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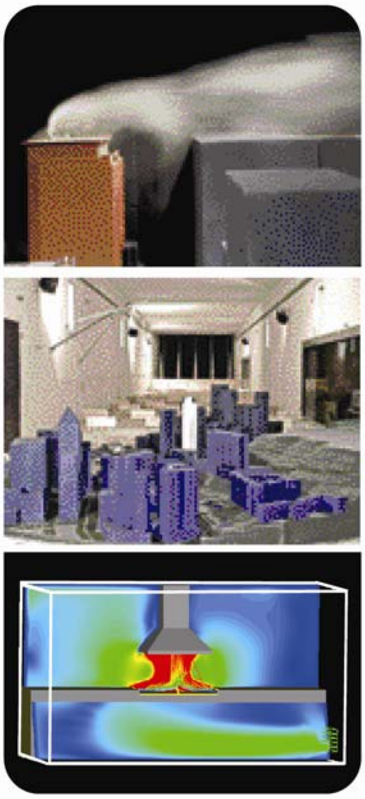
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

FINAL REPORT



Wind Assessment for:

CONCEPT PLAN

University of Technology, Sydney (UTS) Broadway

University of Technology Sydney
15 Broadway
Ultimo
NSW 2007

March 2009

CPP Project: 4874

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Introduction

Cermak Peterka Petersen Pty. Ltd. has been engaged by the University of Technology Sydney (UTS) to provide an opinion based assessment of the impact of the proposed Concept Plan University of Technology, Sydney (UTS) Broadway development on the local wind environment. The purpose of the Concept Plan Stage is to provide a framework for refurbishment and new works for the UTS and a guide to be followed in the planning, design and construction of works to occur between now and 2013.

Although not directly prescribed under the Director-General's requirements, this wind assessment has been compiled to support the Part 3A Concept Plan Application taking into account the environmental impact of both this development and the proposed Fraser's development on the south side of Broadway.

UTS is located at the southern end of the Sydney CBD. The Concept Plan Application is for the Broadway Precinct, bounded by Thomas Street, Wattle Street, Broadway and Harris Streets and the Ultimo Pedestrian Network (UPN), Figure 1.

The Concept Plan involves the demolition, construction and extension of certain buildings on the Broadway Precinct to enable UTS to provide an additional 84,750 m^2 of gross floor area of education, social and sporting facilities, including student housing. The proposal will also enhance existing open space and improve pedestrian, bicycle and vehicular access into the Campus. The project will deliver facilities for up to 15,000 EFTSL (equivalent full time student load) on the campus by 2015, up from 12,200 in 2008.

Concept approval is sought for the following:

- Demolition of existing Building 11 (81 Broadway), Building 12 (113 Broadway) and Building 13 (115 Broadway).
- Building 1 – extension to podium of existing building to a height of 22.47 metres to provide an additional 4,050 m^2 of gross floor area for educational and cultural uses.
- Building 2 – extension to, and refurbishment of, existing building to a height of 24.24 metres to provide an additional 6,750 m^2 of gross floor area for educational uses.
- Building 3 – modifications to existing building to provide café or retail uses on Level 1.
- Building 4 – modifications to existing building to provide café, retail uses or public facilities on Level 1.
- Building 6:
  - extension and modifications to Levels 1-7 of the existing building to provide approximately 5,950 m^2 of gross floor area for educational, retail or café uses;
  - construction of a new 69.20 metre high extension to provide approximately 19,300 m^2 of gross floor area for student accommodation;
  - new pedestrian link between Harris Street and the Ultimo Pedestrian Network through Building 6.
- Building 10 – modifications to existing building to provide vehicular access into the new Broadway Building at basement level, and pedestrian access at ground and upper levels.
- Broadway Building – construction of a new 44.47 metre high building to provide 34,650 m^2 of educational, and café or retail uses plus basement car parking for approximately 160 relocated spaces.

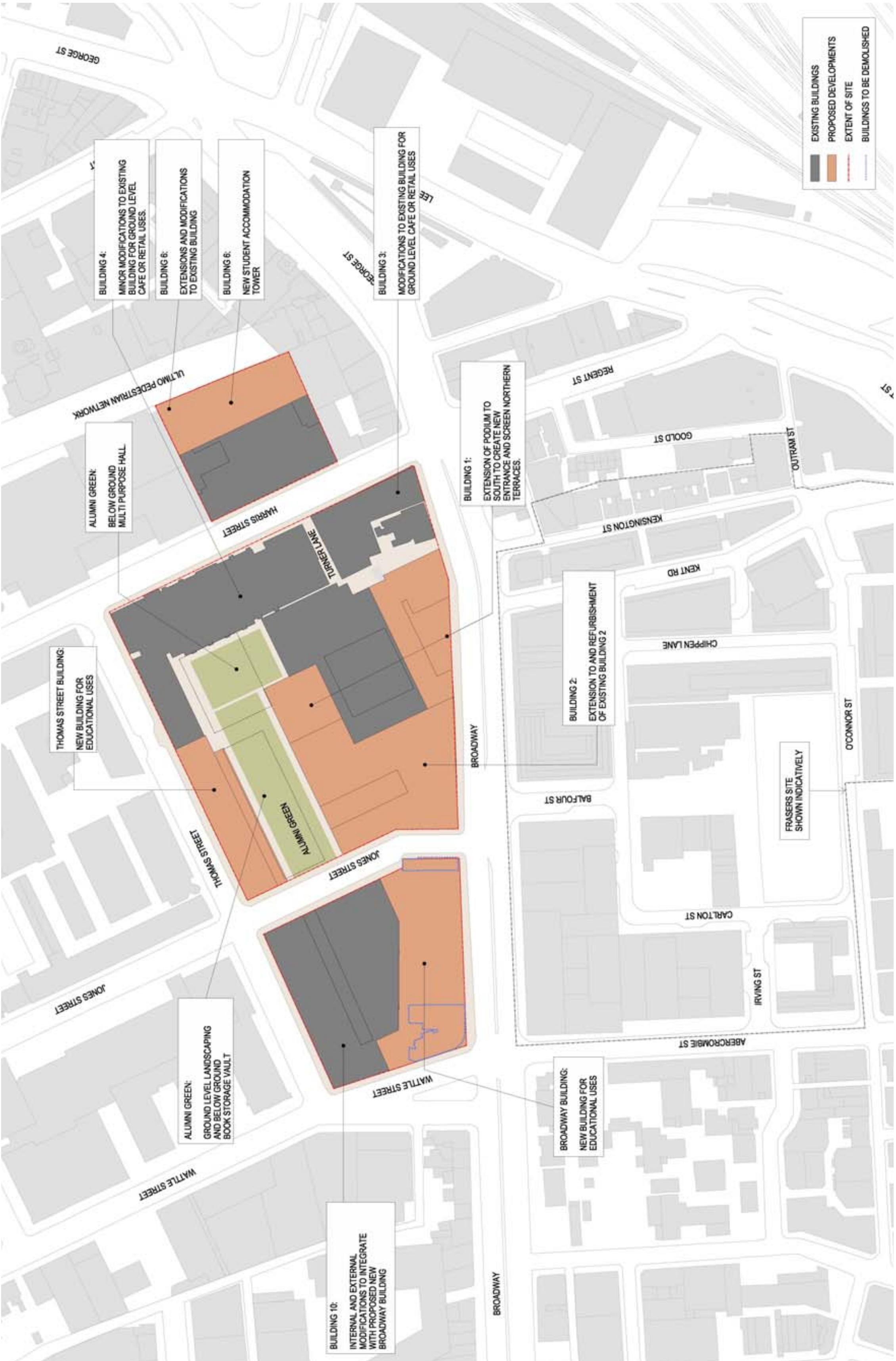


Figure 1 Location of the UTS City Campus plan view.

- Thomas Street Building – construction of new 27.10 metre high building to provide 10,000 m^2 of gross floor area for educational, cultural and café or retail uses.
- Alumni Green:
  - o landscaping;
  - o below ground book storage vault (2,250 m^2 of gross floor area);
  - o below ground multi-purpose sports hall (1,800 m^2 of gross floor area).
- Public domain improvements to Broadway and Thomas, Harris, Wattle and Jones Streets.

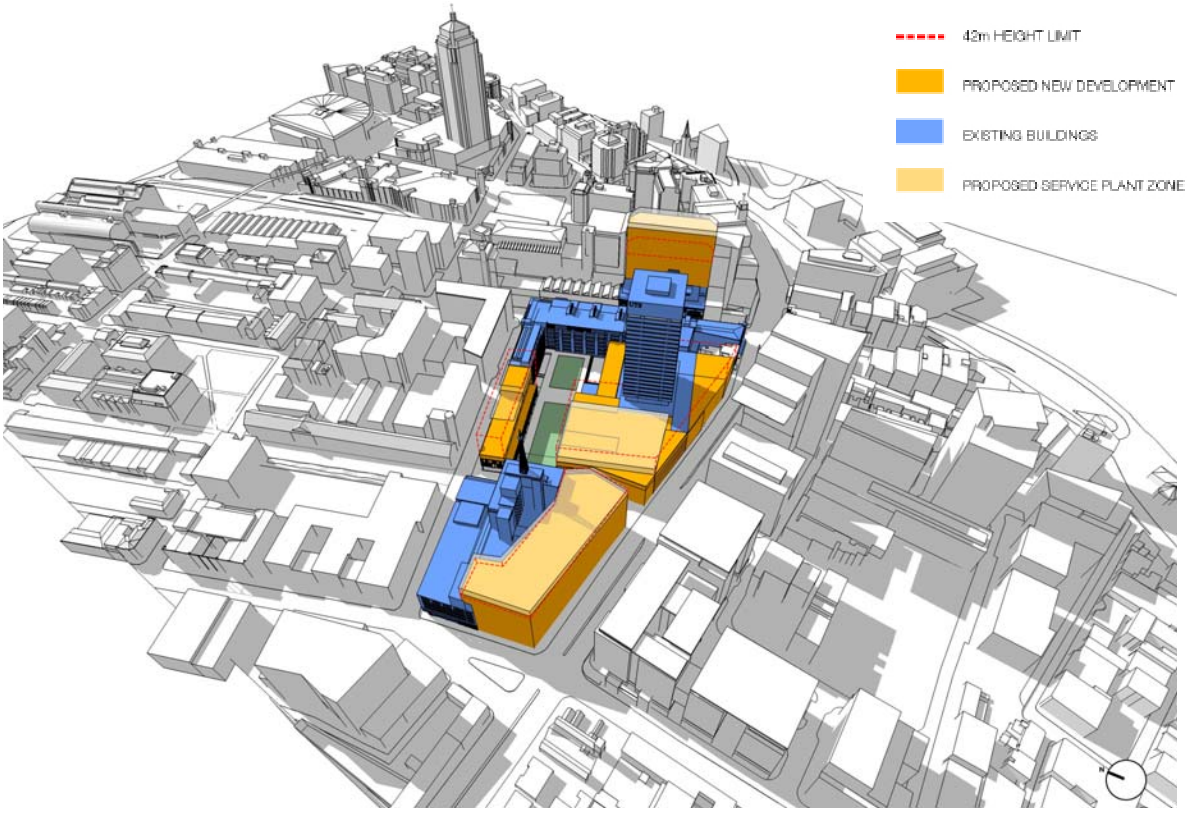


Figure 2 New UTS development sites and significant refurbishment.

UTS sits within a diverse range of building types and uses of similar height and massing. Significant institutions in close proximity to the campus include the ABC headquarters, Sydney Institute of TAFE, The Powerhouse Museum and the proposed Frasers on Broadway to include 250,000 m^2 of mixed use development and replacing the previous Carlton United Breweries site. Important in terms of wind impact is the mutual interaction these surrounding developments have with the UTS City Campus.

Sydney Wind Climate

The proposed development lies approximately 7 km to the north of the Sydney Airport Bureau of Meteorology anemometer (BoM Station 947670). In the absence of any surrounding development it is considered the wind climate at the UTS site would be similar to Sydney Airport given a similar proximity to the eastern seaboard. At the UTS site there is significant surrounding development which will perturb the local wind environment as discussed later in this report. Analysis based on Met Bureau mean wind speed data from 1986 through to 2007 was used to produce the local wind characteristics,

Figure 3. Key characteristics of the coastal Sydney wind climate are:

- Summer winds occur mainly from the south, southeast, and northeast. Winds from the south generally provide the strongest gusts during summer and are associated with cold frontal systems. Onshore northeast sea breezes will have moderate but prolonged intensity, bringing cooling breezes to coastal locations in the summer months. Summer thunderstorms come from the west and tend to have an intense, but short duration gust front.
- Winter and early spring winds occur mainly from the south and west quadrants. West quadrant winds will provide some of the strongest winds affecting Sydney throughout the year.

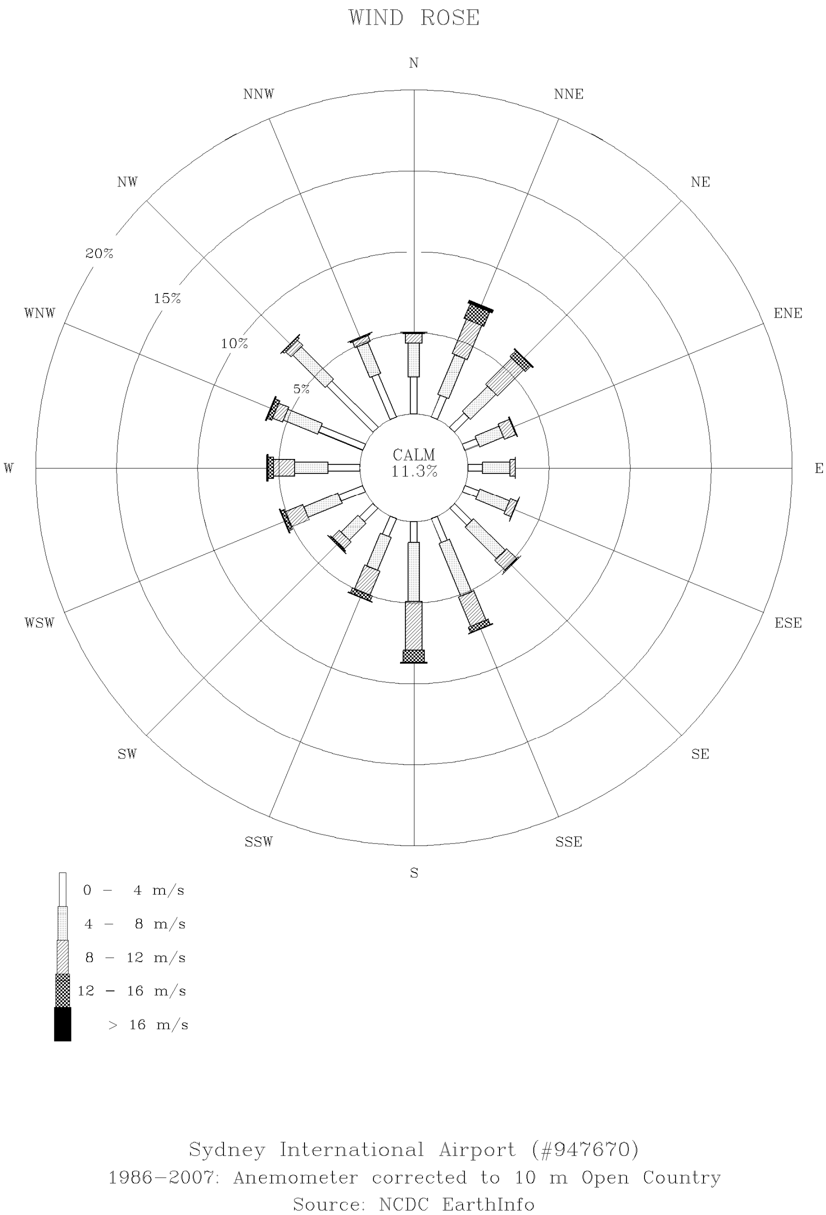


Figure 3: Wind rose for Sydney Airport anemometer site

Environmental Wind Speed Criteria

Prior to assessing the wind environment it is imperative to establish suitable targets in terms of the desired environmental wind conditions for particular pedestrian activities. 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, e.g. Melbourne (1978, referenced by Sydney City and other Australian Councils) and Lawson (1990). Common to the cited criteria is a suggested list of suitable human activities corresponding to the various levels of wind intensity and regularity.

Wind tunnel testing is required to quantify wind conditions at the site against these established criteria. Nevertheless, at this early planning stage CPP can provide a qualitative estimate of the level of wind intensity at different locations throughout the UTS site based upon experience gained from previous wind tunnel tests. For consistency with the Melbourne and Lawson criteria, wind conditions in this qualitative report are later described in terms of:

- Long term stationary - generally acceptable for stationary, long exposure activities (e.g., outdoor alfresco dining).
- Short term stationary - generally acceptable for stationary short exposure activities (e.g., window shopping, or sitting in plazas).
- Comfort of walking - generally acceptable for walking; wind conditions below safety concern. This is the maximum level of wind intensity generally considered acceptable for walking in public domain locations.
- Safety concerns - completely unacceptable for walking in main public accessways under the impact of strong gusty winds.

All new construction at UTS will target a five star Green Star rating in the Education Tool of the Green Building Council of Australia, except for the new Thomas Street building, which will target a six star Green Star rating. One of the key strategies needed to achieve the five star rating will be efficient mechanical ventilation systems that would incorporate mixed-mode ventilation in offices and natural ventilation in circulation and core spaces. Natural ventilation of public spaces is a guiding design approach that has also been recommended for the development of the base of Building 1 as part of the new atrium and entrance to the campus. Hence the need to mitigate stronger winds at pedestrian locations needs to be balanced against the need to provide adequate breeze resource for natural ventilation.

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 UTS City Campus Concept Plan site are discussed below:

Downwash

Figure 4 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.

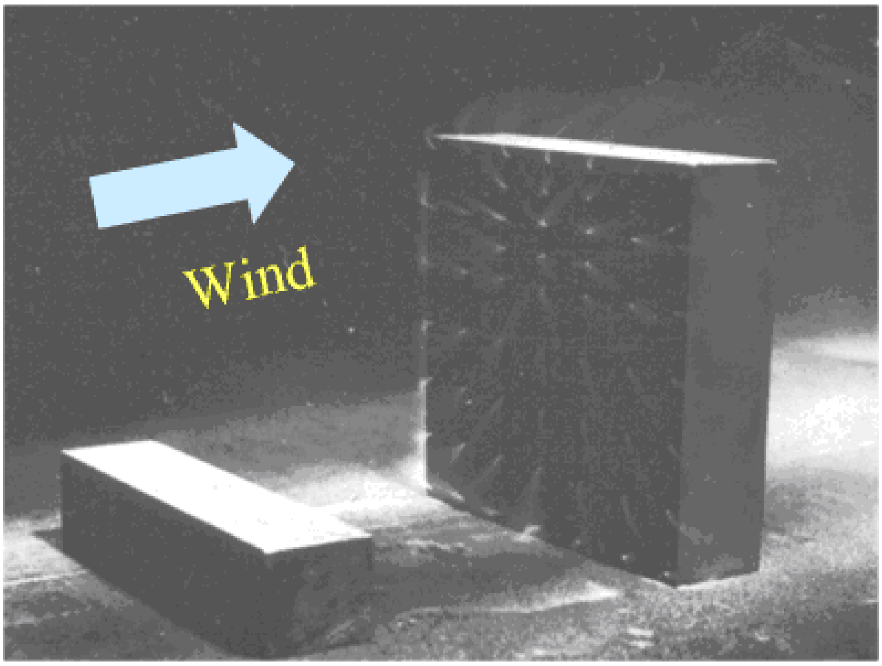


Figure 4: Flow visualisation of wind hitting a large building

Figure 5 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.

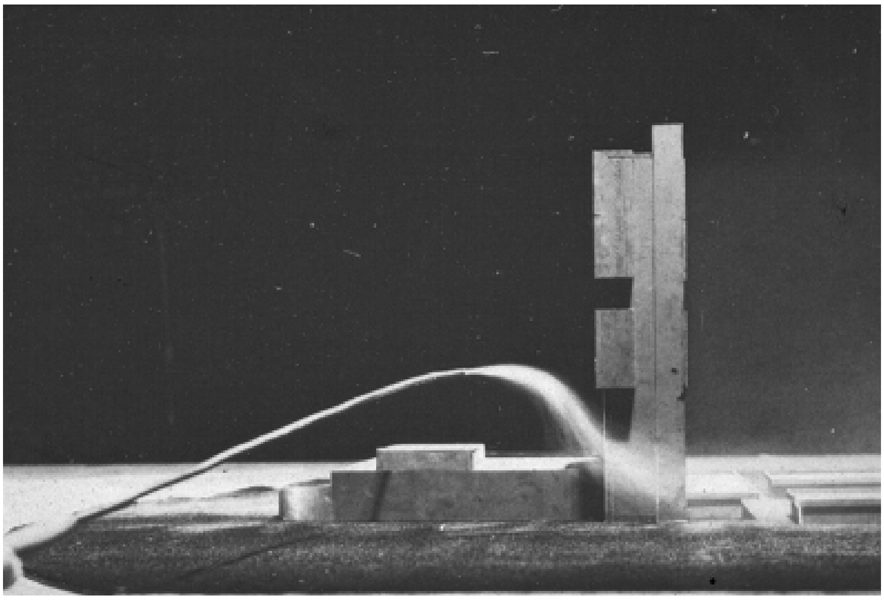


Figure 5: Flow visualisation around a tall building

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 6.

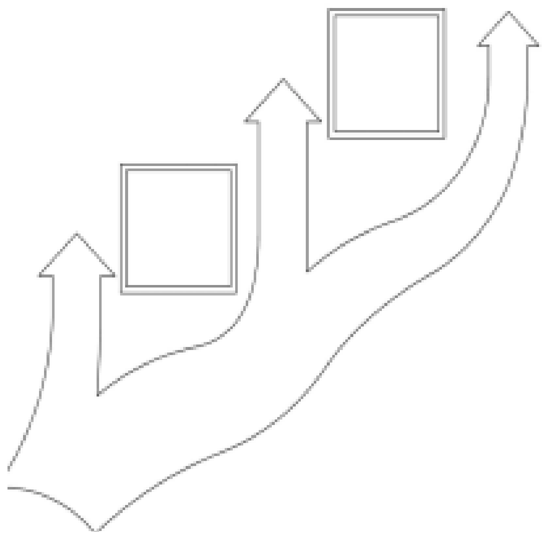


Figure 6: Wind channelling between buildings – venturi flow

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 7. 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.

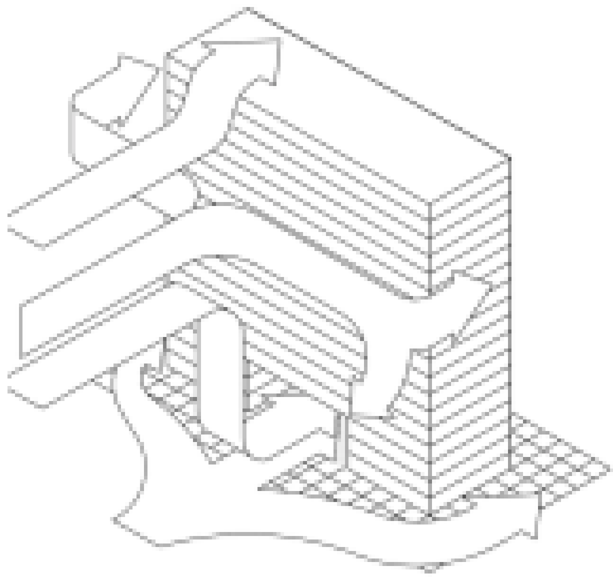


Figure 7: An arcade or open column plaza under a building frequently generates strong pedestrian wind conditions.

Impact of Prevailing Winds on Existing UTS Building Envelopes

It is useful to understand the interaction of prevailing Sydney winds with existing buildings throughout the UTS precinct prior to predicting the wind interaction with the Concept Plan scheme.

The site is exposed to winds from the west and south as described in the BVN Masterplan report Site Analysis. Uncomfortable wind conditions are known to occur at some locations throughout the precinct, most noticeably on Broadway in the vicinity of the existing tower building under the action of westerly winds.

Onshore northeast winds lose considerable intensity as they pass through the southern Sydney CBD and eastern suburbs. Northeast winds have moderate but prolonged intensity at the site with potential to deliver cooling breezes in the summer months.

Most of the City Campus site receives shielding from Sydney's prevailing wind directions by surrounding mid to high-rise development described earlier. The staggered alignment of roads and passageways within and surrounding the precinct will be largely mitigating this channelling effect for prevailing Sydney winds. Roadways such as Thomas Street have large building developments at their southern ends effectively blocking channelling westerly flows. Similarly the impact of prevailing southerly winds is largely reduced at the site because of the available shielding offered by the Chippendale, Surry Hills and Redfern built environments.

Prevailing westerly winds are channelled along the Broadway street corridor with minimal upstream blockage presented by the wide open roadway extending back to the University of Sydney. Channelling westerly winds will continue to flow between building gaps formed by UTS and former Carlton United Brewery developments (prior to their demolition). Coupled with the channelling of the wind is a mild acceleration of flow due to the gently rising topography of Broadway toward the site.

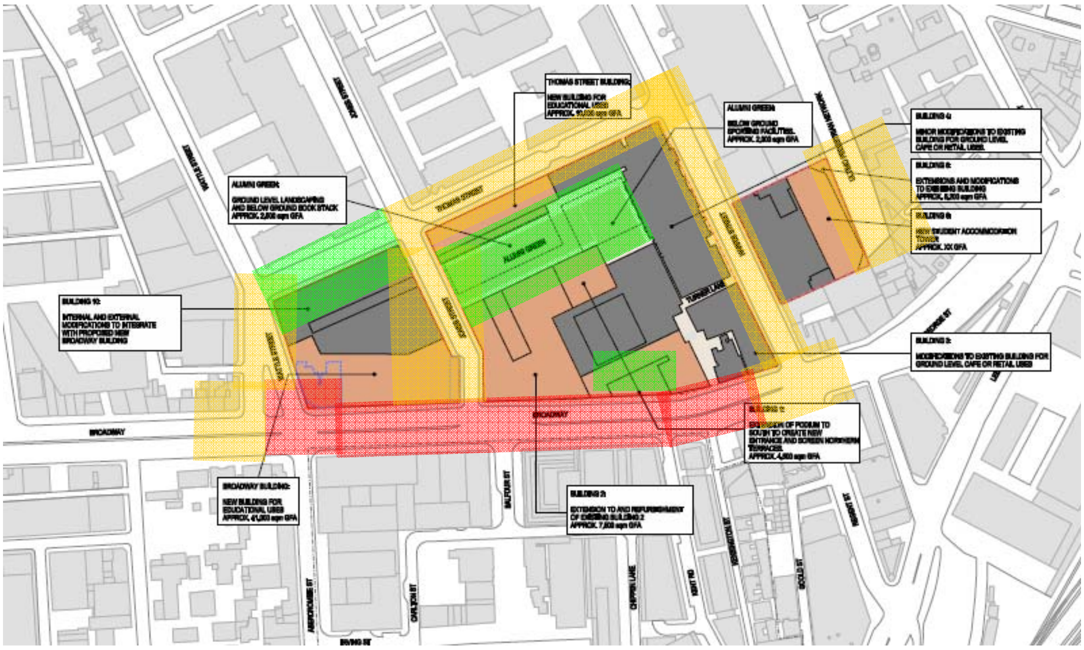
At existing UTS Broadway locations, site winds are likely to occur at intensity levels exceeding conditions considered comfortable for walking, i.e. exceeding the comfort of walking criteria. Existing street landscaping is currently providing some marginal mitigation to these channelling wind flows when the trees are in foliage, Figure 8.

Figure 8: Existing Street Trees - Photo looking north Building 1 Broadway Entry.

Buildings within the UTS City Campus are of similar or lower height to surrounding developments, with the exception of the UTS Building 1 tower. Therefore there is limited upper façade area available to capture upper level wind flows and draw them toward ground level. The UTS Building 1 tower is surrounded around the periphery of its base by podium buildings that are very effective in deflecting downwash flows away from ground pedestrian locations. It is therefore expected downwash flows are having limited impact on the existing site.

Impact of Prevailing Winds on Proposed Concept Plan UTS Building Envelopes

Wind intensity zoning at ground level resulting from the interaction of the Sydney wind climate with the Concept Plan scheme is summarised in Figure 9. Three wind intensity zones are provided corresponding to areas that are considered likely to worsen, ramain similar, or improve relative to the existing condition. These are opinion based generalisations of wind intensity and will need to be verified using further quantitative testing againt the environmental wind speed criteria during detailed design.



Red Zones wind conditions worsened over existing.

Orange Zones wind conditions similar to existing.

Green Zones wind conditions improved over existing

Figure 9: Wind Intensity Zoning Exterior Locations – Concept Plan UTS.

Broadway

Flow around proposed buildings in Concept Plan UTS will display similar channelling patterns to those anticipated above for the existing buildings. Westerly winds will be channelled through the site between building gaps and the street corridors, particularly Broadway. Compared with existing conditions, the wind flow along Broadway will be accelerated due to the increased massing of the Concept Plan Building 1, 2 and Broadway buildings, and the proposed Frasers on Broadway development to the south. This wind interaction is described schematically by red arrows in Figure 10.

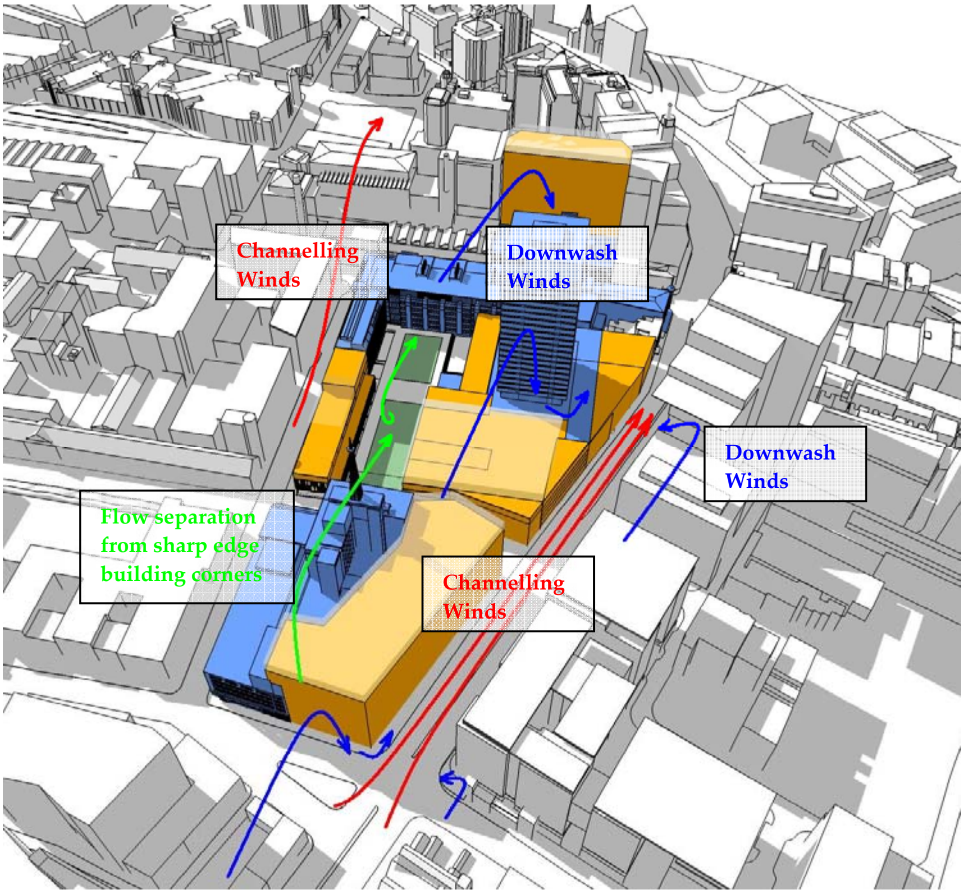


Figure 10: Interaction of Westerly Winds with the UTS Concept Plan.

In particular, the extension to Building 2 to the Broadway street boundary, and the new four storey facade forming the revitalised entrance to Building 1, will provide additional confinement to channelling flows at roadside locations. Wind conditions within the protected pocket formed by the roadside screens and the Building 1 entrance however are likely to improve compared with existing conditions. Care should be taken during detailed design to ensure channelling westerly flows do not penetrate this space. There is also some exposure of the Building 1 entrance to southerly winds through upstream building gaps in the Frasers Broadway site.

Figure 11: Building corridor lining Broadway.

Also important in terms of downwash flows is the additional massing of the new 9-storey Broadway building at the extreme western end of the campus. Channelling flows will impact at upper levels of the new building and flow toward ground level as illustrated by the blue arrows in Figure 10. As these buildings do not have podiums or awnings to intercept the downwash flow, upon reaching ground level the wind will accelerate around the building corner at ground level producing an area of localised higher flow. Similar downwash will occur from both the UTS and Frasers Towers, but a large portion of this flow will be intercepted by lower building roofs before reaching ground level.

Given the above, the intensity of winds on Broadway is likely to increase compared to the existing condition. Localised areas of high winds will need to be ameliorated during detailed design to ensure no locations on Broadway exceed the safety concern criterion.

Thomas Street and Ultimo Road

Other roadways with an approximate east-west alignment such as Thomas Street and Ultimo Road will experience channelling westerly winds with a similar intensity to existing conditions.

A new tower development at the extreme western end of Thomas Street (located on the western side of Harris Street) may reduce winds marginally from the existing condition over the southern length of the roadway. The proposed new Thomas Street building is located largely within the wake of upstream developments under the action of westerly wind and is unlikely to alter the local wind environment significantly.

Jones Street and Alumni Green

Jones Street has an approximate north-south alignment and will likely receive significant shielding from the proposed 9-storey Broadway building from west and southwest winds. The future Frasers Broadway site will also provide shielding to the UTS site as a whole from southerly winds, but note there is north-south alignment of one of the internal Frasers Broadway streets with Jones Street. On balance, it is considered wind conditions on Jones Street will remain largely unchanged from existing and winds along the northern half of Jones Street at least will be below the comfort of walking criterion described above under "Environmental Wind Speed Criteria".

Westerly winds impacting with upstream developments have the potential to create gusty shear flow separations as illustrated by the green lines in Figure 10. These turbulent shear flows have a tendency to move toward ground level and 'reattach' in the lee of a building. These reattached flows can produce intermittent gusty conditions at downstream ground level locations. It is probable that this is already occurring to some extent in Alumni Green and this condition is likely to persist with the proposed Concept Plan scheme. Additional tree planting throughout Alumni Green will assist with the mitigation of this condition, and any issues would be further addressed during detailed design when the intended usage of this space is finalised. Overall, there is expected to be some marginal improvement in wind conditions within Alumni Green compared to the existing condition given the additional surrounding building massing.

Harris Street and Ultimo Pedestrian Network (UPN)

Flow around existing buildings in the vicinity of Harris Street and UPN will display similar patterns and intensities as the existing condition as there is minimal change to building massing near ground level. These streets run approximate north-south and align with Sydney's prevailing south and southeast winds. The impact of prevailing southerly winds will be largely reduced at the site because of the available shielding offered by Chippendale, Surry Hills, and Redfern built environments.

The most significant change will be the increased height to Building 6 student housing with potential for additional downwash flow. It is noted however that the additional levels are currently positioned over the eastern half of the existing podium and the west set-back will intercept downwash flows before reaching Harris Street ground locations. Consideration will be needed during detailed design to protect UPN Street level locations from the impact of downwash generated by milder northeast winds.

Other Internal Streets

The Concept Plan proposes to create a number of significant new internal streets and connections. Some of these connections will pass through existing and proposed building massing with the potential to connect a positive pressure region on the windward side with a negative pressure region on the lee side. These conditions would occur for any buildings of similar massing and can be addressed fully during the detailed design phase with the inclusion of air lock doors.

Some existing passageways include double sliding door sets that provide a seal to existing internal cross flows when the doors are all closed, e.g. Building 6 leading to Harris Street footbridge. These will be unsuitable at the locations marked in Figure 12, as simultaneous door opening will provide no resistance to strong internal flows.

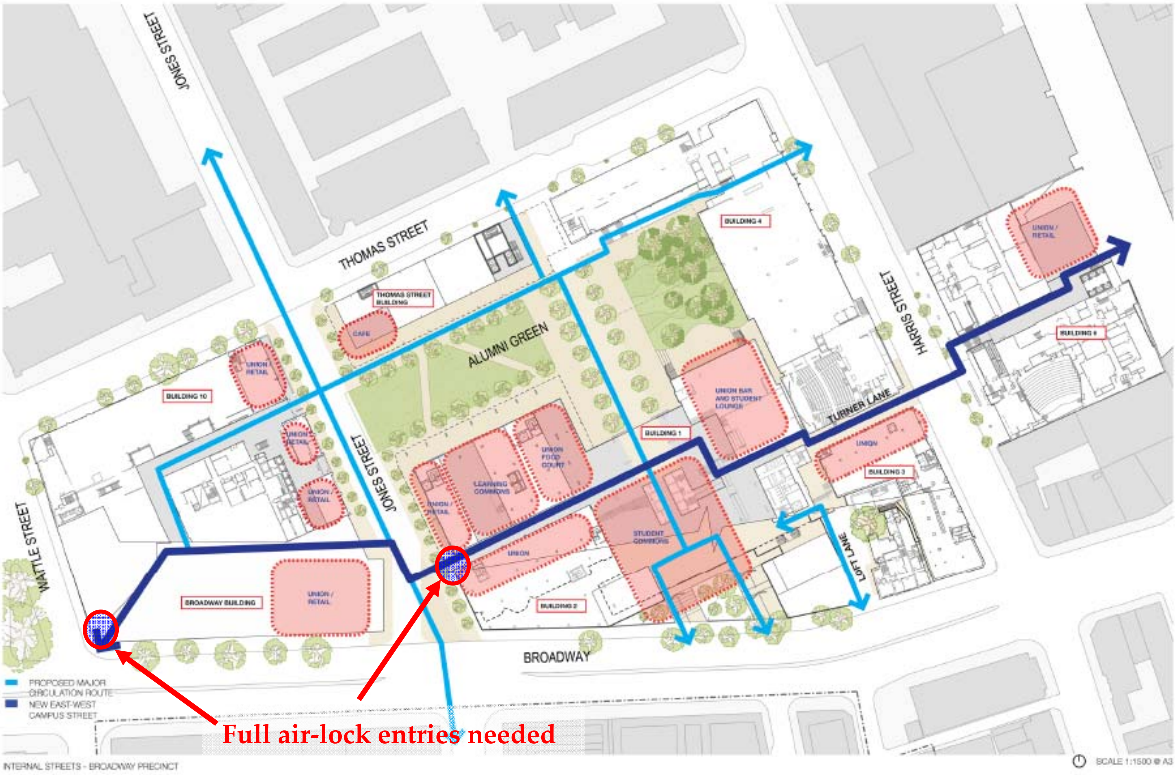


Figure 12: Internal Streets, Broadway Campus.

Another critical passageway in terms of wind impact will be the clear link through Building 1 from the Broadway Entrance across Alumni Green, Figure 13. At this preliminary design stage it is proposed to include rain screens to existing terraces and glazed walls to create a new garden entry microclimate. The environmental conditions throughout the Building 1 entrance and passageway should be subjected to rigorous analysis during the detailed design phase to ensure the functionality of the space (breeze and rain penetration, solar access and thermal comfort within the space) whilst also providing the energy saving benefits under Green Star.

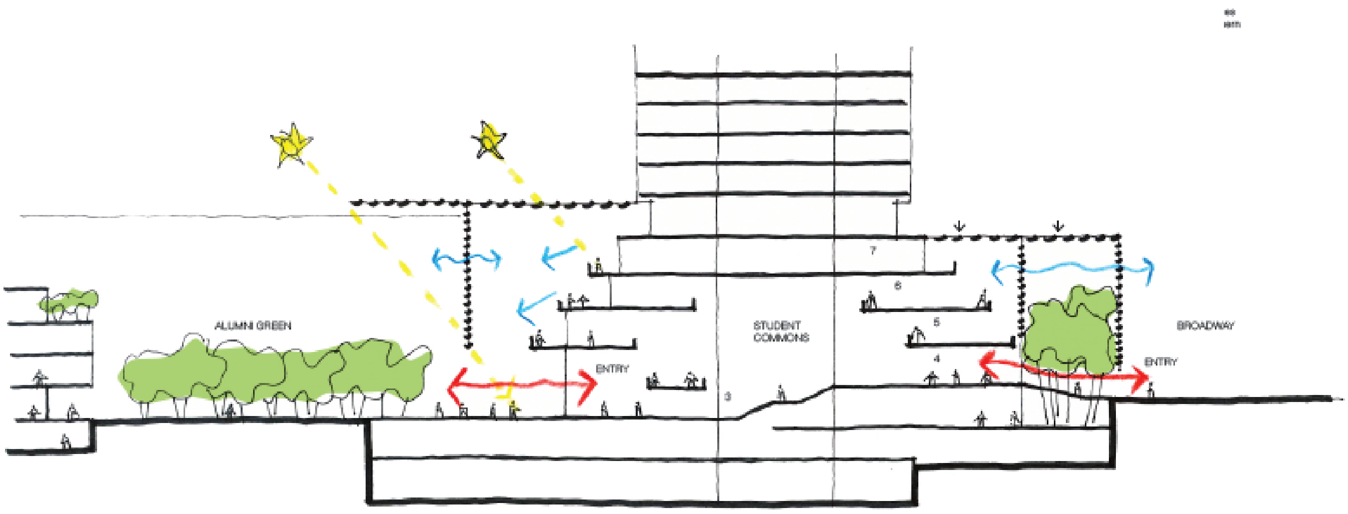


Figure 13: Section through CB01.

Finally, a recommendation has been made to provide shelter at building entries and awnings where new and existing campus buildings flank University public spaces and public streets. These more localised wind treatments will be necessary to preserve the wind amenity throughout the site, but are beyond the current scope of this overview Concept Plan wind assessment. During detailed design phase each windbreak element should be assessed to ensure that the area is suitable for the intended use. .

Summary

Cermak Peterka Petersen Pty. Ltd. has been engaged by University of Technology Sydney (UTS) to provide an opinion based assessment of the impact of the proposed Concept Plan UTS Broadway Campus development on the local wind environment.

Areas most prone to higher wind velocities have been identified; in particular building gaps associated with channelling winds and internal flows through proposed internal passageways. Winds throughout the site have been assessed qualitatively and compared with established wind acceptability criteria and these have been summarised in schematic format. Significant wind impacts include:

- Broadway will likely experience the strongest channelling flows as westerly winds are accelerated between the significantly increased massing of the Concept Plan UTS Building 1, 2 and Broadway buildings, and the future Frasers on Broadway building massing to the south. The wind impact of both buildings together is much more significant than either development in isolation. Local planting and awning configurations on both developments may be sufficient to ameliorate any unsatisfactory conditions along Broadway.
- Particular care will be required during the detailed design planning stages to ensure new internal streets and connections are protected from the passage of strong environmental wind flows.
- Wind conditions within the Building 1 entrance are likely to improve from existing conditions. Care should be taken during detailed design to ensure environmental wind flows do not penetrate the space.

Detailed serviceability issues associated with landscaping, outdoor cafes, door placement, internal pressure issues etc. will be considered during detailed design. The need to mitigate stronger winds at pedestrian locations needs to be balanced against the need to provide adequate breeze resource for natural ventilation and Green Star rating.

Architectural Drawings

Assessment of wind effects in this report has been based upon the 3D skp drawings and the UTS City Campus Masterplan 2020 prepared by Bligh Voller Nield issued September 2008.

References

Lawson, T.V., (1990), The Determination of the wind environment of a building complex before construction, Bristol University, England.

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