the existing buildings of Stage 01 and Stage 02, it is recommended to retain the existing tree planting within and around the precinct where possible. Conditions can be improved further through the use of low-level vegetation such as shrubs/hedges or planter boxes. When utilised below tree canopies, they provide protection from low level winds, especially for more sensitive areas where longer duration activities are intended.

Additionally, in areas where stronger winds are expected, wind screens in the form of impermeable screens, porous screens, signage etc. which are strategically located may be required. In areas where longer duration stay is expected, such as café or restaurant seating areas, or communal recreation areas, additional localised screening, tenancy-operated screening deployable during windy conditions, or additional planting are recommended.

5.2 North-Easterly Sector Prevailing Winds

5.2.1 Stage 01

5.2.1.1 Key Wind Impacts

The future built form of Stage 01 is comprised of five building masses of Buildings A, B, C, D and G. Building D provides partial shielding from north-easterly winds. However, these prevailing winds are still expected to flow along the Ground Level areas of the Stage 01 buildings, side-streaming along the footpath on Pennant Hills Road and the south-eastern aspects of Buildings A, B and C. However, the pedestrian pathway along the street is offset from the buildings and as such, will have a more acceptable wind environment than areas directly adjacent to the buildings.

The north-easterly prevailing winds are still expected to create funnelling effects between Buildings A and B, Buildings B and C, and Building C and D. These hot spot locations on the Ground Level that have been identified in Figure 4 which are expected to be impacted by corner acceleration and funnelling of the north-easterly winds through the relatively narrow space between the building masses. The high tower form of Building B and Building C will generate hot spot areas due to down-washing effects in the areas outlined on the Ground Level Figure 4, as well as the communal areas between these buildings. The outdoor area of the Child Care Centre on the western aspect of Building G is likely to be shielded from the north-easterly winds by the building itself.

The higher towers and podiums of Buildings C and D will provide some shielding to Building G from north-easterly winds. However, there is still expected to be some adverse conditions at the building's north-east corner and northern aspect due to direct wind flow from these prevailing winds. It is also expected that winds funnelling between Buildings B and C will impact on the southeastern aspect of the building.

Building D is expected to encourage north-easterly prevailing winds to side-stream along the northeast and southeast frontages. These side-streaming winds are also likely to corner accelerate at the south-eastern and north-eastern corners of the future built form as indicated in Figure 4. Neighbouring areas of the Stage 02 development and recreational zones are expected to experience wind conditions equivalent to those of the existing site due to the overall shielding provided by the future built form of Building D.

The elevated podium areas for the Stage 01 buildings are expected to have elevated wind levels due to side streaming, corner acceleration effects and funnelling as shown in Figure 5. Additionally, the elevated podium areas of Buildings B and C are expected to have elevated wind conditions at the southern tower corners, where the towers meet the podium due to corner acceleration effects, as shown in Figure 5.

Private Balconies located on the corners of the proposed towers are expected to have wind conditions exceeding the comfort and safety criteria on some of the upper levels, as they will be exposed to higher wind speeds above the shielding influence of the surrounding developments, and will be subject to corner acceleration effects.

5.2.1.2 Possible Wind Mitigations

The proposed dense vegetation and tree planting within the proposed deep soil zones along Pennant Hills Road is expected to alleviate the undesirable wind conditions. Further awnings to mitigate downwash and the inclusion of evergreen trees and dense vegetation will act to break up the side streaming on these building frontages.

To mitigate the adverse side-streaming wind conditions along frontages of the Stage 01 buildings, it is recommended to incorporate awnings spanning the entire south-eastern Pennant Hills Road aspect, as well as the north-eastern and south-western aspects of the precinct in which funnelling is likely to occur. Furthermore, tree planting and/or screening to help break up wind flows is also recommended. In order to reduce the effect of corner-accelerated flows, treatments such as localised porous screenings, landscaping and/or building chamfers to trip the wind as it accelerates around corners are recommended, particularly for Buildings B and C.

For the outlined elevated podium areas, it is recommended to incorporate either 1800m high vegetation or impermeable balustrades along the perimeter of elevated communal areas situated on the building podium or rooftop areas. Accompanying this, it is recommended to incorporate 3m high x 4m wide porous screens or pergola/gazebos if these spaces are intended for pedestrian/communal use.

Figure 4: North-Easterly Wind Flow Hotspots
Future Built Form in Stage 01 - Ground Level Plan

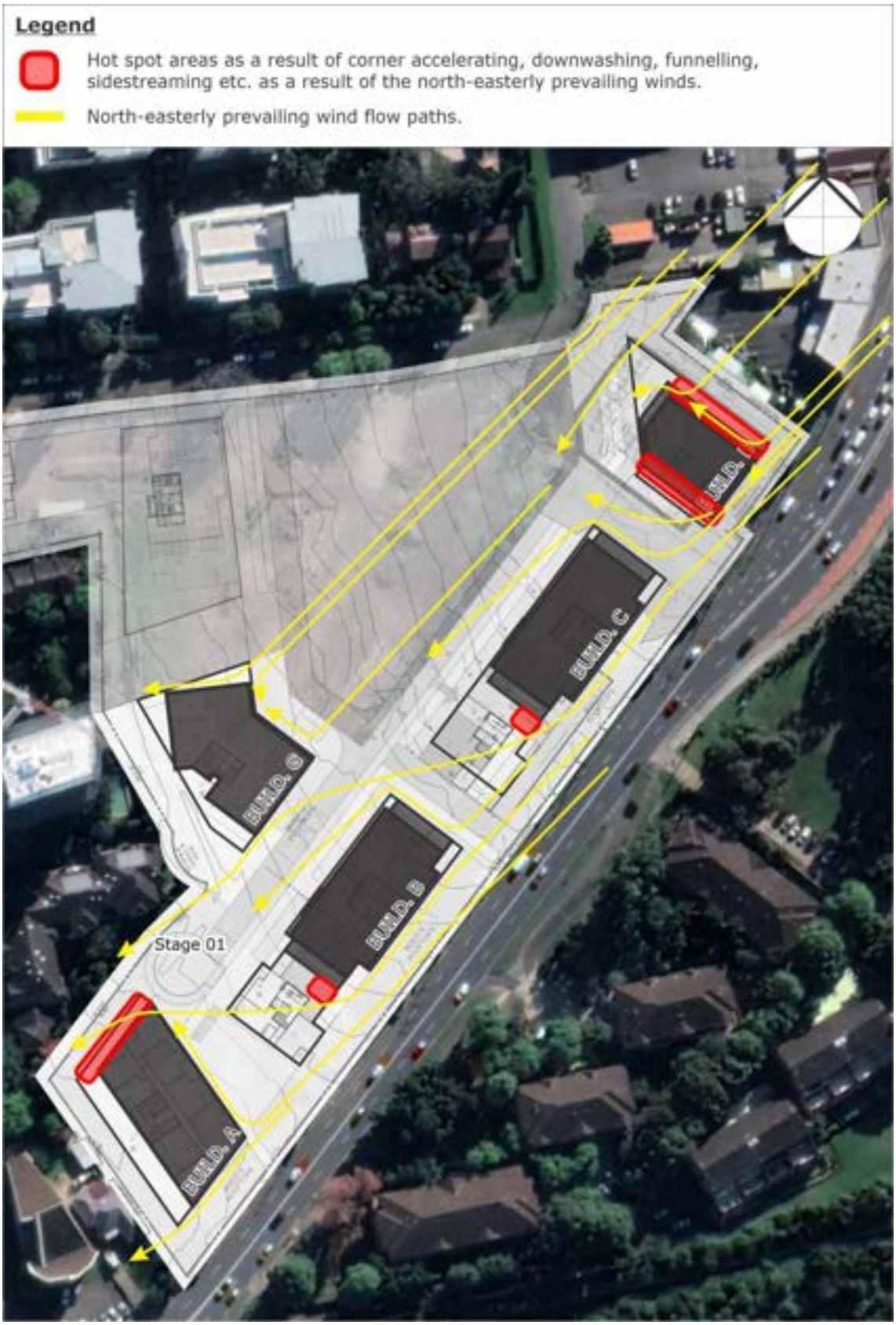

Figure 5: North-Easterly Wind Flow Hotspots
Future Built Form in Stage 01 - Podium Level Plan

5.2.2 Stage 02

5.2.2.1 Key Wind Impacts

The Stage 02 buildings are partially shielded from the prevailing north-easterly winds by the mid-rise residential buildings along Shirley Street. However, the winds are still expected to flow around these buildings and onto the Ground Level areas of Building E and Building F. The tower setbacks from the north and east are expected to be beneficial in reducing potential down-washing winds onto trafficable Ground Level areas.

The hot spot locations on the Ground Level that have been identified in Figure 6 which are expected to be impacted by the prevailing north-easterly winds. The orientation of the future built form in Stage 02 relative to the north-easterly prevailing winds is expected to cause side-streaming winds along the northern and eastern aspects of the podium and corner accelerating flows at the north-western and south-eastern corners of the building. Despite the western and southern frontages being shielded from the prevailing north-easterly winds, these winds still have to potential to spill over onto the northern portion of the western aspect and over the southern edge of the podium, as shown by the flow path in Figure 6. Furthermore, the tower form of Building E and Building F will produce corner acceleration and funnelling through the open communal areas between the towers. The lower southern terrace area of Building F is also likely to have corner acceleration impacts at the northeast corner due to side streaming along the eastern façade of the building mass into the terrace, as shown in Figure 7.

The elevated podium areas for the Stage 02 buildings are expected to have elevated wind levels due to side streaming, corner acceleration effects and funnelling as shown in Figure 7.

5.2.2.2 Possible Wind Mitigations

To mitigate these adverse effects, it is recommended to incorporate awnings along Shirley Street and the eastern aspect of Building F. Additionally, it is recommended to introduce additional tree planting and dense hedging and or vegetation along the designated soft landscaped area along Shirley Street to reduce the impact of any north-easterly winds that may side-stream along these street frontages. To reduce corner acceleration effects, incorporating evergreen trees planting and/or localised porous screening to help break up the flow at building corners is recommended.

The elevated areas are recommended to incorporate either 1800m high vegetation or impermeable balustrades along the perimeter of elevated communal areas situated on the building podium or rooftop areas.

Figure 6: North-Easterly Wind Flow Hotspots
Future Built Form in Stage 02 – Ground Level Plan

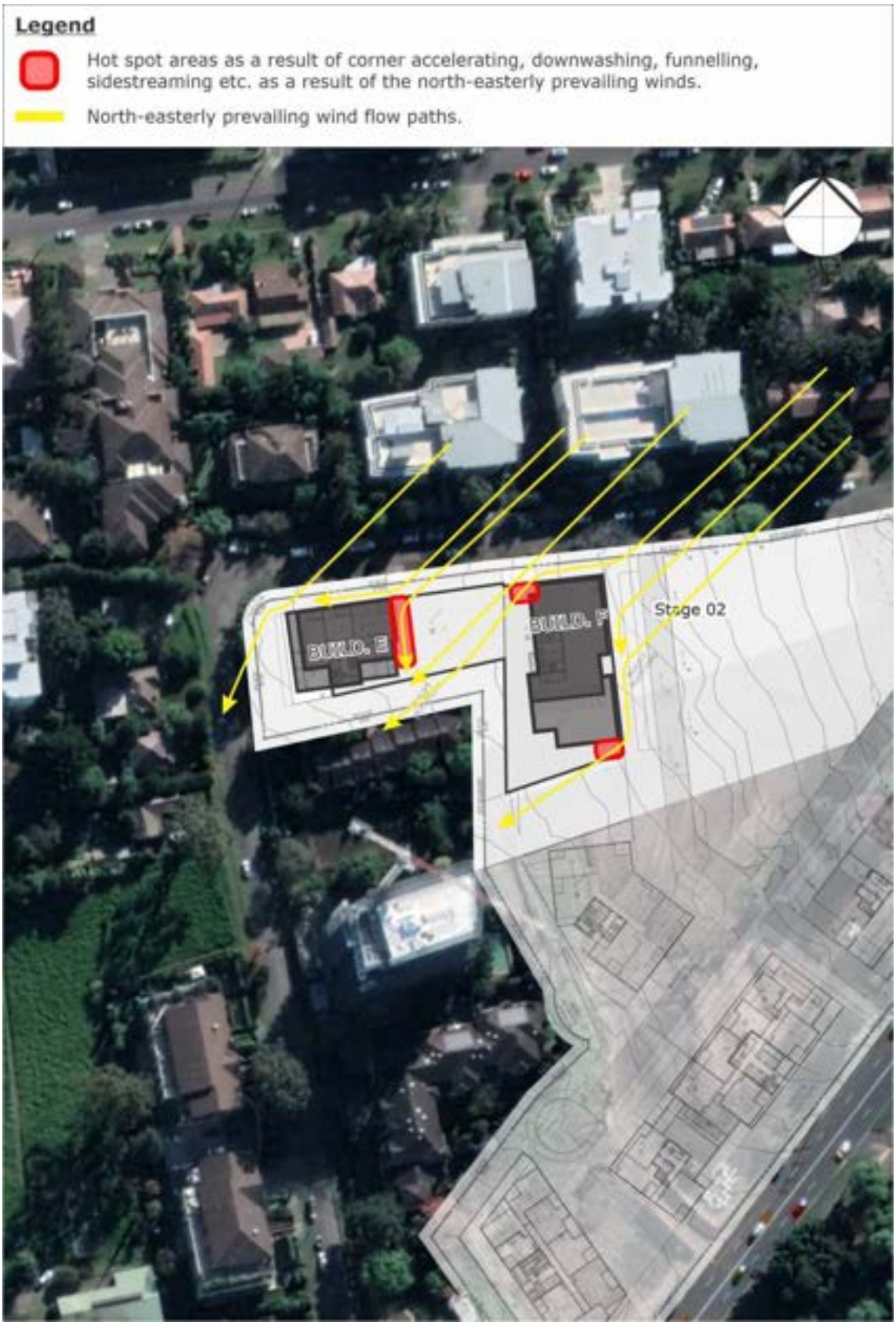

Figure 7: North-Easterly Wind Flow Hotspots
Future Built Form in Stage 02 - Podium Level Plan

5.3 South-South-Easterly Sector Prevailing Winds

5.3.1 Stage 01

5.3.1.1 Key Wind Impacts

The prevailing south-south-westerly winds are expected to affect areas indicated by the wind hot spots in Figure 8. Corner accelerating flows are expected around the north-eastern and southern corners of the Stage 01 buildings. The orientation of the Pennant Hills Road frontage exposes it to south-south-easterly winds which will side-stream along the eastern aspect of the built forms, as indicated in Figure 8. Furthermore, the prevailing southerly winds are expected to funnel between Buildings A-D, as well as between Building A and the neighbouring mid-rise building to the west. South-south-easterly winds are also expected to downwash from the towers above and cause significant corner acceleration effects at the building corners.

The outdoor area of the Child Care Centre on the north-western side of Building G is expected to be adversely impacted by the funnelling and side streaming south-easterly winds. It is recommended to include a full-height impermeable screen along the southern edge of the outdoor area to deflect these winds.

Figure 9 details the expected wind impacts on the communal terrace areas of the Stage 01 buildings. The podium rooftop areas of Buildings A and G are predicted to predominantly be unaffected by the south-south-easterly winds with shielding from the built form itself but will still be impacted by corner acceleration and side streaming along the south-western to north-eastern facades. The larger podium communal areas of Buildings B and C are more exposed to the prevailing south-south-easterly winds and will be expected to have adverse wind conditions. Similarly Building D will have adverse wind impacts from direct winds, as well as increased side streaming and down wash effects due to the narrow spacing between the Building C and Building D towers.

5.3.1.2 Possible Wind Mitigations

To the ensure that the Stage 01 frontages are suitable for their intended use, it is recommended to incorporate tree planting and screening along the south and eastern frontages of the precinct to mitigate these side-streaming and funnelling winds. To reduce the effect of corner accelerated flow, treatments such as localised screening, landscaping and or chamfering the corner to trip the wind as it accelerates around corners of the future built form are recommended to be considered. Particularly along Pennant Hills Road and through the internal pedestrian and vehicle access areas of the staging area. Additionally, awnings along the southeastern aspects of the Stage 01 buildings are recommended to deflect downwash winds.

For the elevated areas shown in Figure 9, it is recommended to incorporate either 1800m high vegetation or impermeable screens along the perimeter of elevated communal areas situated on the building podium or rooftop areas.

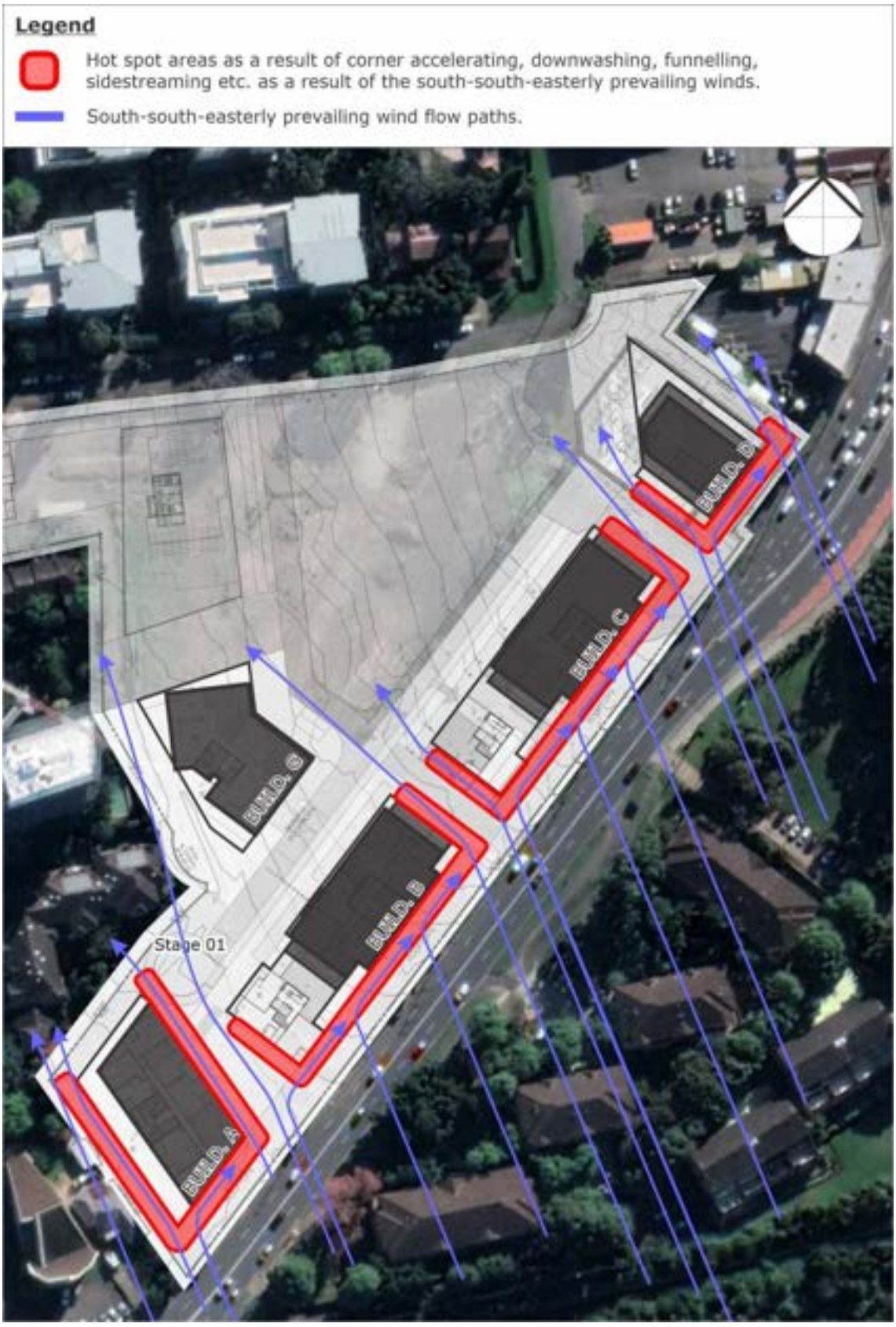

Figure 8: South-South-Easterly Wind Flow Hotspots
Future Built Form in Stage 01 - Ground Level Plan

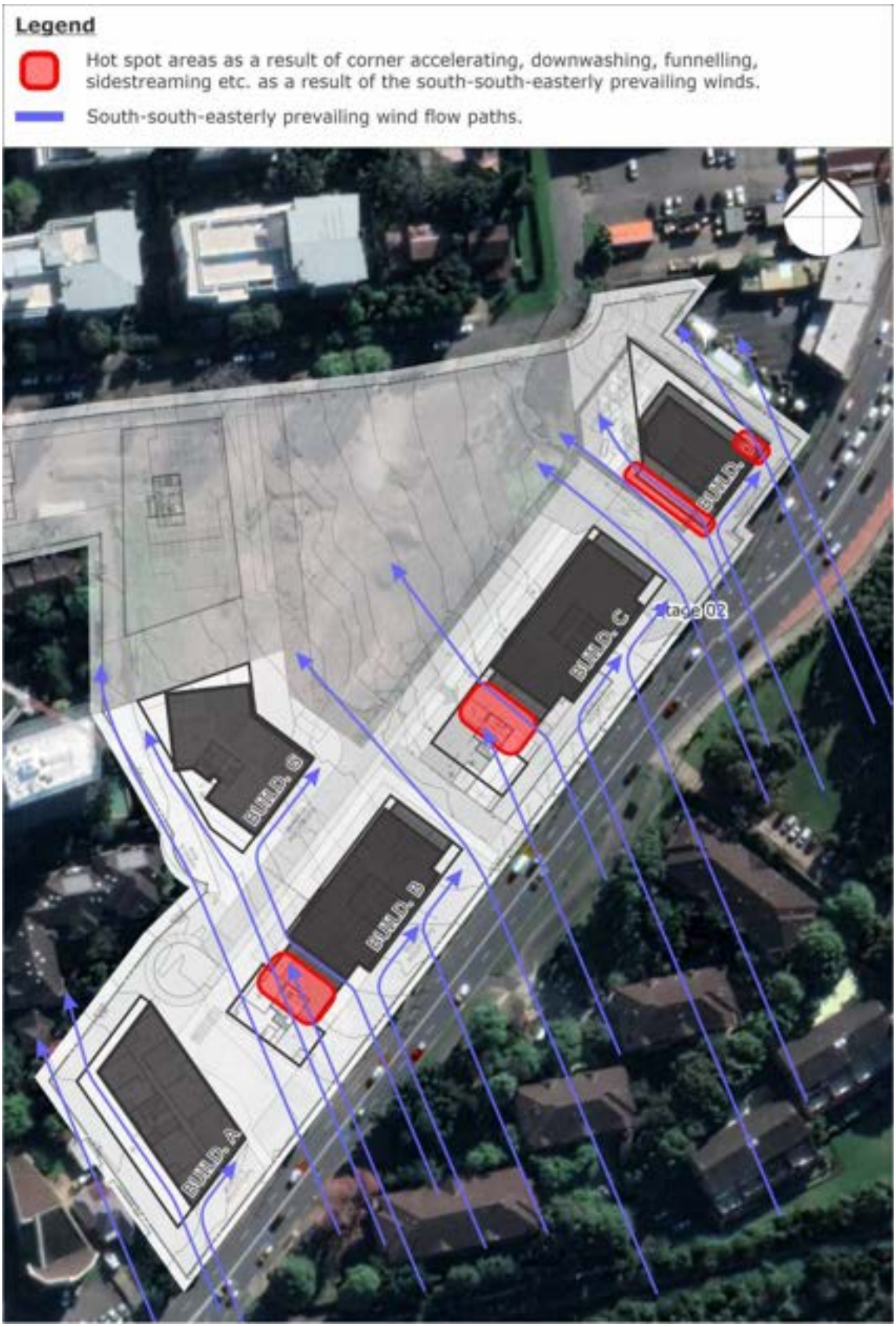

Figure 9: South-South-Easterly Wind Flow Hotspots
Future Built Form in Stage 01 - Podium Level Plan

5.3.2 Stage 02

5.3.2.1 Key Wind Impacts

The mid-high-rise developments under construction to the south and the Stage 01 buildings in future will provide significant shielding to the Stage 02 development from the prevailing south-south-easterly winds. As shown in the flow paths in Figure 10, it is expected that some funnelling of winds between the neighbouring site tower and Building G may impact on the Stage 02 developments. However, the recessed L-shaped design of the shared podium will stagnate these wind flows. The pedestrian pathway along the northern aspect of Stage 02 is expected to be significantly shielded from the prevailing south-south-easterly winds by the built form of the development, as indicated in Figure 10.

The shielding provided by the Stage 01 developments is expected to mostly moderate the south-south-easterly winds over the southern portion of the Stage 02 podium, but funnelling winds between Building G and the western developments are likely to generate adverse effects at podium height of Stage 02. The tower form of Building E and Building F will produce corner acceleration and funnelling through the open communal areas between the towers. There may also be some down spill of these winds onto the ground level areas to the north of the Stage 02 development.

5.3.2.2 Possible Wind Mitigations

It is recommended to incorporate either 1800m high vegetation or impermeable balustrades along the perimeter of elevated communal areas situated on the building podium or rooftop areas to aid in passing the comfort criteria with further implementation and inclusion of an awning along the northern frontage of the Stage 01 Buildings along Shirley Street.

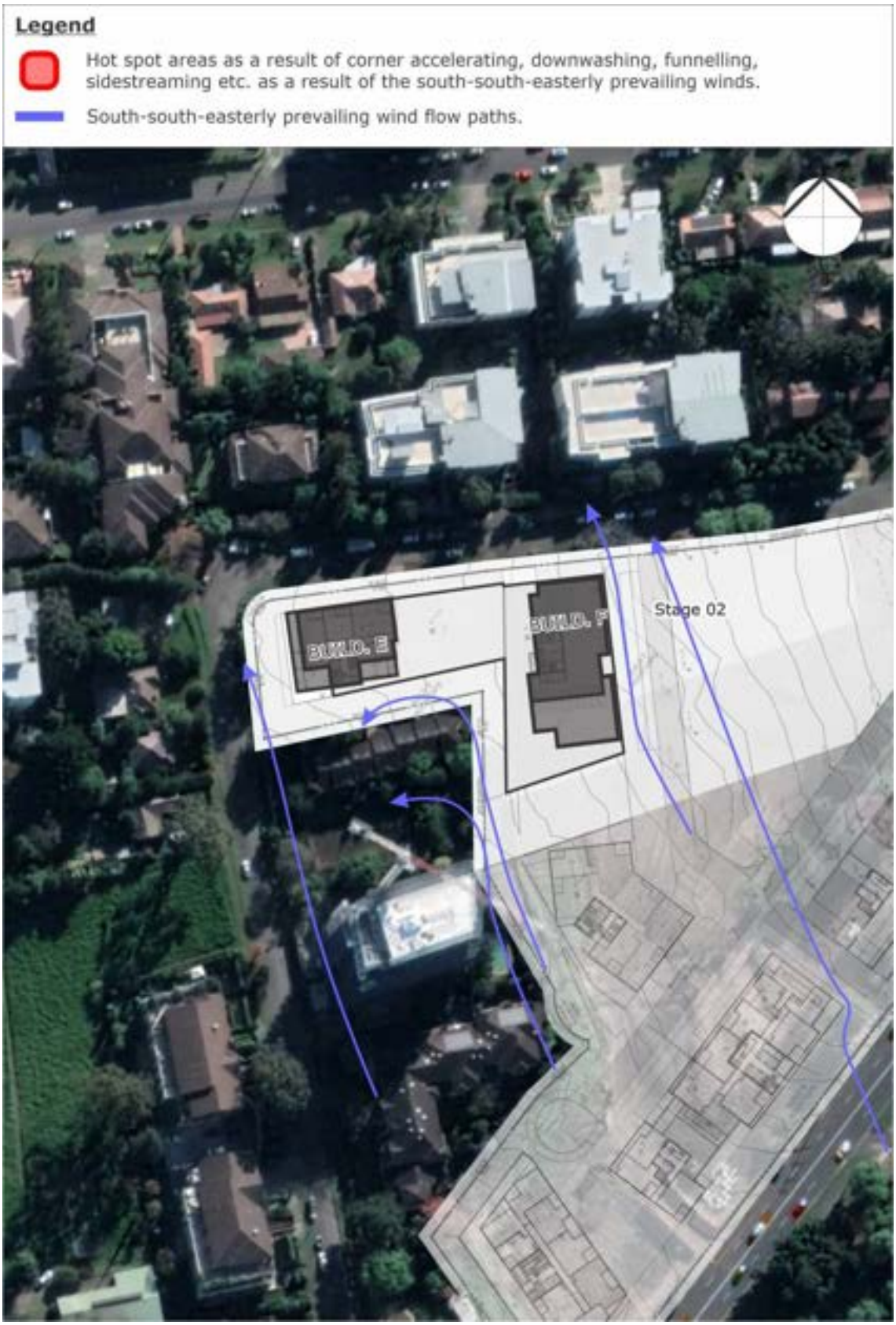

Figure 10: South-South-Easterly Wind Flow Hotspots
Future Built Form in Stage 02 - Ground Level Plan

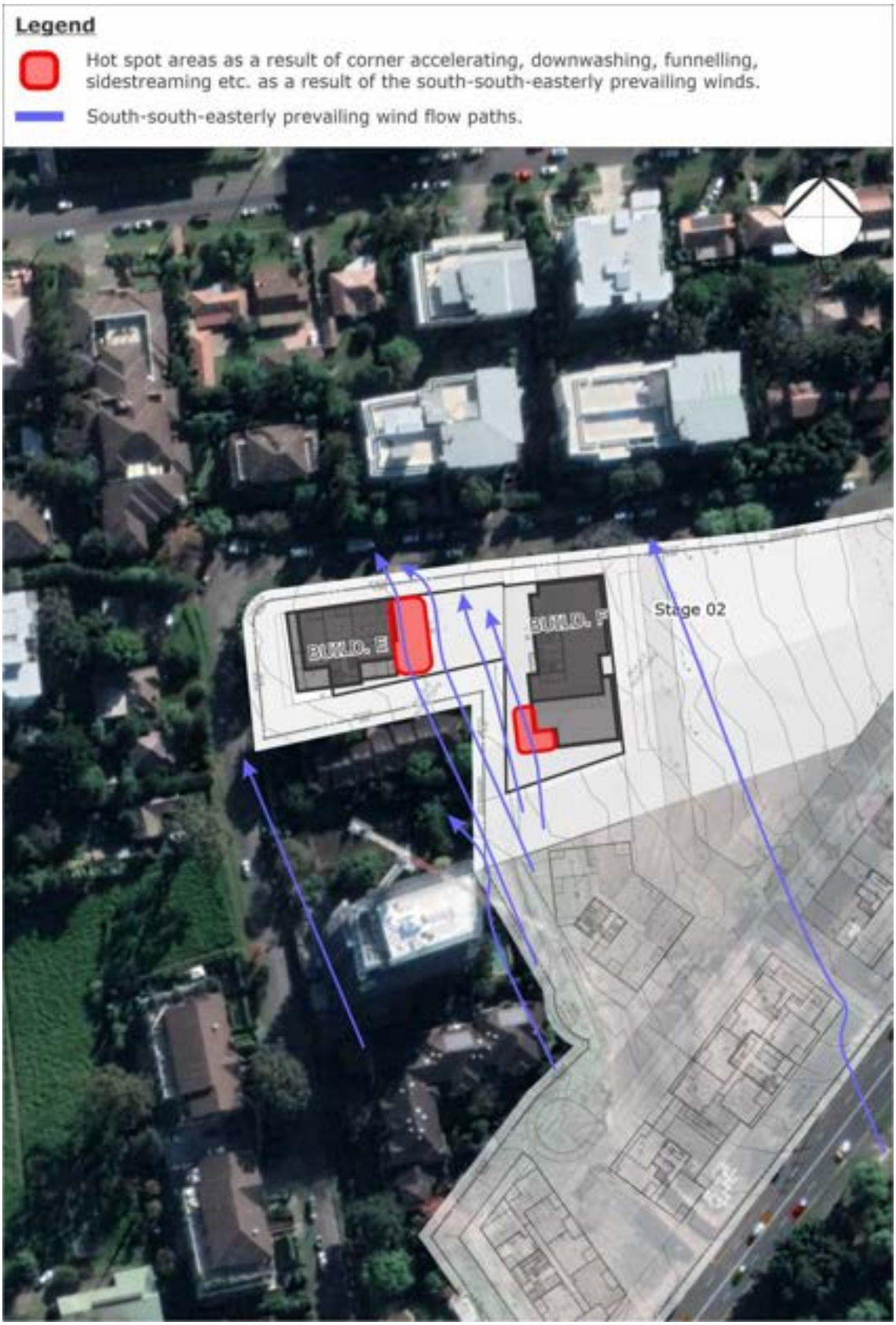

Figure 11: South-South-Easterly Wind Flow Hotspots
Future Built Form in Stage 02 - Podium Level Plan

5.4 Westerly Sector Prevailing WInds

5.4.1 Stage 01

5.4.1.1 Key Wind Impacts

The two mid-rise buildings adjacent to the site to the west provide some shielding to the Stage 01 developments from westerly winds. Much of the Pennant Hills Road frontage of Stage 01 receives significant shielding from the built form of the development itself to the prevailing winds from the west, as indicated in Figure 12. Additionally, the Buildings A and G provide shielding to Building B, as well as partial shielding to Building C. The outdoor area of the Child Care Centre on the northwest of Building G will be slightly impacted by the westerly winds but will be shielded by the mid-rise developments immediately adjacent.

Building A is expected to experience significant side-streaming on the prevailing westerly winds along the northwestern and southwestern frontages, as well as corner acceleration and downwash effects. Side-streaming along the northwestern frontages and corner acceleration effects are also expected to impact subsequent buildings further along Stage 01 as indicated in Figure 12. In addition, the winds are expected to funnel between Buildings B and C, and particularly between Buildings C and D where the separation between the building massing is narrower.

The communal spaces on the elevated terraces areas of the Stage 01 buildings are expected to have impactful wind conditions due to side streaming along the southwestern frontages and corner acceleration effects, as shown in Figure 13.

Private Balconies located on the corners of the proposed towers are expected to have wind conditions exceeding the comfort and safety criteria on some of the upper levels, as they will be exposed to higher wind speeds above the shielding influence of the surrounding developments and will be subject to corner acceleration effects.

5.4.1.2 Possible Wind Mitigations

To mitigate the adverse side-streaming wind conditions along frontages of the Stage 01 buildings, it is recommended to incorporate tree planting and/or screening to help break up wind flows, as well as retention of any existing vegetation and/or trees to the west. Furthermore, to alleviate the potential wind impacts along the area outlined (Child Care Centre) at Building G, it is recommended to cover the area with a canopy or pergola to mitigate the downwash winds in this space.

Landscaping is recommended between Buildings C and D to reduce funnelling effects between these two developments is recommended. In order to reduce the effect of corner-accelerated flows, treatments such as localised porous screenings, landscaping and/or building chamfers to trip the wind as it accelerates around corners are recommended, particularly for Buildings B and C.

For those communal spaces situated on the elevated area of the Stage 01 buildings, it is recommended to incorporate either 1800m high vegetation or impermeable balustrades along the perimeter of elevated communal areas situated on the building podium or rooftop areas.

Figure 12: Westerly Wind Flow Hotspots
Future Built Form in Stage 01 - Ground Level Plan

Figure 13: Westerly Wind Flow Hotspots
Future Built Form in Stage 01 - Podium Level Plan

5.4.2 Stage 02

5.4.2.1 Key Wind Impacts

The orientation of the Stage 02 development is expected to encourage side-streaming of westerly winds along the northern aspect on the Ground Level, as indicated in Figure 14. The Ground Level southern and eastern areas of Stage 02 are expected to experience wind conditions similar to those of the existing site, however, some corner acceleration effects at the western corners are expected. Building E will provide some shielding of westerly winds to Building F.

The open communal terrace are between Buildings E and F are expected to experience funneling impacts as shown in Figure 15. Futhermore, higher westerly winds can channel along Shirley Street between the proposed and existing buildings bordering Shirley Street, however, the façade is setback from the footpath, thereby reducing the side streaming effects along the Shirley Street footpath.

The corner acceleration on the southwestern corners of the Stage 02 massing of Buildings E and F is not expected to adversely affect the pedestrian access present to the south, with the proposed planting expected to reduce the impact in this area. Additionally, the south-western corner of the combined Building E and F podium is situated within a large exlusion zone that is not intended for public use but instead for the inclusion of planting and vegetation.

5.4.2.2 Possible Wind Mitigations

For the open communal terrace, it is recommended to incorporate planting or strategically placed screening in order to mitigate these funnelling conditions within the raised podium communal area. Taller than standard height perimeter balustrades are recommended around the perimeter of the elevated podium area, if intended for pedestrian/communal use. This is to trip direct prevailing winds impacting the large open podium areas.

To help mitigate adverse wind conditions due to side-streaming along Shirley Street, it is recommended to incorporate an awning spanning the entire northern aspect of the future built form in Stage 02, in combination with tree planting and/or screening to help break up the flow.

As a general note for tree planting/landscaping to be effective as a wind mitigation device, the species should be of a densely foliating evergreen variety to ensure year-round effectiveness, particularly for the areas that are expected to be impacted by westerly winds, which prevail during the winter months. Trees should also be planted in clusters with interlocking canopies to effectively absorb incident winds.

Figure 14: Westerly Wind Flow Hotspots
Future Built Form in Stage 02 - Ground Level Plan

Figure 15: Westerly Wind Flow Hotspots
Future Built Form in Stage 02 - Podium Level Plan

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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.

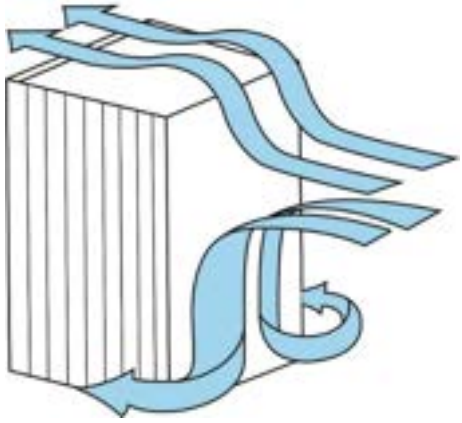

Figure A.1: Downwash Leading to Corner Wind Effect, and Upwash Effects

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.

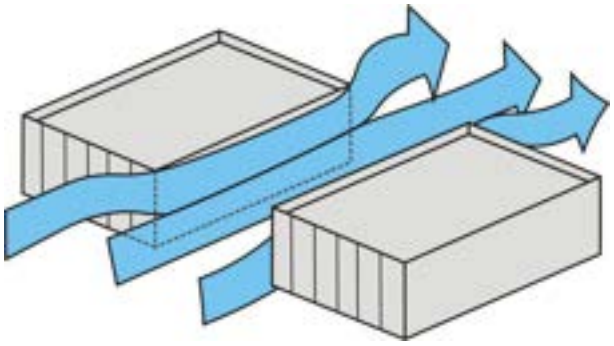

Figure A.2: Funnelling/Venturi Wind Effect

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.

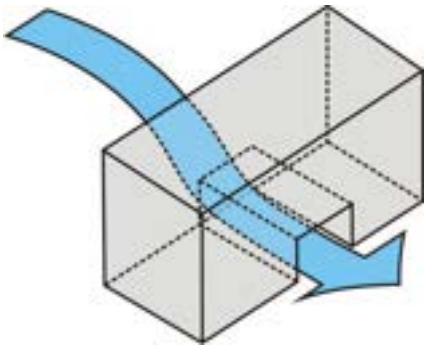

Figure A.3: Gap Wind Effect

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.

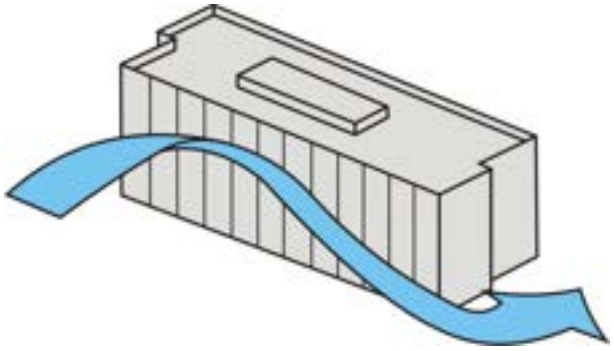

Figure A.4: Sidestream and Corner Wind Effect

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.