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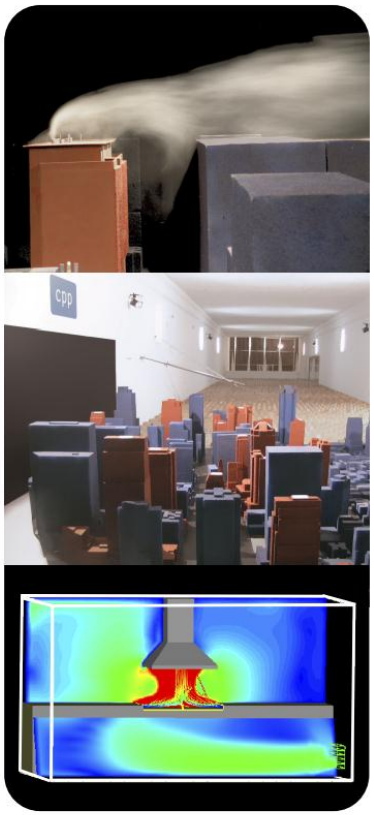
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

**FINAL REPORT - Revision 3**



Wind Impact Assessment for:

# THE HAYMARKET PRECINCT – SYDNEY INTERNATIONAL CONVETION CENTRE, EXHIBITION AND ENTERTAINMENT PRECINCT – SSDA2

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## INTRODUCTION

This report supports a State Significant Development Application (SSD 12_5752) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This report addresses the Director Generals Requirements for SSDA2 dated 21 January 2013 for a 'Site wide Wind Report'. Development Specific Wind Reports incorporating wind tunnel testing will later be prepared for SSDA3, SSDA4 and SSDA5 to meet the DGR requirements.

The Application seeks approval for the establishment of building envelopes and design parameters for a new neighbourhood and a community hub (referred to as The Haymarket) as part of the Sydney international convention, exhibition and entertainment precinct (SICEEP) Project at Darling Harbour.

The project will develop The Haymarket into one of Sydney's most innovative residential and working districts. Through the delivery of the overall project, Daring Harbour will also become home to Australia's largest convention and exhibition facilities, Sydney's largest red carpet entertainment venue, and a hotel complex of up to 900 rooms. The SICEEP Project importantly forms a critical element of the NSW Government's aspiration to "make NSW number one again".

Cermak Peterka Petersen Pty. Ltd. has been engaged by Lend Lease to provide a qualitative assessment of the wind impacts of the proposed redevelopment of The Haymarket precinct, which is at the south end of the proposed SICEEP Project at Darling Harbour, Figure 1. The application is only seeking approval for building envelopes (massing) however the indicative design illustrates that the development is likely to include a combination of high-rise and mid-rise buildings, with a variety of podia structures throughout the development.

This qualitative report makes reference to quantitative wind tunnel test results available for the Public Private Partnership (PPP) SSDA1 component of the project (CPP report '6949 SICEEP Wind Report - final rev2' dated March 2013).

Figure 1: Architectural impression of the proposed SICEEP Project site viewed from the east, with the proposed redeveloped The Haymarket precinct shown at the south (left) of the development site.

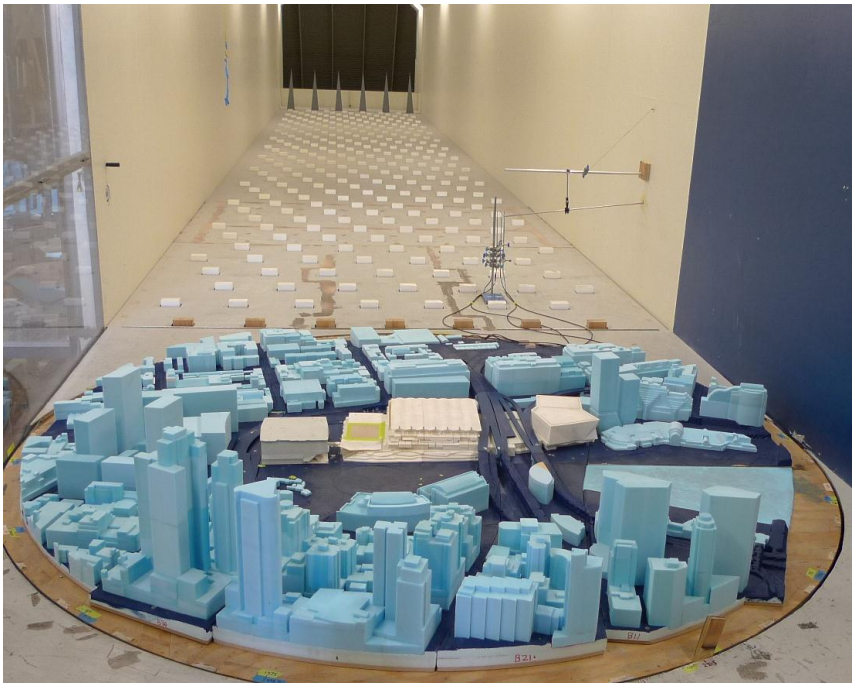

Figure 2: A model of the proposed SICEEP Project Site at Darling Harbour from the east (in the CPP Wind Tunnel)

## CLIENT PROVIDED PROJECT INFORMATION

### Overview of Proposed Development

The proposal relates to a staged development application and seeks to establish concept plan details for The Haymarket, located within the southern part of the SICEEP Site.

The Haymarket will include student housing, public car parking, a commercial office building, and four mixed use development blocks (retail/commercial/residential podium with residential towers above) centred around a new public square to be named Haymarket Square.

More specifically concept approval is sought for the following:

- Demolition of existing site improvements, including the existing Sydney entertainment Centre (SEC), Entertainment car park, and part of the pedestrian footbridge connected to the Entertainment car park and associated tree removal;
- North-west block – construction of a part public car park and part commercial/office building;
- North-east block – construction of a mixed use podium (comprising retail, commercial, above ground parking, and residential) with three residential buildings above;
- South-east block - construction of a mixed use podium (comprising retail, commercial, above ground parking, and residential) with three residential buildings above;
- South-west block - construction of a mixed use podium (comprising retail, commercial, above ground parking, and residential) with three residential buildings above;
- North block – construction of a mixed use building comprising retail, commercial and residential;

- Student housing – construction of two buildings providing for up to 1,000 beds;
- Public domain improvements including a new square, water features, new pedestrian streets and laneways, streetscape embellishments, and associated landscaping. (It is intended that a Stage 2 DA seeking approval for parts of the public domain (The Boulevard and Haymarket Square) will be lodged with the first residential stage);
- Reconfiguration and upgrade of Darling Drive (part);
- Remediation strategy; and
- Car parking rates.

## Background

The existing convention, exhibition and entertainment centre facilities at Darling Harbour were constructed in the 1980s and have provided an excellent service for Sydney and NSW.

The facilities however have limitations in their ability to service the contemporary exhibition and convention industry which has led to a loss in events being held in Sydney.

The NSW Government considers that a precinct-wide renewal and expansion is necessary and is accordingly committed to Sydney reclaiming its position on centre stage for hosting world-class events with the creation of the Sydney international convention, exhibition and entertainment precinct.

Following an extensive and rigorous Expressions of Interest and Request for Proposals process, Darling Harbour Live (formerly known as 'Destination Sydney'- a consortium comprising AEG Ogden, Lend Lease, Capella Capital and Spotless) was announced by the NSW Government in December 2012 as the preferred proponent to transform Darling Harbour and create the new Sydney international convention, exhibition and entertainment Precinct.

Key features of the Darling Harbour Live Preferred Master Plan include:

- Delivering world-class convention, exhibition and entertainment facilities, including:
    - Up to 40,000m2 exhibition space;
    - Over 8,000m2 of meeting rooms space, across 40 rooms;
    - Overall convention space capacity for more than 12,000 people;
    - A ballroom capable of accommodating 2,000 people; and
    - A premium, red-carpet entertainment facility with a capacity of 8,000 persons.
- Providing up to 900 hotel rooms in a hotel complex at the northern end of the precinct.
- A vibrant and authentic new neighbourhood at the southern end of the precinct, called 'The Haymarket', home to an IQ Hub focused on the creative industries and high-tech businesses, apartments, student accommodation, shops, cafes and restaurants.
- Renewed and upgraded public domain, including an outdoor event space for up to 25,000 people at an expanded Tumbalong Park.
- Improved pedestrian connections linking to the proposed Ultimo Pedestrian Network drawing people between Central, Chinatown and Cockle Bay Wharf as well as east-west between Ultimo/Pyrmont and the City.

## Site Description

The SICEEP Site is located within Darling Harbour. Darling Harbour is a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District that provides a mix of functions including recreational, tourist, entertainment and business.

With an area of approximately 20 hectares, the SICEEP Site is generally bound by the Light Rail Line to the west, Harbourside shopping centre and Cockle Bay to the north, Darling Quarter, the Chinese Garden and Harbour Street to the east, and Hay Street to the south.

The SICEEP Site has been divided into three distinct redevelopment areas (from north to south) – Bayside, Darling Central and The Haymarket. The Application Site area relates to The Haymarket as shown in Figure 3.


Figure 3: The SICEEP Site

## Planning Approvals Strategy

In response to separate contractual agreements with the NSW Government and staging requirements Lend Lease (Haymarket) Pty Ltd is proposing to submit a number of separate development applications for key elements of the overall Project.

This staged development application involves the establishment of building envelopes and design parameters for a new neighbourhood and a community hub (The Haymarket) within the southern part of the SICEEP Site. Detailed development applications will accordingly follow seeking approval for specific aspects of The Haymarket in accordance with the approved staged development application.

Separate development applications will be lodged for the PPP component of the SICEEP Project (comprising the convention centre, exhibition centre, entertainment facility and associated public domain upgrades) and Hotel complex.

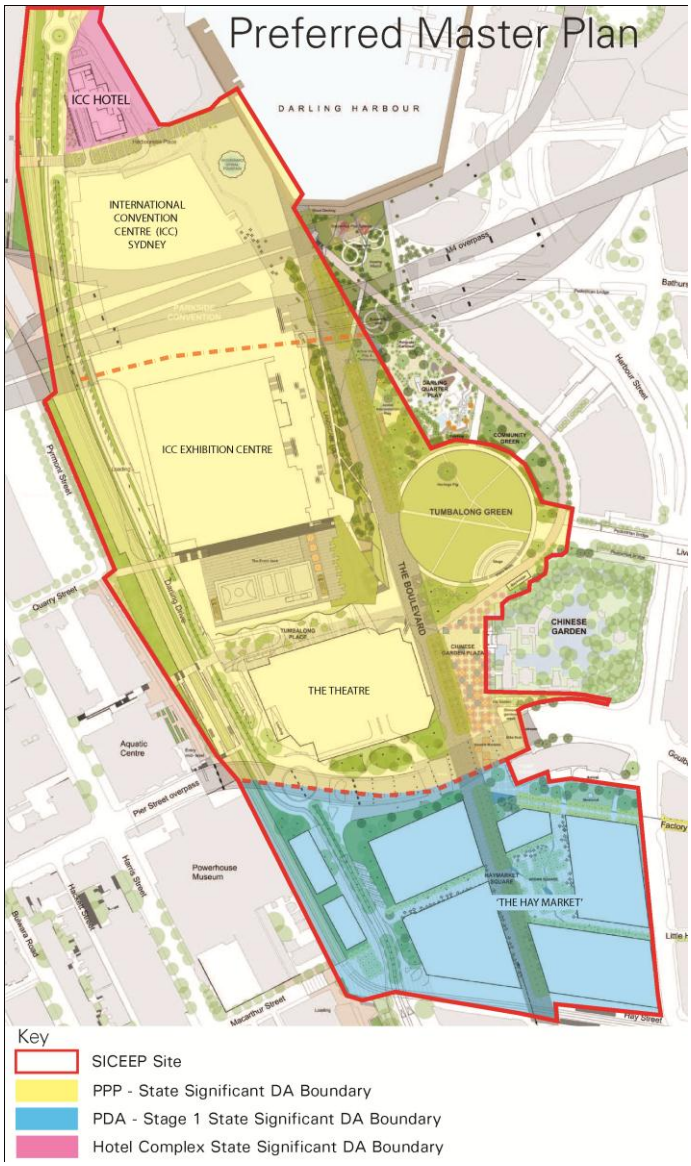


Figure 4: The Preferred Master Plan

## SICEEP PROJECT SITE

This report makes reference to City of Sydney, (2004), "Central Sydney Development Control Plan 1996" and City of Sydney (2010), "Draft Development Control Plan 2010, Part 2 General Provisions", and addresses the Director Generals Requirements for SSDA2 dated 21 January 2013 for a 'Site wide Wind Report'.

The wind impact of the PPP component of the SICEEP development has been addressed through a wind tunnel study described in CPP report '6949 SICEEP Wind Report - final rev2' dated March 2013. Other areas of the full development, (the SSDA6 ICC Hotel and this SSDA2 redevelopment of the Haymarket Precinct), have been addressed through site wide opinion based wind impact assessment to meet the DGR requirements, with reference to the PPP wind tunnel study. Development Specific Wind Reports incorporating wind tunnel testing will later be prepared for SSDA3, SSDA4 and SSDA5 to meet the DGR requirements.

## SYDNEY WIND CLIMATE

The proposed development lies approximately 7 km to the north of Sydney Airport Bureau of Meteorology anemometer. The wind rose for the airport is shown in Figure 5 and is considered to be representative of prevailing winds at the site. It is evident that the prevailing winds from coastal Sydney come from the north-east, south, and west. Winds from the north-east tend to be summer sea breezes and bring welcome relief on summer days. Winds from the south tend to be cold and tend to be associated with frontal systems that can last several days and occur throughout the year. Winds from the west are amongst the strongest of the year and are associated with large weather patterns and thunderstorm activity. These winds occur throughout the year and can be cold or warm depending on the inland conditions.

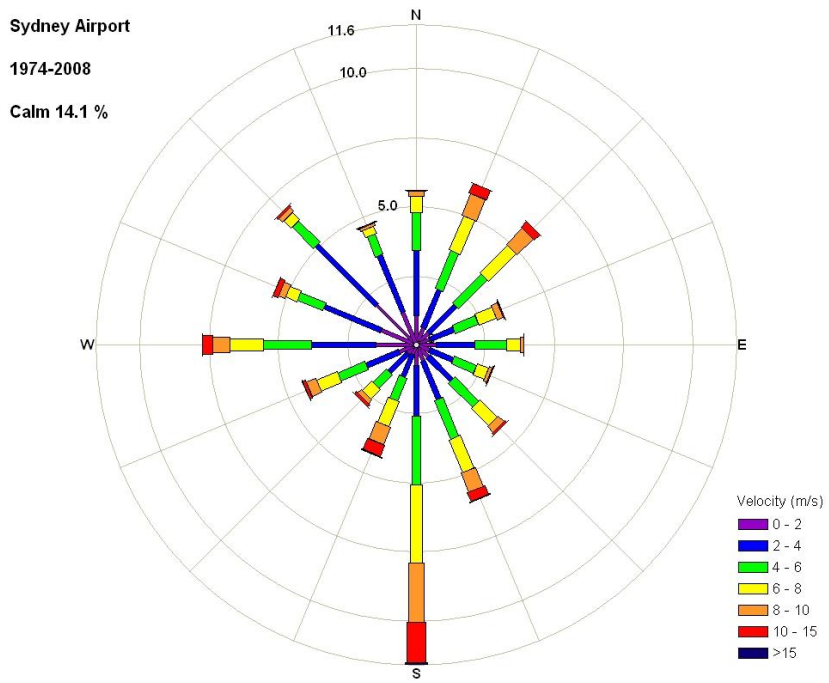


Figure 5: Wind rose for Sydney Airport

## ENVIRONMENTAL WIND SPEED CRITERIA

It is generally accepted that wind speed and the rate of change of wind velocity are the primary parameters that should be used in the assessment of how wind affects pedestrians. Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. 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 remarkably good agreement.

The wind assessment criteria in the Sydney City Council development control plan (DCP) are based on the work of Melbourne (1978) and relate to a once per annum gust wind speed. These criteria yield no direct information on the mean wind climate or the percentage of year that serviceability winds occur, which are of most use to town planners and architects. The wind assessment criteria used herein are those of Lawson (1990), which are described in Table 1 for both pedestrian comfort and distress. The benefits of these criteria over many in the field are that they use both a mean and gust equivalent mean (GEM) wind speed to assess the suitability of specific locations. The criteria based on the mean wind speeds define when the steady component of the wind causes discomfort, whereas the GEM wind speeds define when the wind gusts cause discomfort.

Sydney is relatively windy, with an average wind speed at 10 m reference height of approximately 4 m/s (8 kt, 14 kph) at Sydney Airport, and five percent of the time the mean wind speed is in excess of 9.5 m/s (18 kt, 34 kph). Converting the five percent of the time wind speed at Sydney Airport to a typical pedestrian level in a generic urban environment of similar building massing to Haymarket would result in about 6.0 m/s (12 kt, 22 kph). Comparing this with the comfort criteria of Table 1 suggests that the pre-existing locale would only just be acceptable for pedestrian walking prior to development; hence any recreational outdoor activity for any significant development of this site will likely require significant amelioration from prevailing Sydney wind directions.

Table 1: Pedestrian comfort criteria for various activities

| | |
|---|---|
| **Comfort** (maximum wind speed exceeded 5% of the time) | |
| <2 m/s | Outdoor dining |
| 2 - 4 m/s | Pedestrian sitting (considered to be of long duration) |
| 4 - 6 m/s | Pedestrian standing (or sitting for a short time or exposure) |
| 6 - 8 m/s | Pedestrian walking |
| 8 - 10 m/s | Business walking (objective walking from A to B or for cycling) |
| > 10 m/s | Uncomfortable |
| **Distress** (maximum wind speed exceeded 0.022% of the time, twice per annum) | |
| <15 m/s | General access area |
| 15 - 20 m/s | Acceptable only where able bodied people would be expected; no frail people or cyclists expected |
| >20 m/s | Unacceptable |

The wind speed is either a mean wind speed or a gust equivalent mean (GEM) wind speed. The GEM wind speed is equal to the 3 s gust wind speed divided by 1.85.

## WIND FLOW MECHANISMS

Wind interaction with the built environment can be grouped into basic flow mechanisms commonly producing higher velocities at pedestrian level. Some key flow mechanisms such as downwash and channelling relevant to the SICEEP Project are discussed in Appendix 1.

## IMPACT OF PREVAILING WINDS ON PROPOSED DESIGN SCHEME

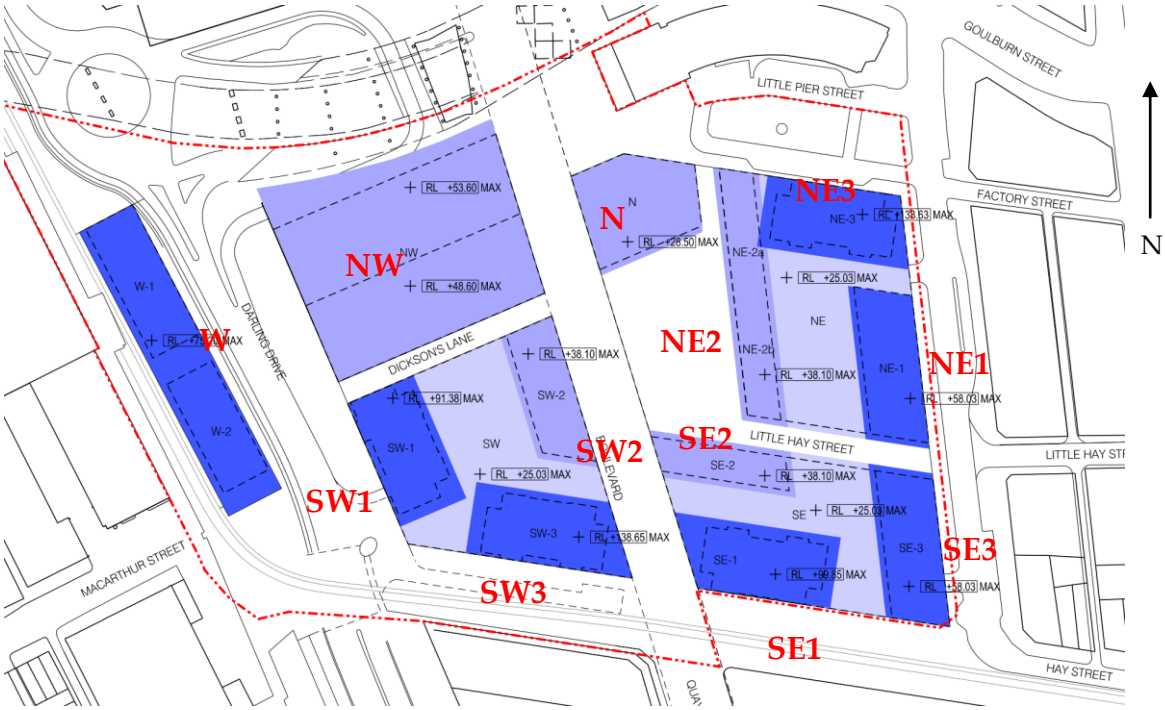


Figure 6: Maximum building envelope of The Haymarket precinct

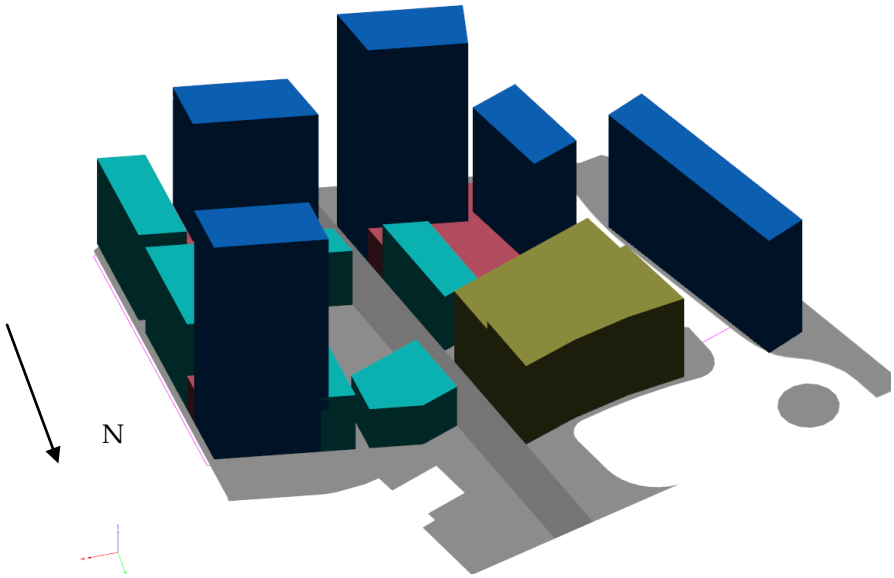


Figure 7: Perspective view of the maximum building envelope of The Haymarket precinct, viewed from the north.

The application is only seeking approval for building envelopes (massing) however the indicative design illustrates that the development is likely to include a combination of high-rise and mid-rise buildings, with a variety of podia structures throughout the development, Figure 6 and Figure 7.

Taller buildings will induce downwash for wind directions normal to the façade of the tower, and at locations where the tower façade extends to ground level with little to no interference from a podium (see Appendix 1). In these cases windy conditions can be expected at the ground-level windward corners of the buildings. An example of such a location where there is potential for this to occur is between the SW3 and SE1 towers.

Instances of channelling wind flow (Appendix 1) are expected to occur for the currently configured massing between the student housing to the west of the precinct for winds from the west, and along Darling Drive, the Boulevard and Harbour Street during winds from the south. This will produce localised strong wind conditions possibly exceeding the walking criterion without amelioration.

During the PPP tests described in CPP report '6949 SICEEP Wind Report - final rev2' dated March 2013, an indicative massing model of the Haymarket precinct was included with some measurements taken over the northern perimeter. A localised area of faster conditions was observed during the wind tunnel testing of the PPP development at the northwest corner of the Haymarket precinct. These faster conditions result primarily from a combination of channelling and downwash during winds from the south quadrant, with the PPP development buildings to the north not adversely impacting this area. The occurrence of such conditions will be dependent on the final form of the buildings within the precinct, and can be addressed during the detail design of the buildings.

A mitigation strategy can be developed with the design team during development of the Haymarket building forms, which could include a combination of horizontal and vertical wind breaks, and a more advantageous overall shape of the buildings and its lower level layout. Mitigation strategies such as awnings, fins, or landscaping would be developed during detailed design.

Other areas within The Haymarket precinct such as the Urban Square are expected to receive wind shielding from prevailing winds by surrounding building structures and are expected to be better suited for pedestrian sitting activities such as outdoor dining.

## SUMMARY

Cermak Peterka Petersen Pty. Ltd. has been engaged by Lend Lease to provide a qualitative assessment of the impact of the proposed The Haymarket precinct on the local wind environment. This report addresses the Director Generals Requirements for SSDA2 dated 21 January 2013 for a 'Site wide Wind Report'. Development Specific Wind Reports incorporating wind tunnel testing will later be prepared for SSDA3, SSDA4 and SSDA5 to meet the DGR requirements.

The SSDA2 application is only seeking approval for building envelopes (massing) however the indicative design illustrates that the development is likely to include a combination of high-rise and mid-rise buildings, with a variety of podia structures throughout the development.

Taller buildings within Haymarket will induce downwash for wind directions normal to the façades of the towers, and windy conditions can be expected at the ground-level windward corners of the buildings. Instances of channelling wind flow are also expected to occur for the currently configured massing at some locations. This will produce localised strong wind conditions possibly exceeding the walking criterion without amelioration.

The strength of the conditions in windy locations will depend on the final architectural form of the towers and other structures, and can be confirmed using wind tunnel tests at later stages of the design. A mitigation strategy can be developed with the design team during development of the Haymarket building forms, which could include a combination of horizontal and vertical wind breaks, and a more advantageous overall shape of the buildings and its lower level layout. Mitigation strategies such as awnings, fins, or landscaping would be developed during detailed design.

Detailed serviceability issues associated with landscaping, outdoor cafes, door placement, internal pressure issues etc. will be considered during further design development and will require wind tunnel testing for verification.

This qualitative report makes reference to quantitative wind tunnel test results available for the Public Private Partnership (PPP) SSDA1 component of the project. Based on the results of these tests it is considered the PPP development buildings to the north will not adversely impact the Haymarket precinct.

## REFERENCES

Lawson, T.V., (1990), The determination of the wind environment of a building complex before construction, *Department of Aerospace Engineering, University of Bristol*, Report Number TVL 9025.

Melbourne, W.H., (1978), Criteria for environmental wind conditions, *Journal of Industrial Aerodynamics*, Vol.(3), pp.241-249.

# APPENDIX 1: BLUFF BODY AERODYNAMICS

Wind interaction with the built environment can be grouped into basic flow mechanisms commonly producing higher velocities at pedestrian level. Some key flow mechanisms relevant to the SICEEP Design Scheme site are discussed below:

## Downwash

Figure 8 illustrates the typical flow pattern around a tall building when the wind is perpendicular to the wide face. In this figure smoke is being injected at various points on the model surface and then being blown away by the wind giving an indication of the flow direction, strength, and level of turbulence. It is evident that the building stops the flow at a point about two thirds up the height of the building in the centre of the windward face, and then radiates out in all directions. The fastest flows are typically experienced along the top edge and at the bottom windward corners. At ground level there is a large vertical component of the wind coming down the face of the building – often referred to as downwash. To limit the amount of flow reaching ground level, the tower can be placed on a podium, or awning roofs can be attached to protect pedestrians.

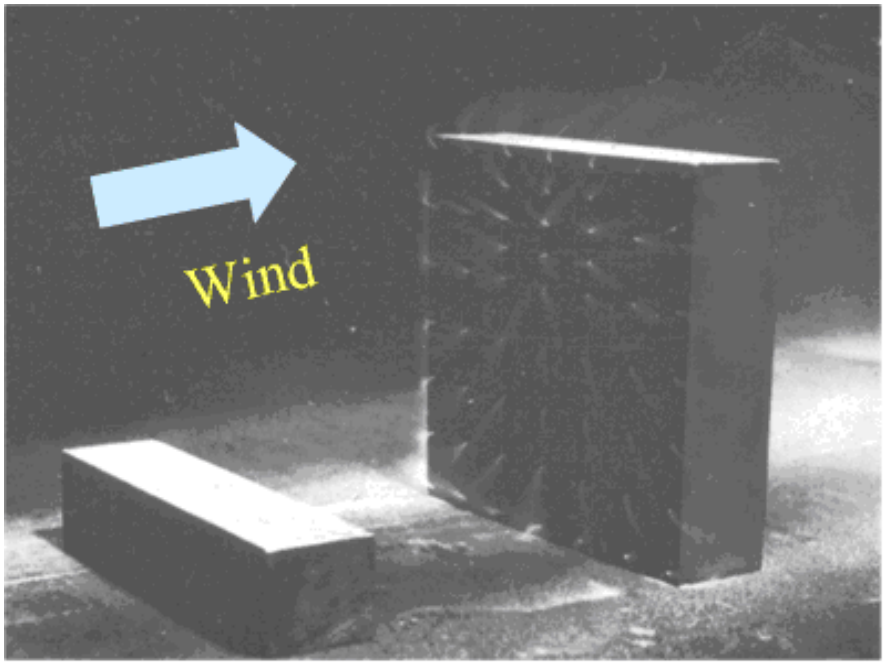


Figure 8: Flow visualisation of wind hitting a large building

Figure 9 shows the case where smoke is released in the approach flow in line with the centre of the building and below the stagnation point. Upon hitting the building the smoke is accelerated around the side of the building and drawn down to ground level in the form of downwash; once the wind reaches the ground it is then accelerated around the ground-level corners. This emphasises the complex nature and vertical component of the flow.

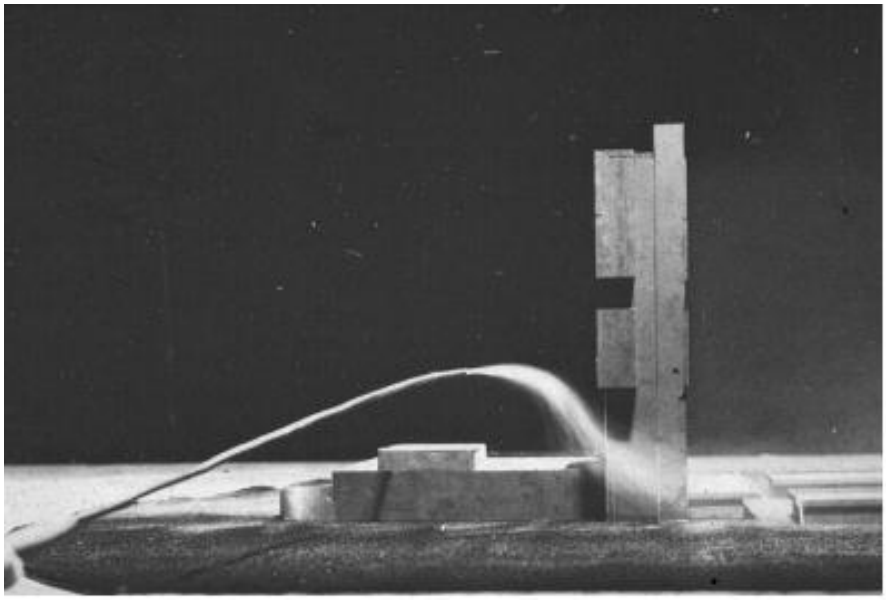

Figure 9: Flow visualisation around a tall building

## Channelling Flow

Another important bluff body interaction is the channelling of winds between building gaps whereby upstream winds accelerate to higher velocities as wind is squeezed through building gaps, Figure 10.

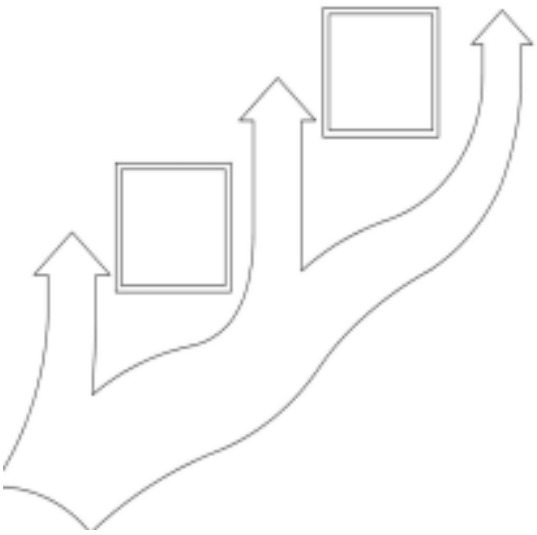

Figure 10: Wind channelling between buildings – venturi flow

## Arcades

Another massing issue which may be a cause of strong ground level winds is an arcade or thoroughfare opening from one side of a building to the other. This effectively connects a positive pressure region on the windward side to a negative pressure region on the lee side; a strong flow through the opening results, Figure 11. To mitigate this effect an airlock can be installed; the best solution is a revolving door, with automatic sliding doors possible depending on the volume of pedestrian traffic.

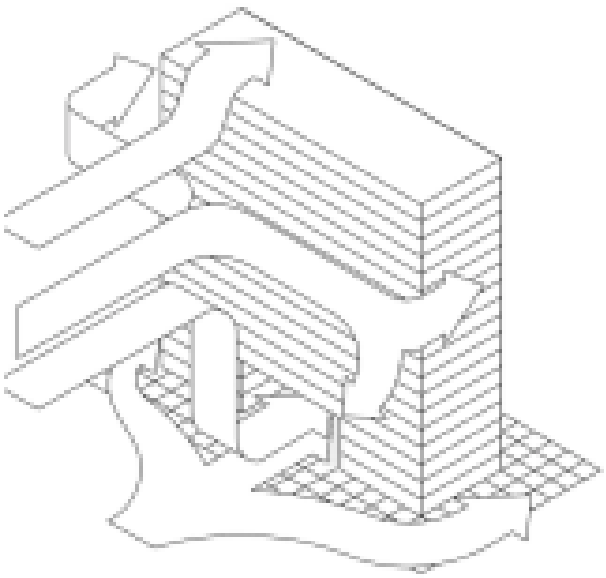

Figure 11: An arcade or open column plaza under a building frequently generates strong pedestrian wind conditions.