Lend Lease (Millers Point) Pty Limited

Barangaroo South - Concept Plan Amendment (MP06_0162 MOD4)

Wind Impact Assessment

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1 Introduction

1.1 Background

On the 20 December 2009, Lend Lease (Millers Point) Pty Limited (Lend Lease) was appointed as the preferred proponent to develop Stage 1 of Barangaroo: comprising of Blocks 1 to 4 and associated public recreation areas.

The area of land that is subject to the Concept Plan Amendment is indicatively shown in Figure 1, and is herein referred to as “Barangaroo South” or the “Site”. It comprises an open apron which is largely reclaimed over water and is identified in the existing approved Concept Plan as Blocks 1 – 4 and the immediately adjacent public recreation area. Barangaroo South also extends beyond the western edge of the existing apron and includes a north-west oriented intrusion into the existing waters of Darling Harbour (see Figure 1).

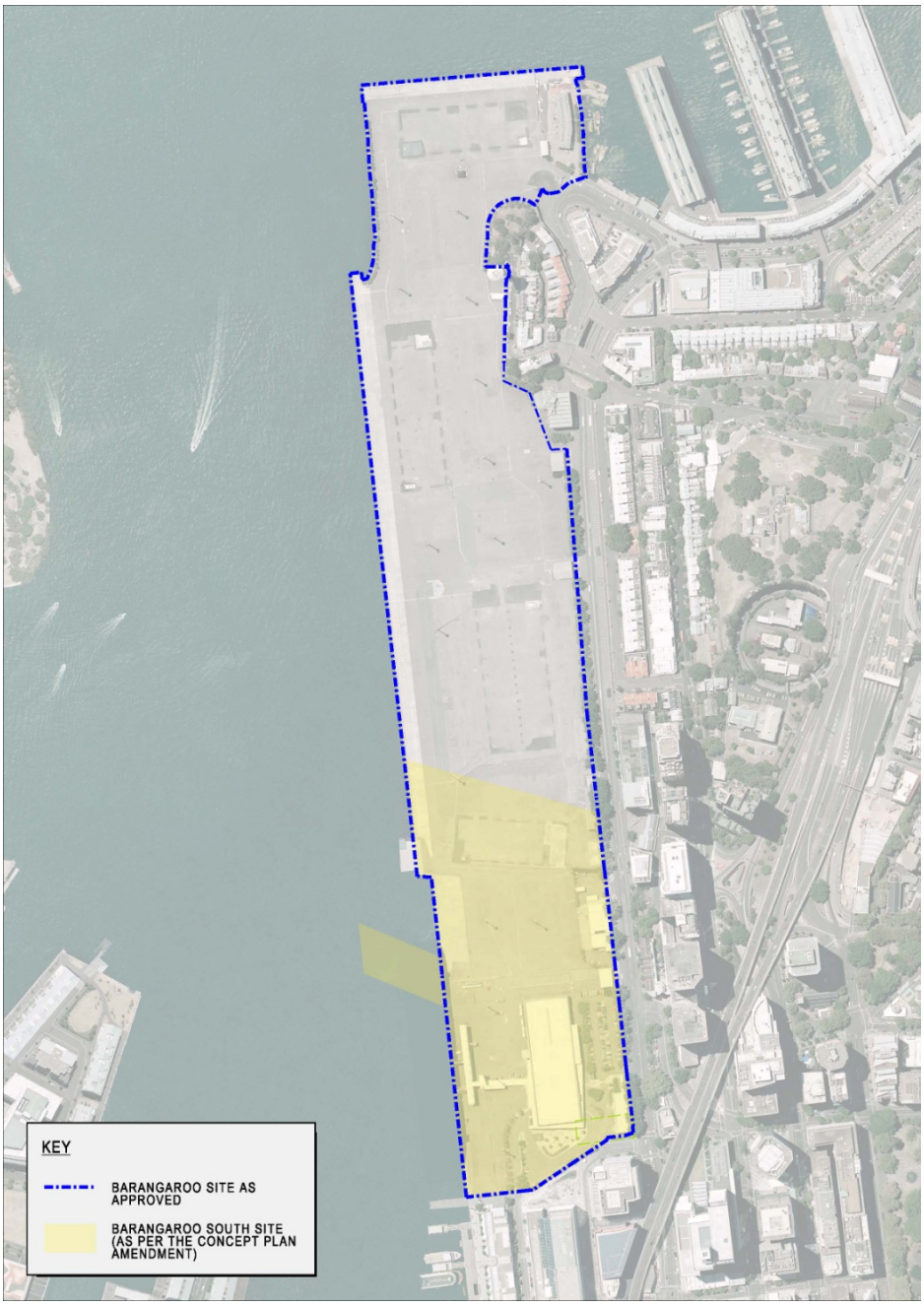

Figure 1: Indicative Site Boundary for Barangaroo South

1.2 Planning History

On 9 February 2007 the Minister approved a Concept Plan for the site and on 12 October 2007 the land was rezoned to facilitate its redevelopment. The Approved Concept Plan allowed for:

- a mixed use development involving a maximum of 388,300m^2 of gross floor area (GFA) contained within 8 blocks on a total site area of 22 hectares;
- approximately 11 hectares of new public open space/public domain, with a range of formal and informal open spaces serving separate recreational functions and including a 1.4km public foreshore promenade;
- maximum building heights and maximum GFA for each development block within the mixed use zone; and
- public domain landscape concept, including parks, streets and pedestrian connections.

A condition of consent also required two enlarged water intrusions into the Barangaroo site, one at the northern end and one at the southern end and the creation of a natural northern headland.

Modification No. 1 was approved in September 2007 which corrected a number of minor typographical errors.

On 25 February 2009 the Minister approved Modification No. 2 to the Concept Plan. The Approved Concept Plan as modified allowed for a mixed use development involving a maximum of 508,300m^2 of gross floor area (GFA) contained within 8 blocks on a total site area of 22 hectares.

On 11 November 2009 the Minister approved Modification No. 3 to the Concept Plan to allow for a modified design for the Headland Park and Northern Cove. The Approved Concept Plan as modified allowed for a mixed use development involving a maximum of 489,500m^2 of gross floor area (GFA) contained within 7 blocks on a total site area of 22 hectares.

The proposed Concept Plan Amendment (MP 06_0162 MOD 4) seeks the Minister's consent for:

- additional GFA within Barangaroo South predominantly related to an increase in residential GFA ;
- redistribution of the land use mix;
- an increase in height of a number of the proposed towers within the Barangaroo South;
- the establishment of the new pier and landmark building extending into the Harbour; and
- reconfiguration and activation of the public waterfront area through the introduction of uses including retail and residential to the west of Globe Street.

1.3 Purpose

This report has been prepared by Cermak Peterka Petersen Pty. Ltd. and Arup in support of the Concept Plan Amendment (MP06_0162 MOD4) for Barangaroo. It addresses the Director General Requirements and provides an opinion based assessment of the impact of the proposed Barangaroo South development on the local pedestrian level wind environment. This qualitative assessment precedes environmental wind tunnel studies which will be undertaken for relevant building project applications to quantitatively assess the wind environment throughout the site.

2 Site Wind Exposure

Barangaroo is located to the east of Darling Harbour and directly to the north of the King Street Wharf precinct. The topography rises steeply to the east of the site toward Kent Street and the Western Distributor road deck. The Barangaroo South residential and commercial development will consist of twenty buildings. The indicative design plan is shown in Figure 2 below. Approximate heights of the buildings are noted on Figure 3 and Figure 4.

The site is most exposed to winds from the prevailing western quadrant.

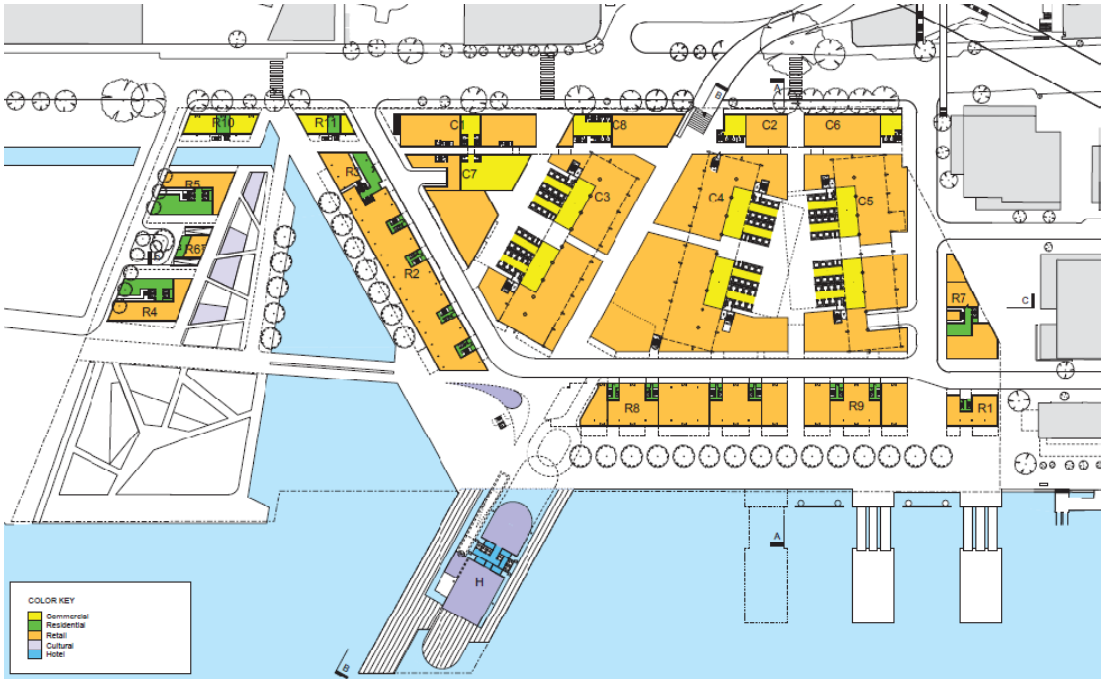

Figure 2: Concept Plan Amendment Indicative Design Plan

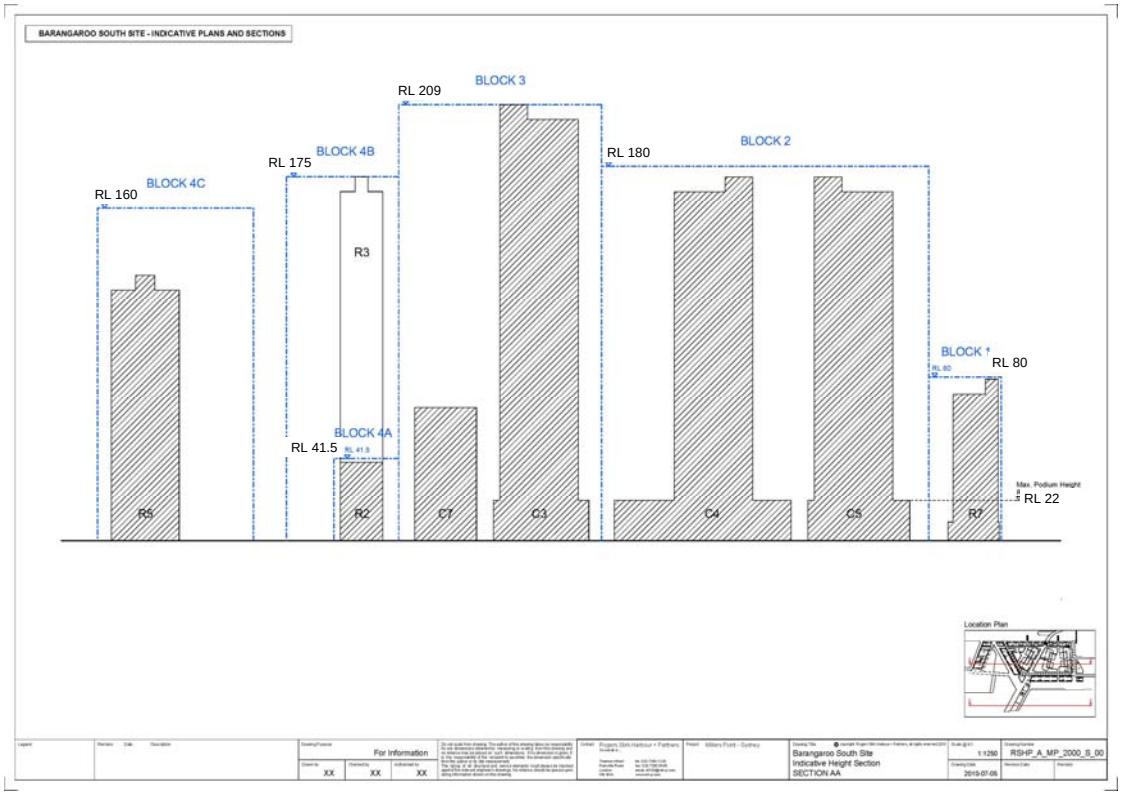

Figure 3: Concept Plan Amendment Indicative Building Heights

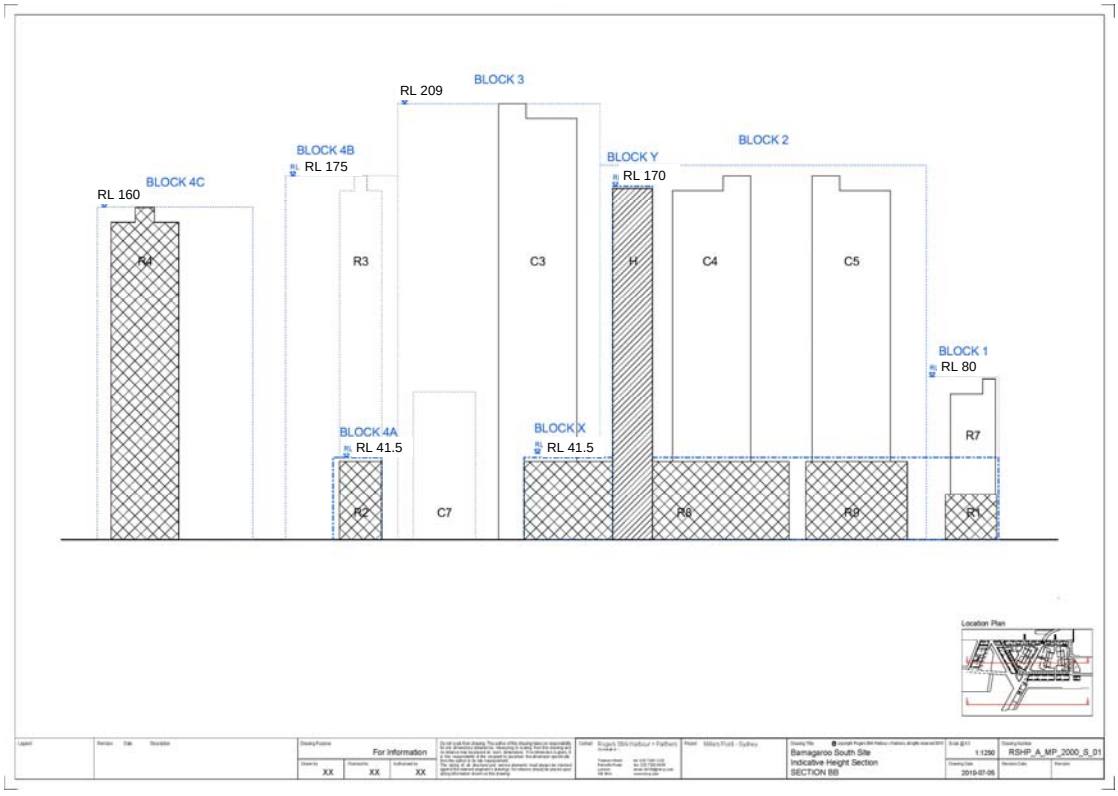

Figure 4: Concept Plan Amendment Indicative Building Heights

3 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.

Typical wind assessment criteria are those of Lawson (1990), as shown in Table 1. The benefits of these criteria are that they use both a mean and gust equivalent mean (GEM) wind speed to assess the suitability of specific locations.

Comfort (maximum wind speed exceeded 5% of the time)	
<2 m/s	Outdoor fine 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.	

Table 1: Pedestrian comfort criteria for various activities

4 Sydney Wind Climate

The measured wind climate for Sydney Airport is presented in Figure 5. Prevailing strong winds tend to come from the north-east, south, and west directions. North-east winds tend to be summer sea breezes bringing relief on warm days. South winds are associated with frontal systems, tend to be cold and are often associated with rain. West winds are associated with virtually all weather patterns, but are particularly strong during late winter and spring during synoptic gale events.

Sydney is relatively windy, with an average wind speed at 10 m reference height of approximately 4m/s (8kt, 14kph), and five percent of the time the mean wind speed is in excess of 9.5m/s (18kt, 34kph). Converting the five percent of the time wind speed to typical pedestrian level at the site would result in about 6.0m/s (12kt, 22kph). Comparing this with the comfort criteria of Table 1 indicates that the locale would be acceptable for pedestrian walking.

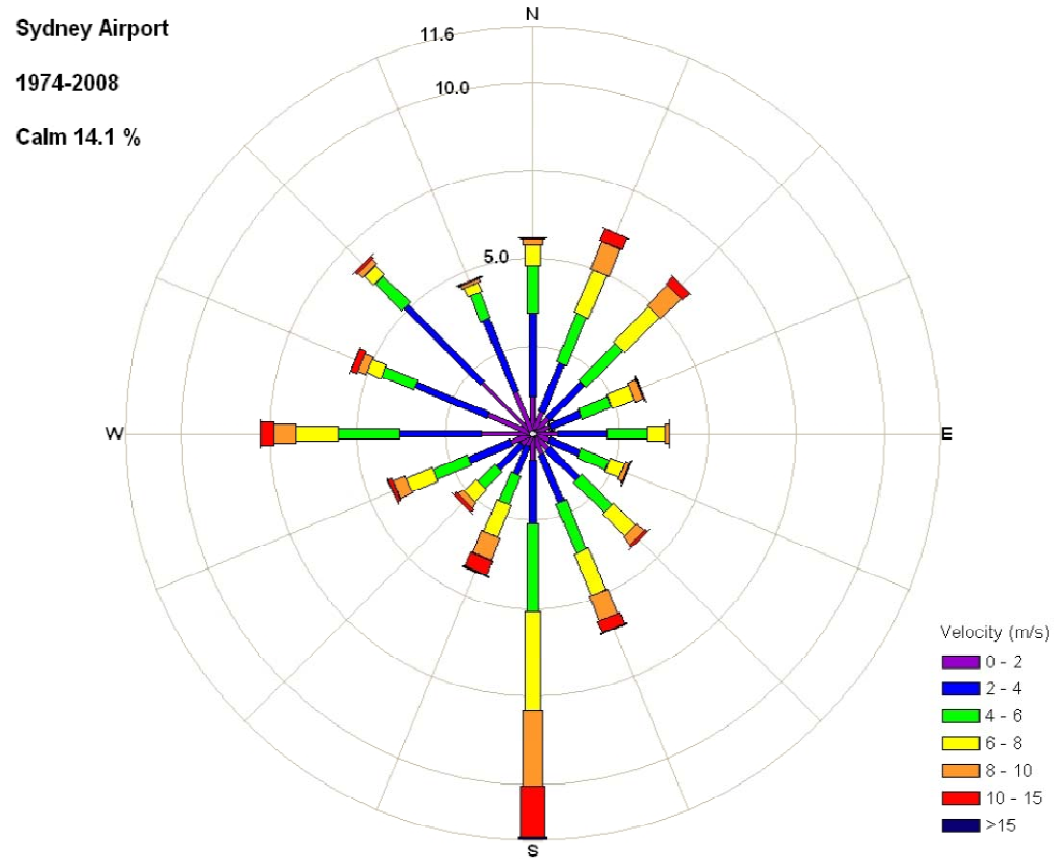

Figure 5: Wind rose for Sydney Airport

5 Wind Flow Mechanisms

When the wind hits a relatively large isolated building, the wind is accelerated down and around the windward corners, Figure 6; this flow mechanism is called downwash. In Figure 6 smoke is being released into the wind flow to allow the wind speed, turbulence, and direction to be visualised. The image on the left shows smoke being released across the windward face. The image on the right shows smoke being released into the flow at about a third of the height in the centre of the face. Both images show a portion of the flow being driven to ground level. Any undercroft areas at the base of the building tend to have accelerated flows.

Channelling occurs when the wind is accelerated between two buildings or along straight streets with buildings on either side.

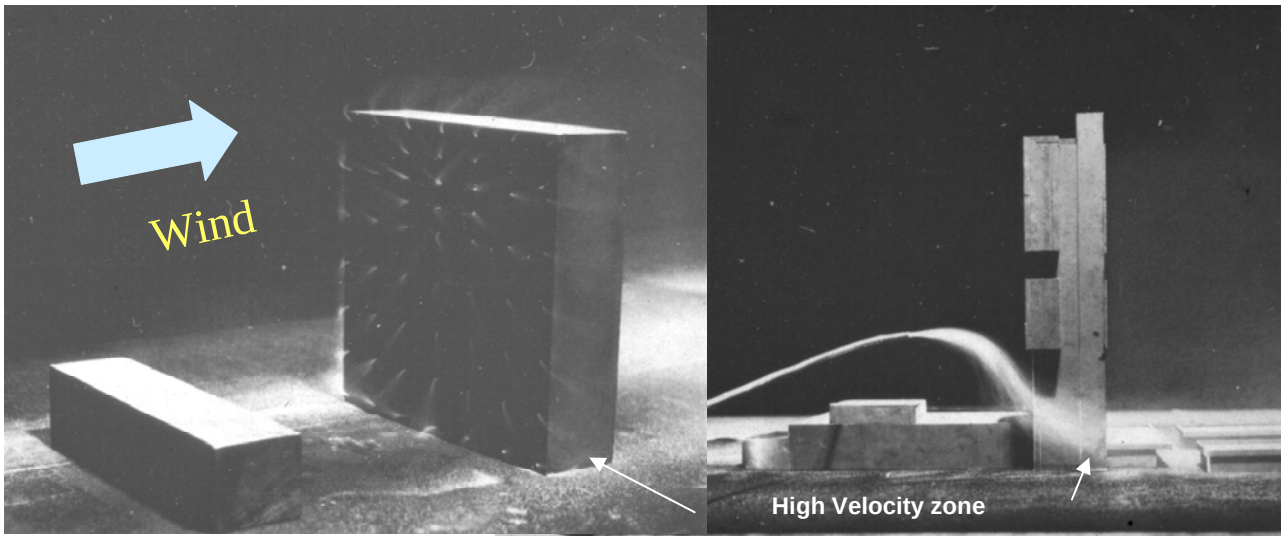

Figure 6: Flow visualisation around a tall building

6 Environmental Wind Assessment

Environment wind affects in cities is well understood, and the design of Barangaroo South is being undertaken in consideration of the likely wind affects in the creation of a public realm useable for a variety of uses at different times of the day and/or year. This will require detailed consideration and wind tunnel testing of the building forms and amelioration techniques during the design development and detailed design phases.

This wind assessment has been undertaken on the basis of the indicative concept plan design as illustrated in Figure 2, Figure 3 and Figure 4. Although wind amelioration treatments are suggested, further assessment will be undertaken as the form of the individual buildings is developed through the future design stages.

The site is located to the west of Sydney CBD, which reasonably protects the site for winds from the north-east, but is more exposed to winds from the south and west.

In Sydney, winds from the south are channelled along the north-south aligned streets. With Barangaroo South being towards the north of the CBD, these flows have already been established in direction from upstream buildings along Sussex, Shelley and Lime Streets. Southerly winds reaching the tall commercial towers within the site will create downwash causing windy conditions. This will be most prevalent at the south-east corner of the site where overhanging buildings will divert flow into the internal north-south laneway. The use of podium levels could be effective in diverting the wind away from pedestrians. Wind tunnel modelling should be undertaken at future design stages to investigate the likely pedestrian level conditions and to propose effective mitigation strategies. Treatments such as increasing the extent of the podium or the introduction of suitable awning, screen and roof structures could be tested to provide acceptable conditions.

Suitable protection to the pedestrian link through Building C5 should be considered to avoid windy conditions generated from a combination of the channelled flow along Shelley Lane and downwash from Building C5. Unabated, this will propagate through the links under C4 and C3. To alleviate these affects, options for introduction of suitable awning structures and public domain planting can be investigated during detailed design, and further alternatives such as installation of localised screens or revolving doors may be investigated if a higher level of treatment is considered necessary for the desired conditions.

Differential heights of the towers that are in close proximity to each other will promote some downwash in the gaps between the towers. The staggered nature of the tall towers in plan, and the awning roofs proposed between Buildings C4 and C5 will reduce the effects on the pedestrian level wind conditions compared with aligned towers.

For winds from the south, the isolated Landmark Building to the west of the site will create downwash, resulting in an increase in wind speed near the south-east and south-west corners at ground level. The proposed Landmark Building is likely to consist of an elevated slender tower over a comparatively larger structure. With the consideration of a combination of appropriately designed and positioned awnings, combined with public domain planting and ground plane wind breaks and screens, additional shelter could be provided for pedestrians and developed further as part of the detailed design of the Landmark Building.

Winds from the west are currently accelerated up the slope to the east of the site, causing windy conditions along Napoleon and Margaret Streets, Hickson Road, and Gas Lane. Extending the city to the west creates additional blockage to the wind, which is expected to generally improve wind conditions in these areas.

Throughout the development, there are expected to be windy conditions at times between adjacent tall towers caused by a combination of downwash and channelling of westerly winds. The staggered orientation of the tall towers will reduce the adverse wind conditions; however the taper in plan to the east is likely to accelerate the higher level flow. The provision of podia under the commercial towers, and appropriately designed and positioned

awnings around the base of the towers will provide additional shelter for pedestrians. It will be necessary to provide amelioration to manage the likelihood of some windy conditions which are expected to occur along the major access route between Buildings C3 and C4, and C4 and C5. Local windy conditions will be created between Buildings R10 and R11 with the acceleration of flow between residential towers R5 and R3. Mitigation measures are to be investigated further as necessary following wind tunnel testing as part of the detailed design of these buildings.

The residential Buildings R8 and R9 to the west of the site will induce circulation of winds from the west in Globe Street promoting downwash from Buildings C4 and C5. The provision of the podium to C4 and C5 will reduce the effect of these winds descending to ground level. Wind conditions around the western corners of Buildings R4 and R5 are expected to be windy under certain conditions caused by the downwash from Building R4. Options such as awnings on the western edge wrapping around the corners, or substantial landscaping to the west would ameliorate these expected conditions and are to be investigated further as part of design development for these buildings.

The cultural building, located to the east of the Landmark Building will be prone to windy conditions for a large portion of the year. The design of this building will need to consider wind effects and incorporate appropriate mitigation measures to allow maximum functionality. Wind tunnel modelling should be undertaken at a future design stage to obtain a reliable prediction of the likely wind environment effects and to test any recommended treatment options. Treatments such as tree planting, awnings and other physical structures could be appropriate for this location.

The westerly winds will have an impact on the wind environment within the open spaces on the western edge of the site along the foreshore. The indicated planting will assist in maintaining acceptable wind conditions, however depending on the planning of the open space elements, techniques such as earth mounds or physical structures could be considered.

7 Conclusion

The proposed design will tend to improve wind conditions along Hickson Road and the pedestrian routes to Kent Street. With appropriate detailed design, wind conditions around the development as described in Concept Plan Amendment – Modification No. 4 (MP06_0162 MOD4) can be made to be acceptable for the intended use. Quantifying the wind conditions around the site will be investigated via wind tunnel testing at appropriate future design stages.

8 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.