



WATERLOO METRO QUARTER OVER STATION DEVELOPMENT

Environmental Impact Statement Appendix LL - Wind Impact Assessment

**SSD-10437 Southern Precinct
SSD-10439 Central Precinct and
SSD-10440 Northern Precinct**

Detailed State Significant Development
Development Application

Prepared for **Waterloo Developer Pty Ltd**

15 February 2021

Reference	Description
Applicable SSD Applications	SSD-10437 Southern Precinct SSD-10439 Central Precinct SSD-10440 Northern Precinct
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1. Glossary and abbreviations

Reference	Description
ACHAR	Aboriginal Cultural Heritage Assessment Report
ADG	Apartment Design Guide
AHD	Australian height datum
AQIA	Air Quality Impact Assessment
BC Act	Biodiversity Conservation Act 2016
BCA	Building Code of Australia
BC Reg	Biodiversity Conservation Regulation 2017
BDAR	Biodiversity Development Assessment Report
CEEC	critically endangered ecological community
CIV	capital investment value
CMP	Construction Management Plan
Concept DA	A concept DA is a staged application often referred to as a 'Stage 1' DA. The subject application constitutes a detailed subsequent stage application to an approved concept DA (SSD 9393) lodged under section 4.22 of the EP&A Act.
Council	City of Sydney Council
CPTED	Crime Prevention Through Environmental Design
CSSI approval	critical State significant infrastructure approval
CTMP	Construction Traffic Management Plan
DA	development application
DPIE	NSW Department of Planning, Industry and Environment
DRP	Design Review Panel
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority
EPA Regulation	Environmental Planning and Assessment Regulation 2000
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESD	ecologically sustainable design

Reference	Description
GANSW	NSW Government Architect's Office
GFA	gross floor area
HIA	Heritage Impact Assessment
IAP	Interchange Access Plan
LGA	Local Government Area
NCC	National Construction Code
OSD	over station development
PIR	Preferred Infrastructure Report
POM	Plan of Management
PSI	Preliminary Site Investigation
RMS	Roads and Maritime Services
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SEPP 55	State Environmental Planning Policy No 55—Remediation of Land
SEPP 65	State Environmental Planning Policy No. 65 – Design Quality of Residential Apartment Development
SRD SEPP	State Environmental Planning Policy (State and Regional Development) 2009
SREP Sydney Harbour	State Regional Environmental Plan (Sydney Harbour Catchment) 2005
SSD	State significant development
SSD DA	State significant development application
SLEP	Sydney Local Environmental Plan 2012
Transport for NSW	Transport for New South Wales
TIA	Traffic Impact Assessment
The proposal	The proposed development which is the subject of the detailed SSD DA
The site	The site which is the subject of the detailed SSD DA
VIA	Visual Impact Assessment

Reference	Description
WMQ	Waterloo Metro Quarter
WMP	Waste Management Plan
WSUD	water sensitive urban design

2. Executive summary

This planning report has been prepared by RWDI Anemos Ltd. (RWDI) to accompany a detailed State significant development (SSD) development application (DA) for the following Precincts: Southern Precinct Central Precinct and Northern Precinct over station development (OSD) at the Waterloo Metro Quarter site.

This report has been prepared to address the relevant conditions of the concept SSD DA (SSD 9393) and the Secretary's Environmental Assessment Requirements (SEARs) issued for the detailed SSD DA (SSD 10437 SSD 10439 and SSD 10440).

This report concludes that the proposed Southern Precinct, Central Precinct, Northern Precinct OSD is suitable and warrants approval.

Additional commentary is provided for the wind conditions on the terrace areas for the remaining buildings should further improvements on the wind conditions be desired.

Detailed testing for alternative mitigation scheme associated with the Cope Street Plaza was undertaken after discussion with the Design Review Panel. This included an alternative landscape arrangement throughout the Cope Street Plaza which responded to the wind flow patterns noted from flow visualisation modelling to break-up the recirculation wind flow patterns. After presentation to the Design Review Panel of these alternative wind mitigation approaches, the Panel accepted the investigations undertaken in response to the Panels comments re. wind mitigation, and supported the design team's recommendation not to plant additional trees to the Cope Street entrance, as the anticipated wind conditions are already acceptable and any minor improvement to wind mitigation afforded by additional does not outweigh the impediment they may create to wayfinding, accessibility and solar access.

The results presented in this report are the final solution presented to the Design Review panel which as noted above were accepting and supporting of.

3. Introduction

This report has been prepared to accompany a detailed State significant development (SSD) development application (DA) for the following precincts: Southern Precinct Central Precinct and Northern Precinct over station development (OSD) at the Waterloo Metro Quarter site. The detailed SSD DA is consistent with the concept approval (SSD 9393) granted for the maximum building envelope on the site, as proposed to be modified.

The Minister for Planning, or their delegate, is the consent authority for the SSD DA and this application is lodged with the NSW Department of Planning, Industry and Environment (DPIE) for assessment.

The detailed SSD DA seeks development consent for the design, construction and operation of:

Southern Precinct

- 25-storey residential building (Building 3) comprising student accommodation, to be delivered as a mixture of studio and twin apartments with approximate capacity of 474 students
- 9-storey residential building (Building 4) above the southern station box to accommodate 70 social housing dwellings
- ground level retail tenancies including Makerspace and gymnasium lobby, and loading facilities
- level 1 and level 2 gymnasium and student accommodation communal facilities
- landscaping and private and communal open space at podium and roof top levels to support the residential accommodation
- new public open space including the delivery of the Cope Street Plaza, including vehicle access to the site via a shared way from Cope Street, expanded footpaths on Botany and Wellington streets and public domain upgrades
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

Central Precinct

- 24–storey residential building (Building 2) comprising approximately 126 market residential and 24 affordable housing apartments, to be delivered as a mixture of one-bedroom, two-bedroom and three-bedroom apartments
- ground level retail tenancies, community hub, precinct retail amenities and basement carpark entry
- level 1 and level 2 community facilities (as defined in the SLEP) intended to be operated as a childcare centre
- landscaping and private and communal open space at roof top levels to support the residential accommodation
- new public open space including the delivery of the Church Square, including vehicle access to the basement car park via a shared way from Cope Street, expanded footpaths and public domain upgrades on Botany Road
- external licensed seating areas
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

Northern Precinct

- 17-storey commercial building (Building 1) comprising Commercial floor space, with an approximate capacity of 4000 workers
- ground level retail tenancies, loading facilities serving the northern and central precinct including Waterloo metro station
- landscaping and private open space at podium and roof top levels to support the commercial tenants
- new public open space including the delivery of the Raglan Street Plaza, Raglan Walk and expanded footpaths on Raglan Street and Botany Road and public domain upgrades
- external licensed seating areas
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 8 April 2020, 9 April 2020 and 9 April 2020 and issued for the detailed SSD DA. Specifically, this report has been prepared to respond to the SEARs requirements summarised below.

Item	Description of requirement	Section reference (this report)
Visual and Amenity Impact (Wind)	Include a wind assessment, identifying the impact of the proposal on surrounding wind conditions having regard to the wind study criteria under the Concept Approval and providing any required measures to ameliorate wind impacts at podium level, street level and at the locations of existing and future pedestrian crossings.	7, 8, 9, 10

Table 1 - SEARs requirements

This report has also been prepared in response to the following conditions of consent issued for the concept SSD DA (SSD 9393) for the OSD as summarised in the table below.

Item	Description of requirement	Section reference (this report)
B13 – Wind Impact Assessment	Future development applications for aboveground works shall be accompanied by a Wind Impact Assessment including computer modelling of detailed building form and demonstrating compliance with the criteria in Pedestrian Wind Environment Study by Windtech dated September 2019.	7, 8, 9, 10
B14 – Wind Impact Assessment	The Wind Impact Assessment must consider the locations of future and existing pedestrian crossings and apply standing criteria zones to match the width of crossings and the waiting zones of crossings, including on the opposite side of streets.	7, 8, 9, 10

Table 2 - Conditions of Concept Approval

4. The site

The site is located within the City of Sydney Local Government Area (LGA). The site is situated about 3.3 kilometres south of Sydney CBD and eight kilometres northeast of Sydney International Airport within the suburb of Waterloo.

The Waterloo Metro Quarter site comprises land to the west of Cope Street, east of Botany Road, south of Raglan Street and north of Wellington Street (refer to Figure 1). The heritage-listed Waterloo Congregational Church at 103–105 Botany Road is within this street block but does not form a part of the Waterloo Metro Quarter site boundaries.

The Waterloo Metro Quarter site is a rectangular shaped allotment with an overall site area of approximately 1.287 hectares.

The Waterloo Metro Quarter site comprises the following allotments and legal description at the date of this report. Following consolidation by Sydney Metro (the Principal) the land will be set out in deposited plan DP1257150.

- 1368 Raglan Street (Lot 4 DP 215751)
- 59 Botany Road (Lot 5 DP 215751)
- 65 Botany Road (Lot 1 DP 814205)
- 67 Botany Road (Lot 1 DP 228641)
- 124-128 Cope Street (Lot 2 DP 228641)
- 69-83 Botany Road (Lot 1, DP 1084919)
- 130-134 Cope Street (Lot 12 DP 399757)
- 136-144 Cope Street (Lots A-E DP 108312)
- 85 Botany Road (Lot 1 DP 27454)
- 87 Botany Road (Lot 2 DP 27454)
- 89-91 Botany Road (Lot 1 DP 996765)
- 93-101 Botany Road (Lot 1 DP 433969 and Lot 1 DP 738891)
- 119 Botany Road (Lot 1 DP 205942 and Lot 1 DP 436831)
- 156-160 Cope Street (Lot 31 DP 805384)
- 107-117A Botany Road (Lot 32 DP 805384 and Lot A DP 408116)
- 170-174 Cope Street (Lot 2 DP 205942).

The detailed SSD DA applies to the Southern Precinct Central Precinct Northern Precinct (the site) of the Waterloo Metro Quarter site. The site has an area of approximately 4830sqm 2,460sqm 5,120sqm. The subject site comprises the following allotments and legal description at the date of this report.

Southern Precinct DA

- 130–134 Cope Street (Lot 12 DP 399757) (Part)
- 136–144 Cope Street (Lots A-E DP 108312) (Part)
- 93–101 Botany Road (Lot 1 DP 433969 and Lot 1 DP 738891) (Part)
- 156–160 Cope Street (Lot 31 DP 805384)

- 107–117A Botany Road (Lot 32 DP 805384 and Lot A DP 408116)
- 119 Botany Road (Lot 1 DP 205942 and Lot 1 DP 436831)
- 170–174 Cope Street (Lot 2 DP 205942).

Central Precinct DA

- 130–134 Cope Street (Lot 12 DP 399757) (Part)
- 136–144 Cope Street (Lots A-E DP 108312) (Part)
- 85 Botany Road (Lot 1 DP 27454)
- 87 Botany Road (Lot 2 DP 27454)
- 89–91 Botany Road (Lot 1 DP 996765)
- 93–101 Botany Road (Lot 1 DP 433969 and Lot 1 DP 738891) (Part).

Northern Precinct DA

- 1368 Raglan Street (Lot 4 DP 215751)
- 59 Botany Road (Lot 5 DP 215751)
- 65 Botany Road (Lot 1 DP 814205)
- 67 Botany Road (Lot 1 DP 228641)
- 124–128 Cope Street (Lot 2 DP 228641)
- 69–83 Botany Road (Lot 1, DP 1084919)
- 130–134 Cope Street (Lot 12 DP 399757).

The boundaries of the overall site are identified at Figure 1, and the subject site of the detailed SSD DA is identified at Figures 2 and 3. The site is reasonably flat with a slight fall to the south.

The site previously included three to five storey commercial, light industrial and shop top housing buildings. All previous structures except for an office building at the corner of Botany Road and Wellington Street have been demolished to facilitate construction of the new Sydney Metro Waterloo station. As such the existing site is predominately vacant and being used as a construction site. Construction of the Sydney metro is currently underway on site in accordance with critical State significant infrastructure approval (CSSI 7400).

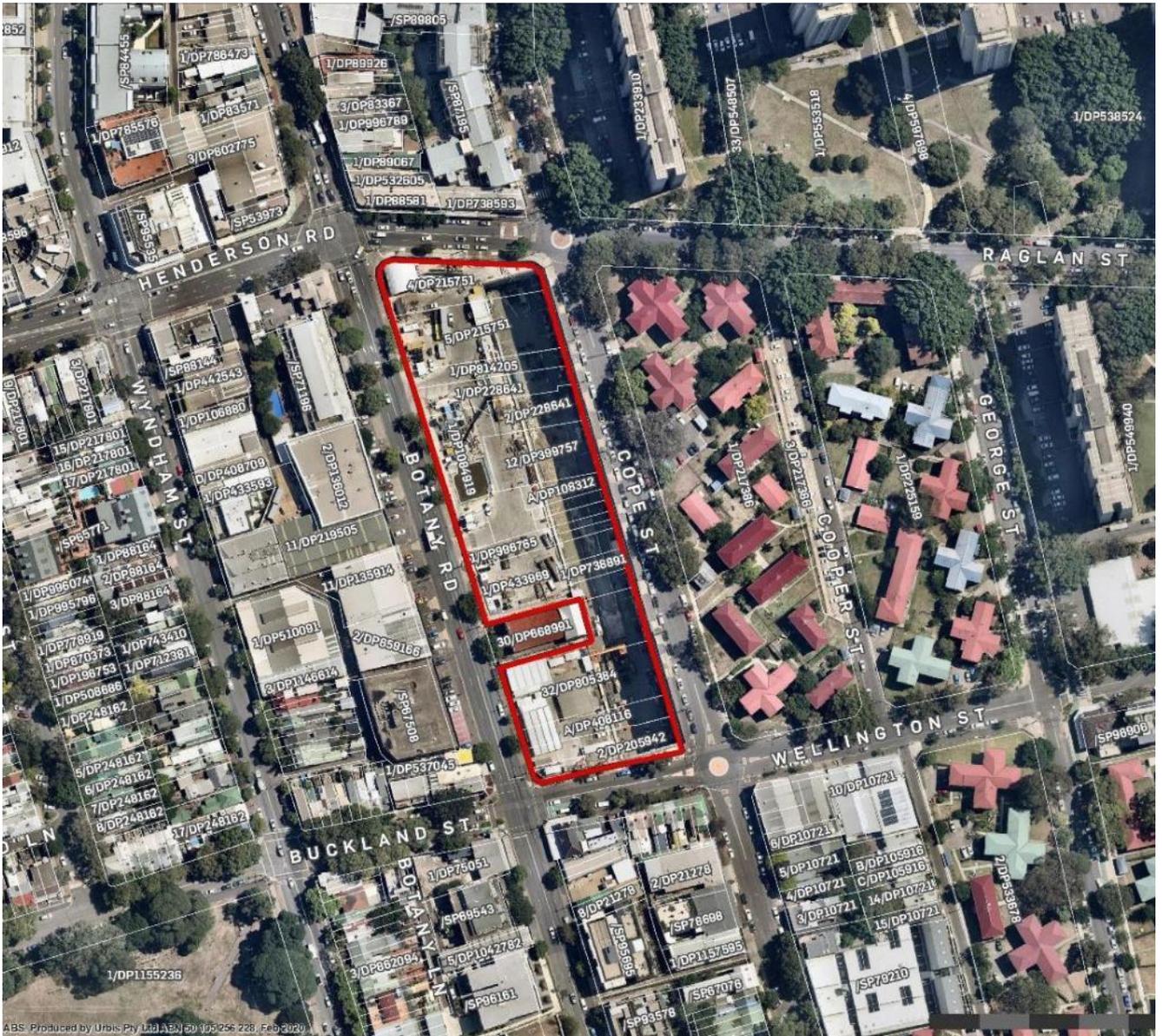


Figure 1 - Aerial image of the site
Source: Urbis

The area surrounding the site consists of commercial premises to the north, light industrial and mixed-use development to the south, residential development to the east and predominantly commercial and light industry uses to the west.

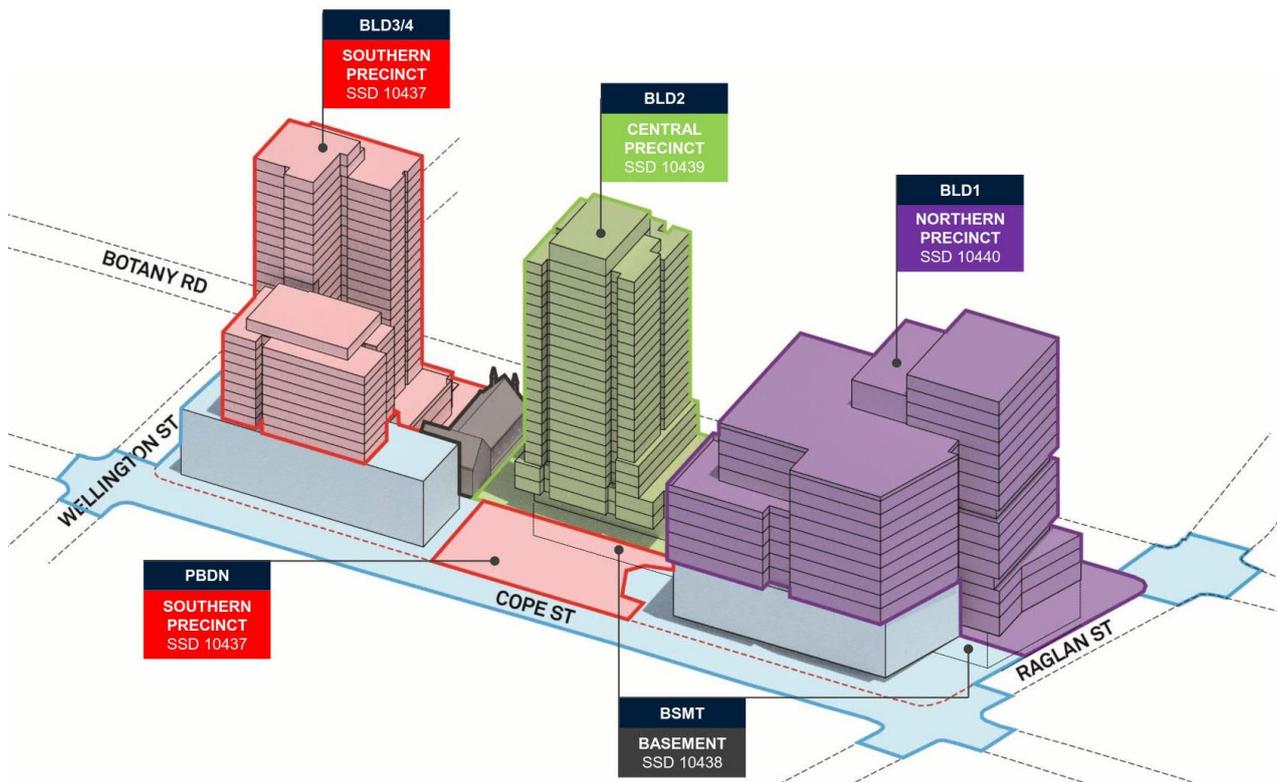


Figure 2 - Waterloo Metro Quarter site, with sub-precincts identified
Source: HASSELL

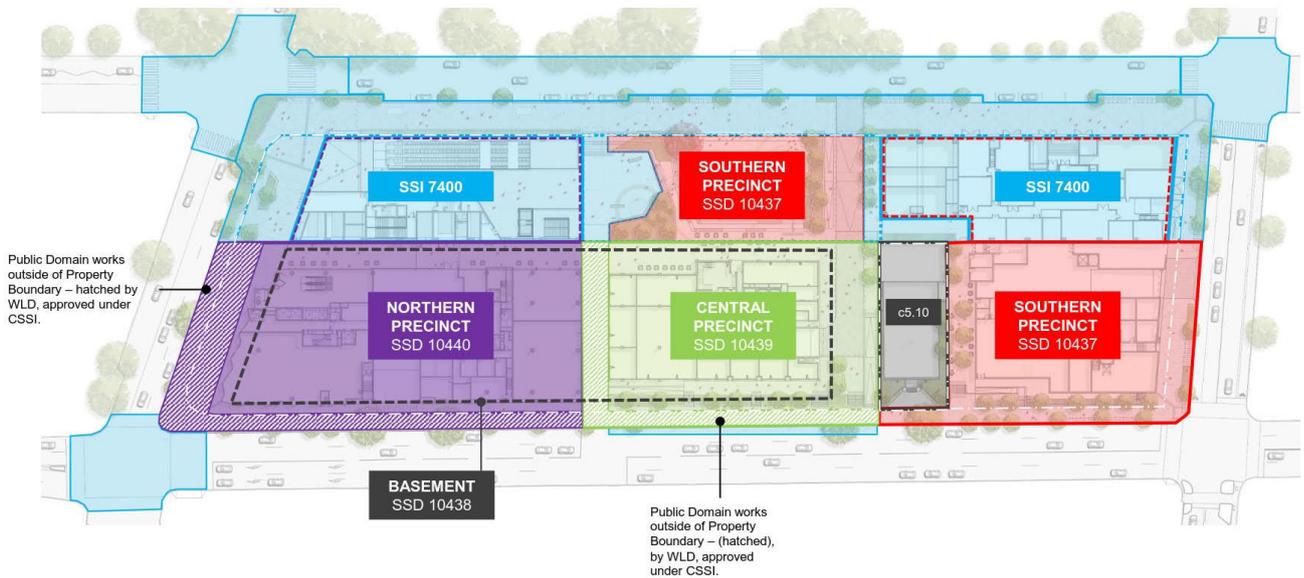


Figure 3 - Waterloo Metro Quarter site, with sub-precincts identified
Source: Waterloo Developer Pty Ltd

5. Background

5.1 About Sydney Metro

Sydney Metro is Australia's biggest public transport project. Services started in May 2019 in the city's North West with a train every four minutes in the peak. A new standalone railway, this 21st century network will revolutionise the way Sydney travels.

There are four core components:

5.1.1 Sydney Metro North West

This project is now complete and passenger services commenced in May 2019 between Rouse Hill and Chatswood, with a metro train every four minutes in the peak. The project was delivered on time and \$1 billion under budget.

5.1.2 Sydney Metro City & Southwest

Sydney Metro City & Southwest project includes a new 30km metro line extending metro rail from the end of Metro Northwest at Chatswood, under Sydney Harbour, through new CBD stations and southwest to Bankstown. It is due to open in 2024 with the ultimate capacity to run a metro train every two minutes each way through the centre of Sydney.

Sydney Metro City & Southwest will deliver new metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and new underground metro platforms at Central Station. In addition, it will upgrade and convert all 11 stations between Sydenham and Bankstown to metro standards.

5.1.3 Sydney Metro West

Sydney Metro West is a new underground railway connecting Greater Parramatta and the Sydney CBD. This once-in-a-century infrastructure investment will transform Sydney for generations to come, doubling rail capacity between these two areas, linking new communities to rail services and supporting employment growth and housing supply between the two CBDs.

The locations of seven proposed metro stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays.

The NSW Government is assessing an optional station at Pyrmont and further planning is underway to determine the location of a new metro station in the Sydney CBD.

5.1.4 Sydney Metro Greater West

Metro rail will also service Greater Western Sydney and the new Western Sydney International (Nancy Bird Walton) Airport. The new railway line will become the transport spine for the Western Parkland City's growth for generations to come, connecting communities and travellers with the rest of Sydney's public transport system with a fast, safe and easy metro service.

The Australian and NSW governments are equal partners in the delivery of this new railway.

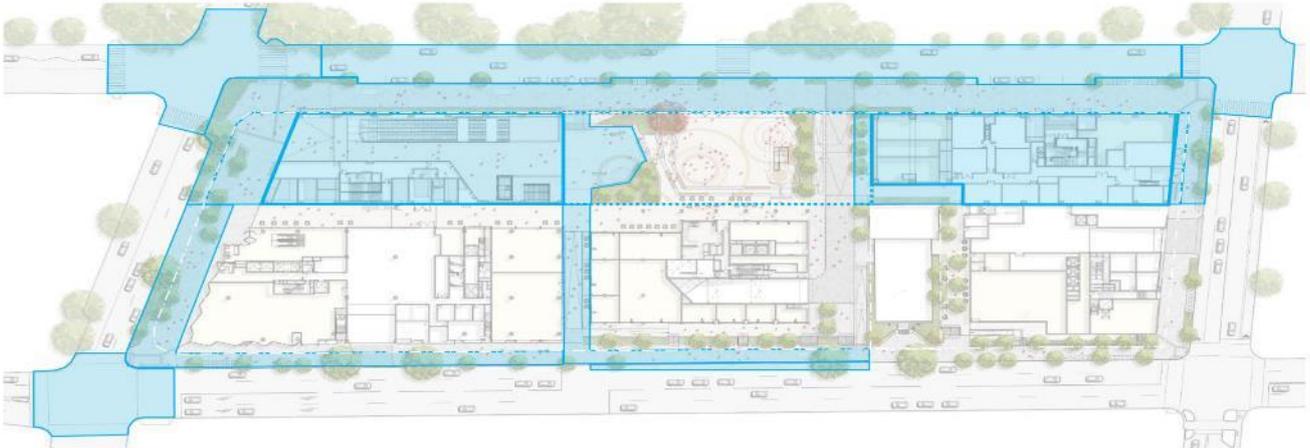


Figure 5 - CSSI Approval scope of works
Source: WL Developer Pty Ltd

5.3 Concept Approval (SSD 9393)

As per the requirements of clause 7.20 of the *Sydney Local Environmental Plan 2012 (SLEP)*, as the OSD exceeds a height of 25 metres above ground level (among other triggers), development consent is first required to be issued in a concept DA (formerly known as Stage 1 DA).

Development consent was granted on 10 December 2019 for the concept SSD DA (SSD 9393) for the Waterloo Metro Quarter OSD including:

- a maximum building envelope for podium, mid-rise and tower buildings
- a maximum gross floor area of 68,750sqm, excluding station floor space
- conceptual land use for non-residential and residential floor space
- minimum 12,000sqm of non-residential gross floor area including a minimum of 2,000sqm of community facilities
- minimum 5% residential gross floor area as affordable housing dwellings
- 70 social housing dwellings
- basement car parking, motorcycle parking, bicycle parking, and service vehicle spaces.

The detailed SSD DA seeks development consent for the OSD located within the Southern Precinct Central Precinct Northern Precinct of the site, consistent with the parameters of this concept approval. Separate SSD DAs have been prepared and will be submitted for the Basement Car Park proposed across the Waterloo Metro Quarter site.

A concurrent amending concept SSD DA has been prepared and submitted to the DPIE which proposed to make modifications to the approved building envelopes at the northern precinct and central building. This amending concept SSD DA does not impact the proposed development within the southern precinct.

6. Proposed development

6.1 Waterloo Metro Quarter Development

The Waterloo Metro Quarter OSD comprises four separate buildings, a basement carpark and public domain works adjacent to the Waterloo Metro station.

Separate SSD DAs will be submitted concurrently for the design, construction and operation of each building in the precinct;

- Southern precinct SSD-10437,
- Basement Car Park SSD-10438,
- Central precinct SSD-10439, and
- Northern precinct-SSD-10440.

An overview of the Development is included below for context. This detailed SSD DA seeks development consent for the design, construction and operation of the Southern Precinct, Central Precinct, and Northern Precinct:

6.1.1 Southern Precinct [Subject DA]

The Southern Precinct comprises:

- 25-storey residential building (Building 3) comprising student accommodation, to be delivered as a mixture of studio and twin apartments with approximate capacity of 474 students
- 9 storey residential building (Building 4) above the southern station box to accommodate 70 social housing dwellings
- ground level retail tenancies including Makerspace and gymnasium lobby, and loading facilities
- level 1 and level 2 gymnasium and student accommodation communal facilities
- landscaping and private and communal open space at podium and roof top levels to support the residential accommodation
- new public open space including the delivery of the Cope Street Plaza, including vehicle access to the site via a shared way from Cope Street, expanded footpaths on Botany and Wellington Streets and public domain upgrades
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

6.1.2 Basement Car Park

The Basement Car Park comprises:

- 2-storey shared basement car park and associated excavation comprising
- Ground level structure
- Carparking for the Commercial Building 1, Residential Building 2, social housing Building 4, Waterloo Congregational Church and Sydney Metro
- Service vehicle bays

- commercial end of trip and bicycle storage facilities
- Retail end of trip and bicycle storage facilities
- residential storage facilities
- shared plant and services.

6.1.3 Central Precinct [Subject DA]

The Central Precinct comprises:

- 24-storey residential building (Building 2) comprising approximately 126 market residential and 24 affordable housing apartments, to be delivered as a mixture of 1 bedroom, 2 bedroom and 3 bedroom apartments
- Ground level retail tenancies, community hub, precinct retail amenities and basement car park entry
- level 1 and level 2 community facilities (as defined in the SLEP) intended to be operated as a childcare centre
- landscaping and private and communal open space at roof top levels to support the residential accommodation
- new public open space including the delivery of the Church Square, including vehicle access to the basement via a shared way from Cope Street, expanded footpaths and public domain upgrades on Botany Road
- external licensed seating areas
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

6.1.4 Northern Precinct [Subject DA]

The Northern Precinct comprises:

- 17-storey commercial building (Building 1) comprising Commercial floor space, with an approximate capacity of 4000 workers
- ground level retail tenancies, loading dock facilities serving the northern and central precinct including Waterloo metro station
- landscaping and private open space at podium and roof top levels to support the commercial tenants
- new public open space including the delivery of the Raglan Street Plaza, Raglan Walk and expanded footpaths on Raglan Street and Botany Road and public domain upgrades
- external licensed seating areas
- signage zone locations
- utilities and service provision
- stratum subdivision (staged).

7. Methodology

RWDI Anemos Ltd. (RWDI) was retained to study the potential wind conditions for the pedestrian accessible areas within and around the subject site associated with the addition of the proposed development, and to provide recommendations to minimise adverse effects, if needed. This quantitative assessment was based on wind speed measurements on a scale model of the subject development and its surroundings in one of RWDI's boundary-layer wind tunnels. These measurements were combined with the local wind records and compared to the wind comfort criteria required for the precinct, outlined in B13 – Wind Impact Assessment, of the conditions of consent for the concept SSD DA (SSD 9393). This notes the required wind comfort and wind speeds for safety in the pedestrian accessible areas. The assessment focused on critical pedestrian areas, public sidewalks and elevated terrace areas.

7.1 Wind Tunnel Study Model

To assess the wind environment around the proposed development, a 1:400 scale model of the project site and surroundings was constructed to be used for the wind tunnel tests of the following 2 configurations:

- Amended DA Envelope Design Scheme (Figure 6);
- Detailed Design Scheme (Figure 7);

Consideration has also been made with regards to the existing wind conditions noted around the subject site as noted in the concept Application wind tunnel study.

The wind tunnel model included all relevant surrounding buildings and topography within an approximately 480 m radius of the study site. The upstream wind and turbulence profiles in the atmospheric boundary layer beyond the modelled area were also simulated in RWDI's wind tunnel. The wind tunnel model was instrumented with 138 specially designed wind speed sensors to measure mean and gust speeds at a full-scale height of approximately 1.5 m above local grade in pedestrian areas and on terraces within and around the study site. Wind speeds were measured for 36 directions in 10-degree increments. The measurements at each sensor location were recorded in the form of ratios of local mean and gust speeds to the mean wind speed at a reference height above the model. The placement of wind measurement locations was based on our experience and understanding of the pedestrian usage for this site.



Figure 6 – Wind Tunnel Study Model – Amended DA Envelope Design Scheme

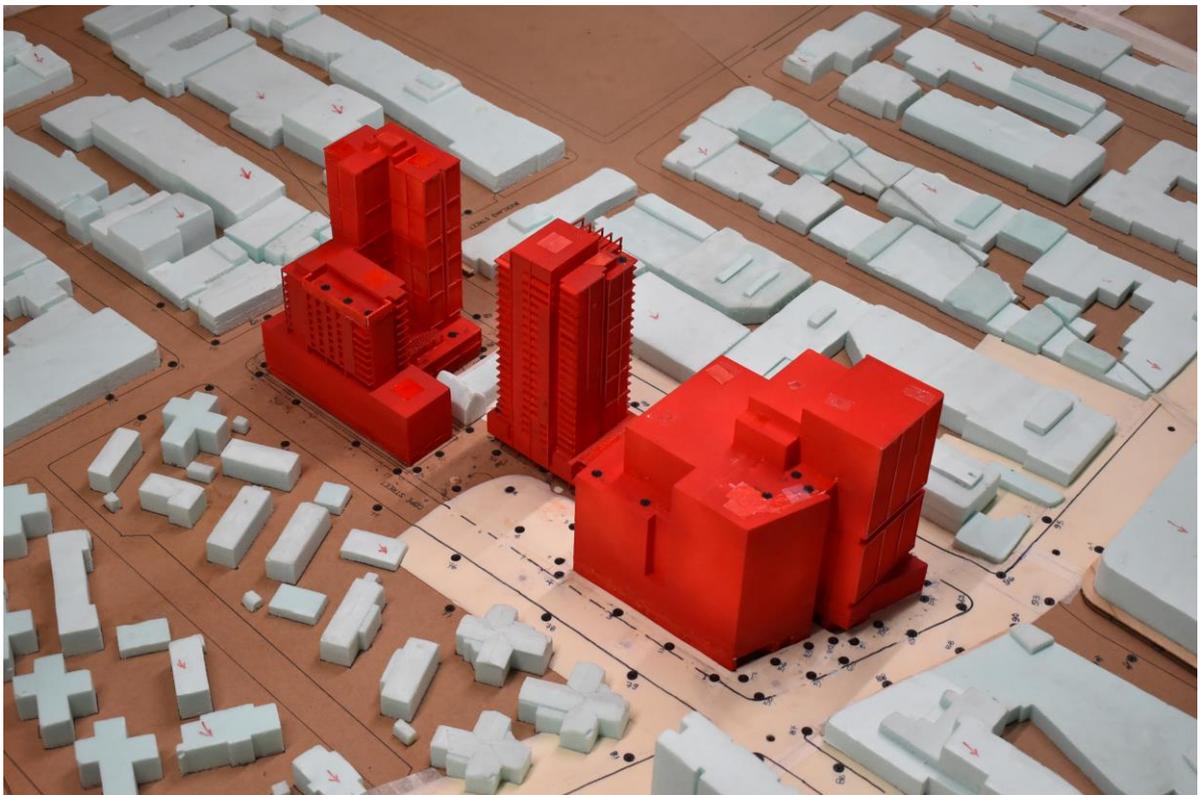


Figure 7 – Wind Tunnel Study Model – Detailed Design Scheme

7.2 Meteorological Data

Wind statistics recorded at Sydney International Airport between 1995 and 2019, inclusive, were analysed for the Summer (November through April) and Winter (May through October) seasons. Figure 8 graphically depicts the directional distributions of wind frequencies and speeds for these two seasons. Winds from the northeast, south-southeast and south are predominant in the summer season, and winds from the west and northwest directions are predominant in the winter season as indicated by the wind roses. Strong winds of a mean speed greater than 30 km/h measured at the airport (at an anemometer height of 10 m) occur for 10.6% and 8% of the time during the summer and winter seasons, respectively, and are predominantly from the southern directions in both seasons. Strong winds from the northeast are also common in the summer.

Wind statistics were combined with the wind tunnel data to predict the frequency of occurrence of full-scale wind speeds. The full-scale wind predictions were then compared with the wind criteria for pedestrian comfort and safety.

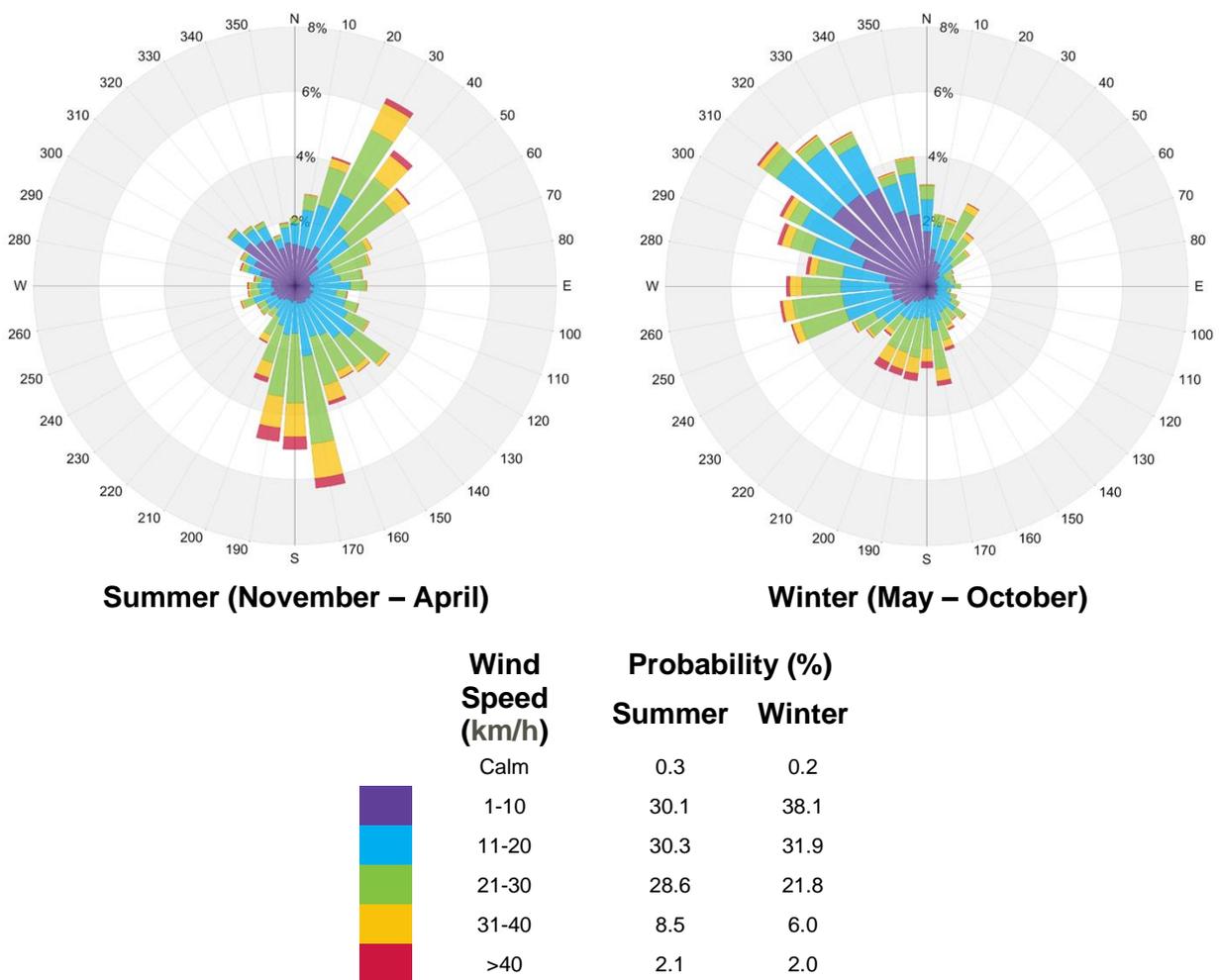


Figure 8 – Directional Distribution of Winds Approaching Sydney International Airport from 1995 to 2019

7.3 Pedestrian Wind Criteria

The pedestrian wind comfort and safety conditions are assessed based on the Lawson Criteria. In general, the combined effect of mean and gust speeds on pedestrian comfort can be quantified by a Gust Equivalent Mean (GEM).

Comfort Category	Mean/GEM Wind Speed (m/s)	Description
Pedestrian Sitting	≤ 4	Low wind speed where, for example, one could read a newspaper without having it blown away
Pedestrian Standing	≤ 6	Comfortable for standing for a short time of exposure at main building entrances, bus stops, and other places
Pedestrian Walking	≤ 8	Wind speeds that would be acceptable for window shopping or strolling along a downtown street

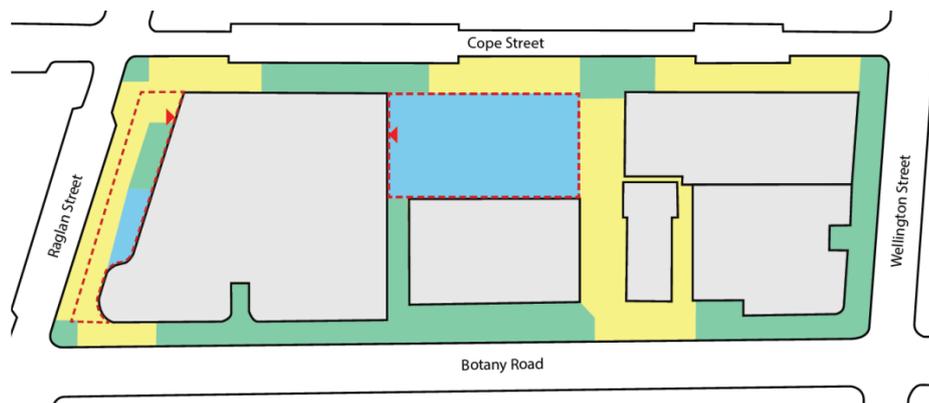
Notes:
 (1) GEM wind speed = gust speed / 1.85; and,
 (2) GEM wind speeds listed above are based on an exceedance of 5% of the time.

Safety Criterion	Gust Wind Speed (m/s)	Description
Wind Safety Standard	> 24	Excessive gust speeds that can adversely affect a pedestrian's balance and footing.

Notes:
 (1) Based on an annual exceedance of 0.1% of the time.

Table 3 – Pedestrian Wind Comfort Criteria

Based on the Development Consent approval for SSD8875, the wind conditions associated with the subject development are required to meet the comfort categories prescribed in the Lawson Criteria in the areas shown in Figure 9.



LEGEND

- Wind comfort standard for walking criteria of 8m/s (5% exceedance)
- Wind comfort standard for standing criteria of 6m/s (5% exceedance)
- Wind comfort standard for sitting criteria of 4m/s (5% exceedance)
- Publicly accessible open space

Figure 9 – Wind Comfort and Safety Targets for the Ground Level areas

7.3.1 Sydney Metro Entrance

Furthermore, requirements are noted by Sydney Metro with regards to anything that will or is likely to result in the Station Project Works, or any part of the Station Project Works, or the carrying out of the Station Project Works (whether on their own or combined with the MQD or the carrying out of the MQD Works), being unable to comply with the requirement set out below (Metro Impact):

Part A – Metro Impact Requirements notes in Table 1, under General Requirements, the following

Metro Impact Requirement
Wind effects in relation to Lawson Comfort Criteria for Business Walking Criteria (C1) at the station Entrance (note: Lawson Comfort Criteria are based on exceedance of the threshold wind speed occurring 5% of the time)

Table 4 – General Requirements for Metro Station Impacts

8. Results and Discussion

The predicted wind conditions are shown on site plans in Figures 10 through 18 located in section of the report. These conditions and the associated wind speeds are also presented in Table 5, located in this section of the report.

The following is a detailed discussion of the suitability of the predicted wind conditions for the anticipated pedestrian use of each area of interest. This includes reference to the noted wind comfort criteria outlined in Section 8.3.

All initial wind tunnel testing has been carried out for the built form design only, without the inclusion of landscaping or wind mitigation elements such as awnings. This enables an initial understanding of the wind flow patterns and comfort conditions due to the built form of the development.

Initial testing of mitigation measures has been considered through the inclusion of building awnings, as detailed, and tree planting as outlined in the landscaping architectural drawing scheme. It should be noted that the trees have been modelled as young trees as expected at the time of their planting (4 m high with a 3 m wide canopy). The trees are noted to be able to grow to a height of 10-12 m with a 10 m wide canopy at maturity (in 10 years) and hence will continue to increase their ability to reduce wind conditions over time.

8.1 Ground Level Areas

Wind conditions for all of the ground level areas within and around the Waterloo Metro Precinct were noted to satisfy the safety limit criteria of 24 m/s. The majority of the ground level areas throughout the precinct are noted to satisfy the sitting or standing criteria throughout the year, with only 5 locations found to satisfy the walking criteria.

The following sections discuss the wind comfort conditions for each area of the precinct.

8.1.1 Surrounding Streets

Wind conditions around the surrounding street are required to satisfy walking conditions along Raglan Street, a mix of walking and standing conditions along Cope Street, standing conditions along Wellington Street and largely standing conditions along Botany Road, as outlined in Figure 9.

Raglan Street

The wind conditions along Raglan Street generally satisfy the standing comfort criteria throughout the year. Localised areas at the eastern and western ends of Raglan Street are exposed to the north-easterlies and westerly winds respectively, which interact with the built form resulting in conditions which satisfy the walking criteria. The inclusion of street trees in their initial state and awnings on the subject development is noted to further improve these conditions by helping to filter these winds directed along Raglan Street and reducing downwashed winds from the form above. As such the majority of the Raglan Street area will satisfy the standing criteria. A portion of the Raglan Plaza space is also noted to satisfy the sitting criteria during the summer months. Only one location at the corner of Raglan Street and Botany Road is noted to marginally exceed the standing criteria (94% of the time satisfy) during the summer months.

It is noted that as the tree planting along Raglan Street matures, the conditions will further improve, with a large number of locations satisfying the sitting criteria, especially during the cooler winter months, as noted in Figures 14 and 15.

Cope Street

Conditions along Cope Street generally benefit from shielding from the westerly and southerly winds by the subject development, however there is some exposure to the north-easterly winds, primarily at the corners due to localised side-stream effects. Conditions are generally found to satisfy the standing criteria along the length of the street with localised areas at the northern and southern ends of the precinct which satisfy walking conditions.

The inclusion of the street trees in their initial state along Cope Street was found to further enhance conditions, providing areas adjacent to Cope Street Plaza as well as both the northern and southern Metro Station boxes which satisfy the sitting criteria as the north-easterly winds are able to be broken down by these elements. Testing for the wind conditions undertaken with the trees in their mature state (Figures 14 and 15) indicates that a growing number of locations will satisfy the sitting criteria, with the remaining locations satisfying the standing criteria. Only the north-eastern corner of Raglan and Cope Street will satisfy the walking criteria, which is an existing wind condition.

Wellington Street

Wellington Street is exposed to the southerly winds, however it is also the narrow aspect of the site. While the central area of the site will satisfy the standing comfort criteria, the eastern corner will experience localised side-stream of the southerly and north-easterly winds and hence satisfies the walking criteria. The western corner is noted to experience uncomfortable conditions, which is due to the recessed colonnade along the Botany Road aspect, resulting in further increase in the local wind conditions.

The initial landscaping and awnings are detailed along Wellington Street, in particular near to the corner locations. As noted in Figures 12 and 13, conditions at the corner of Wellington Street and Botany Road will be able to satisfy standing conditions however closer to the building will satisfy the walking conditions. Areas along Wellington Street will satisfy standing conditions, while the area adjacent to the Building 4 lobby space will provide sitting conditions.

As the trees along Wellington Street mature, the conditions in the future will improve, primarily for the summer months of the year with most locations satisfying the sitting or standing criteria, as shown in Figures 14 and 15. Conditions at the south-western corner of Building 3 and along Wellington Street will be further improved, however limited by the alignment of the street to the prevailing westerly winter winds.

Botany Road

Wind Conditions along Botany Road will generally satisfy the standing comfort criteria, in line with the wind comfort targets. Localised uncomfortable conditions were observed at the corner of Botany Road and Raglan Street due to downwash and side-stream effects. It is noted that the inclusion of the awnings for the Northern, Central and Southern Precinct built forms along Botany Road as well as the tree planting detailed in the landscape plan, conditions will largely satisfy the standing or sitting criteria. Conditions at the entrance to Waterloo Congregational Church were found to satisfy the sitting criteria. Conditions for both Church Square and Church Yard are noted to generally satisfy the standing criteria throughout the year.

As the tree planting matures, conditions are noted to future improve, as detailed in Figures 14 and 15, with only localised spots not satisfying the sitting or standing criteria along Botany Road.

Waiting Areas at Bus Stops and Pedestrian Crossings

The key waiting areas around the site include the Bus Stop zone along Botany Road, adjacent to Building 2, as well as the four main pedestrian crossings at the corners of the precinct. Wind conditions due to the built form and prior to consideration for any mitigation measures, the bus stop zone along Botany Road is noted to generally satisfy the standing criteria, while the pedestrian crossing areas are noted to satisfy the walking criteria.

The inclusion of the noted awning elements on the building designs and street tree planting noted in the landscape design plan resulted in the entire bus stop zone as well as the pedestrian crossing areas satisfying the standing criteria as outlined in the Waterloo Metro Quarter Design and Amenity Guidelines document. Furthermore, areas for the bus stop waiting zone will also satisfy the sitting criteria conditions.

Surrounding Footpaths

Wind Conditions on the pedestrian footpaths opposite the subject development along Botany Road, Cope Street, Raglan Street and Wellington Street were found to generally satisfy the standing criteria. Localised areas of walking criteria were noted at the southern end of Cope Street, central area of Wellington Street, northern end of Botany Road and to the east on Raglan Street. Existing street trees are located in this area however have not been included as part of the wind tunnel study as these are outside the control of the development. Conditions similar to standing would be expected in these locations if these existing trees were to be modelled.

Testing with the inclusion of the trees in their mature form, as well as the nearby trees along Cope Street (as noted in Figures A-7 and A-8), indicates that conditions are further improved with only localised conditions now satisfying the walking criteria.

8.1.2 Cope Street Plaza

Cope Street Plaza is noted to generally satisfy the standing criteria without the consideration of landscaping within the plaza. Some localised areas at the southern end of the plaza satisfy the walking criteria which is in line with the wind comfort standards outlined in Figure 9. Areas adjacent to Building 2 where outdoor seating is noted to be proposed will satisfy the sitting criteria throughout the year without any mitigation measures. Consideration has been made for the inclusion of landscaping in the form of trees at the southern and northern ends of the plaza, with slightly more mature trees along Cope Street. These are noted to ensure that conditions throughout the entire Cope Street Plaza will satisfy either the standing or sitting criteria throughout the year. This includes areas adjacent to Building 2 where seating areas are proposed in the landscape design.

Currently over 30% of the Cope Street Plaza area achieves sitting conditions throughout the year, noting the modelling considered tree planting at an immature state. The majority of the plaza (over 60%) was found to achieve sitting conditions for 90% or more of the time with the northern portion found to be slightly more beneficial during the winter period due to the shielding from the prevailing westerly winds. It should be noted that the wind tunnel modelling does not include the raised planters or moulded soil elements within Cope Street Plaza landscape design. These elements will further enhance localised wind conditions for the adjacent seating areas within Cope Street Plaza.

Locations adjacent to the southern east-west walkway between Cope Street and Botany Road are more exposed to the southerly and westerly winds given their location and hence achieve the sitting criteria around 80-85% of the year. The raised planter bed at the southern end of the plaza space will provide further wind protection to the noted bench seating in the landscape design.

Given the need for a large central open area of the plaza which will be exposed to direct sunlight, it should be noted that some wind flow, especially during the warmer months of the year will be beneficial as this will assist with overall thermal comfort in this plaza area, which is a more true account of human comfort.

An under-croft area is proposed along the eastern aspect of Building 2 connecting to Cope Street Plaza. Testing for the wind conditions in this region, which will be used for retail seating space was found to satisfy the sitting criteria throughout the year without the need for any mitigation measures being included as part of the design. This is due to the built form and positioning of the towers on the site.

Modelling of the trees within Cope Street Plaza in their mature state indicates that at least 50% of the locations will satisfy the sitting comfort criteria. More than 50% is noted during the cooler winter months when winds can have an unwanted cooling effect.

8.1.3 Laneways (Raglan Walk and Grit Lane)

Raglan Walk

Wind conditions within Raglan Walk (linking Raglan Street to Cope Street Plaza) are able to benefit from the alignment of the laneway in the north-south direction and self-shielding by the development. The northern end of the laneway is exposed to the north-easterly winds causing a pressure driven flow through the laneway which will generally occur during the summer months of the year when these winds are more prevalent.

Conditions within the laneway are more favourable during the winter period, with shielding from the westerly winds. As such conditions equivalent to standing and sitting will be provided for patrons. These conditions are generally unchanged as the landscaping matures, given their location outside of this area.

Grit Lane

Grit Lane (linking Botany Road and Cope Street Plaza between Buildings 1 and 2) is exposed to the westerly winds, primarily during the winter months, which has been noted during the concept design phase. This is due to the funnelling of these winds and pressure different between the western and eastern ends of the laneway.

During the summer months, the southerly winds are more influential, hence the inclusion of the noted awnings on Building 1 and landscape plan in Cope Street Plaza and along Botany Road will enhance conditions within the laneway providing standing conditions for pedestrians.

During the winter months, conditions are noted to be marginally uncomfortable (satisfying walking conditions 94% of the time). The inclusion of the awnings along Building 2 and trees planting at the Botany Road end of the laneway are noted to enable walking conditions at the western end of the laneway, reducing to standing conditions further to the east within the laneway.

These conditions are generally unchanged as the landscaping matures, given their location outside of this area.

8.1.4 Metro Station Entrances

The Metro Station was modelled for the Detailed Design with the inclusion of the open through link from Raglan Street to Cope Street Plaza, to ensure any funnelling effect was captured. The results indicate that conditions at the Raglan Street entrance will satisfy the standing criteria throughout the year.

The southern entrance to Cope Street Plaza will satisfy the standing criteria for patron comfort. The noted street trees on Cope Street will provide further improvement for the conditions associated with the ramp and stair access to Cope Street, provide areas suitable for sitting.

Conditions therefore will satisfy the Sydney Metro Entrance requirement for wind comfort of Business Walking conditions.

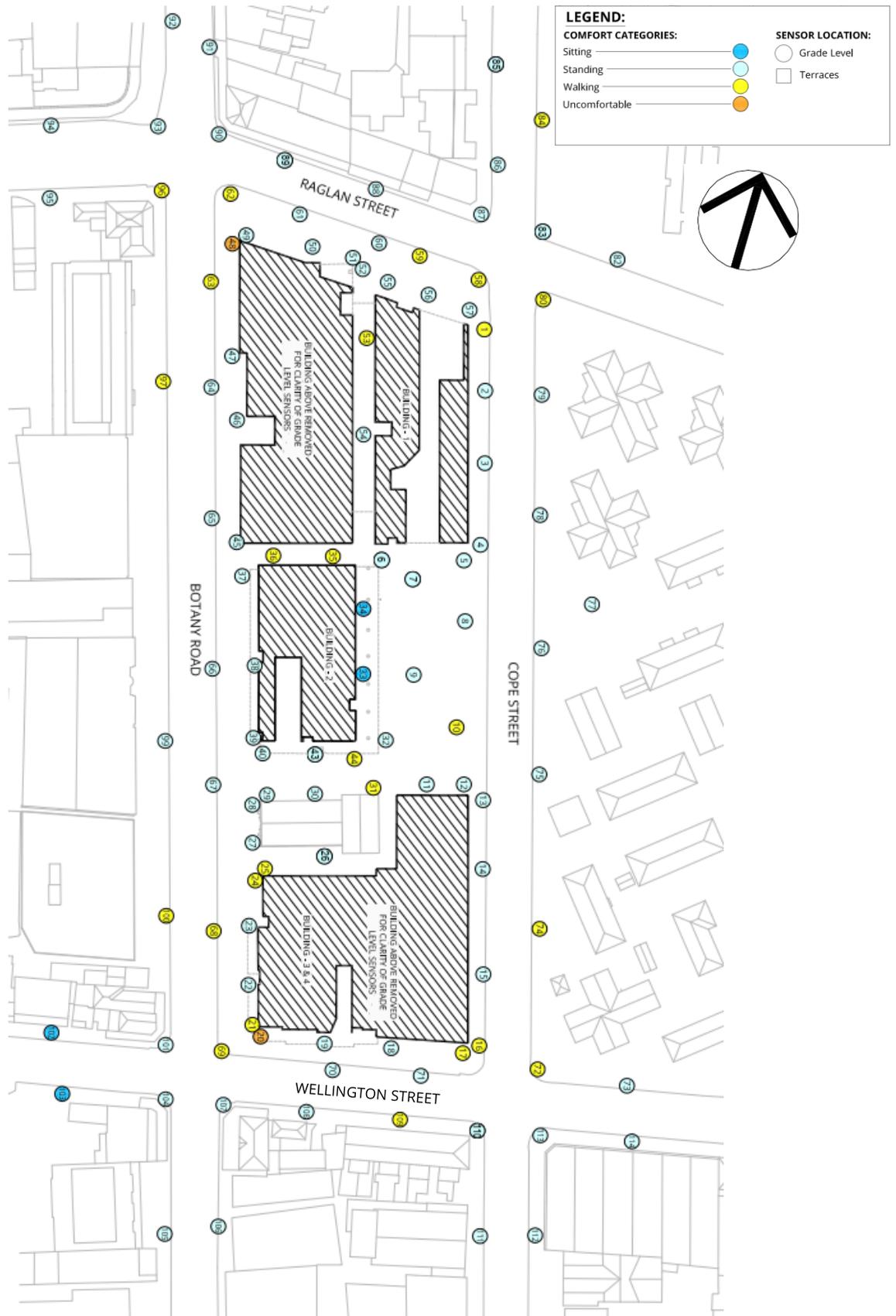


Figure 10 – Detailed Design Ground Level Wind Comfort Results – Summer Period

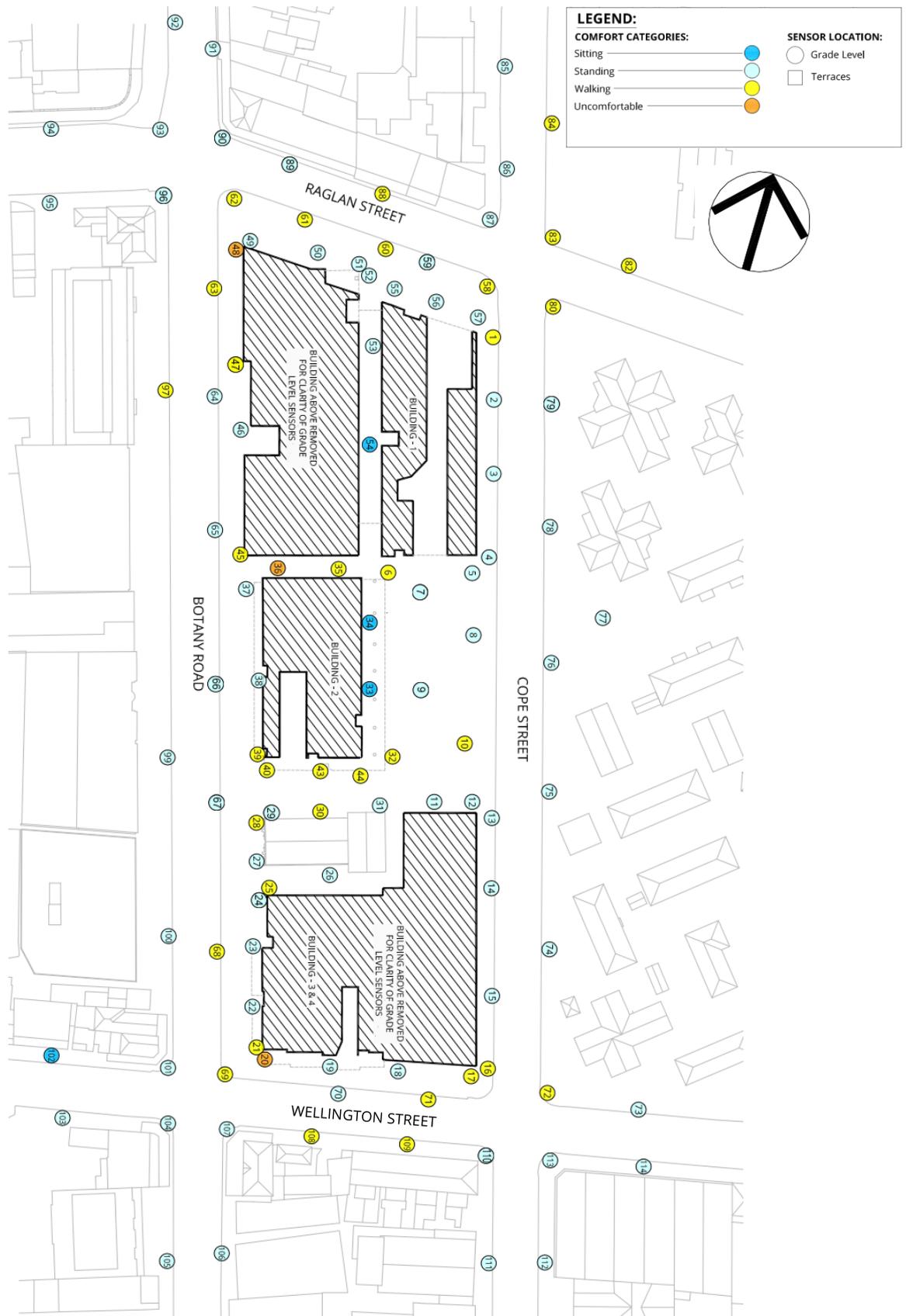


Figure 11 – Detailed Design Ground Level Wind Comfort Results – Winter Period

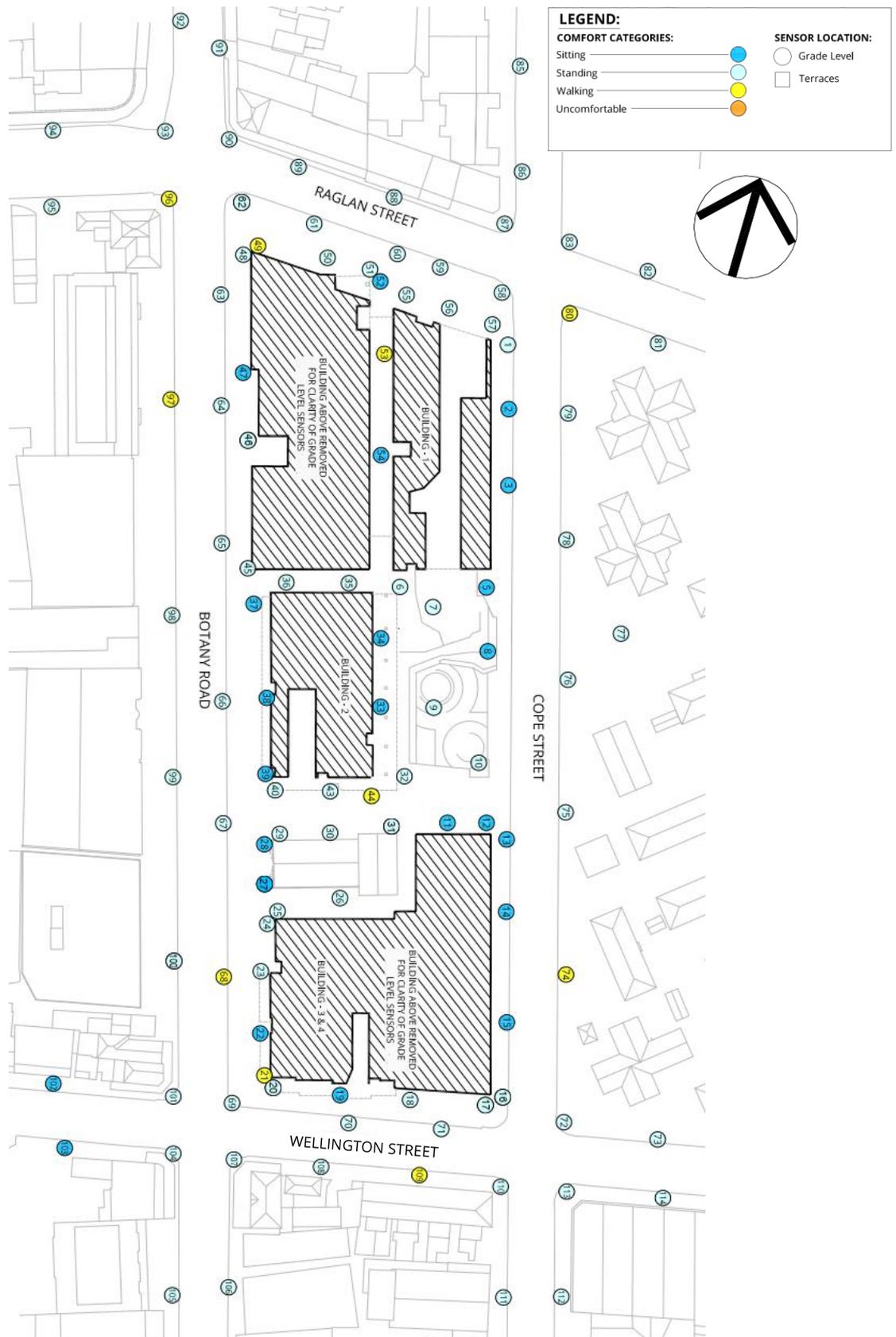


Figure 12 – Detailed Design, including Initial Mitigation, Ground Level Wind Comfort Results – Summer Period

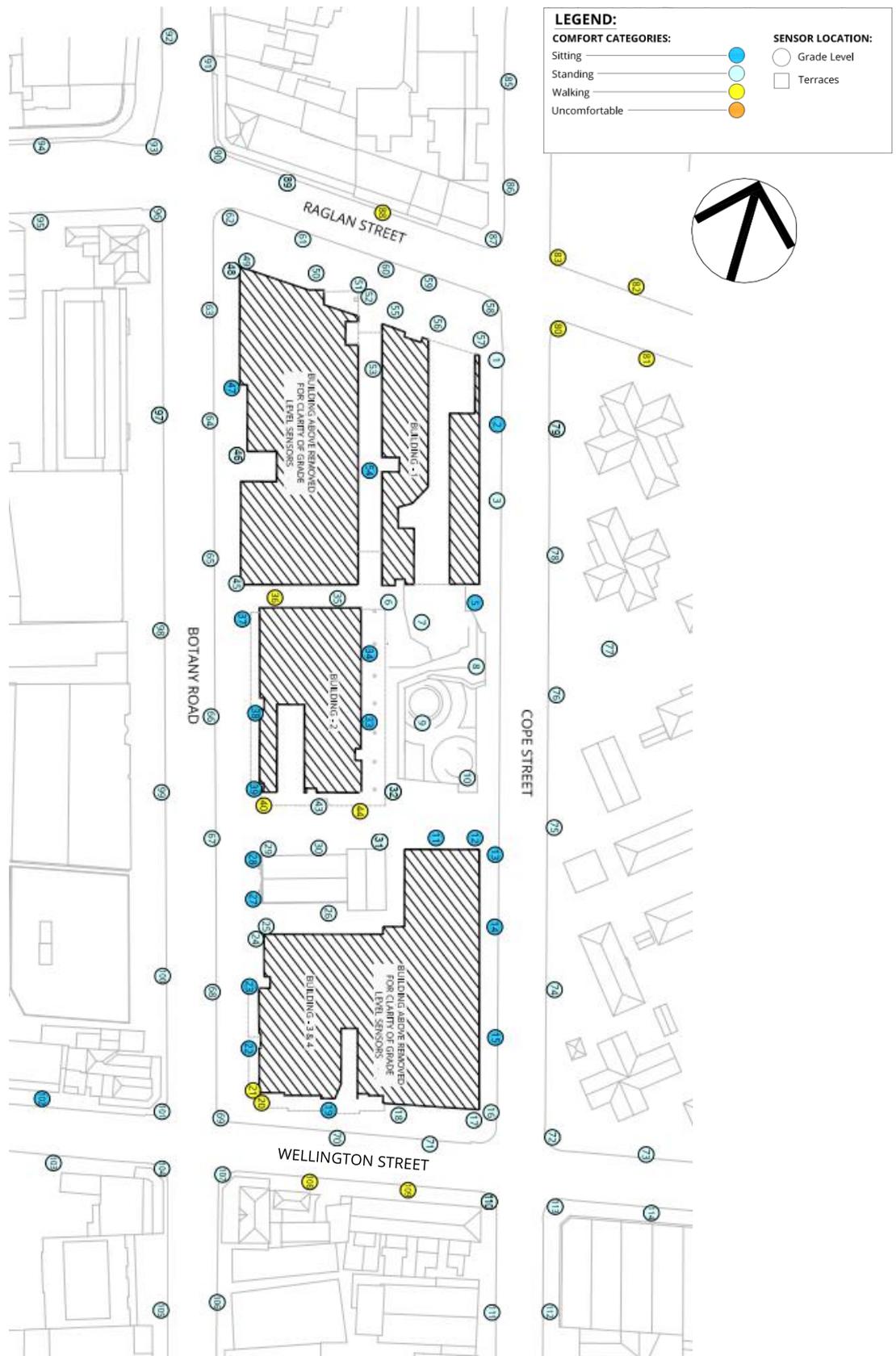


Figure 13 – Detailed Design, including Initial Mitigation, Ground Level Wind Comfort Results – Winter Period

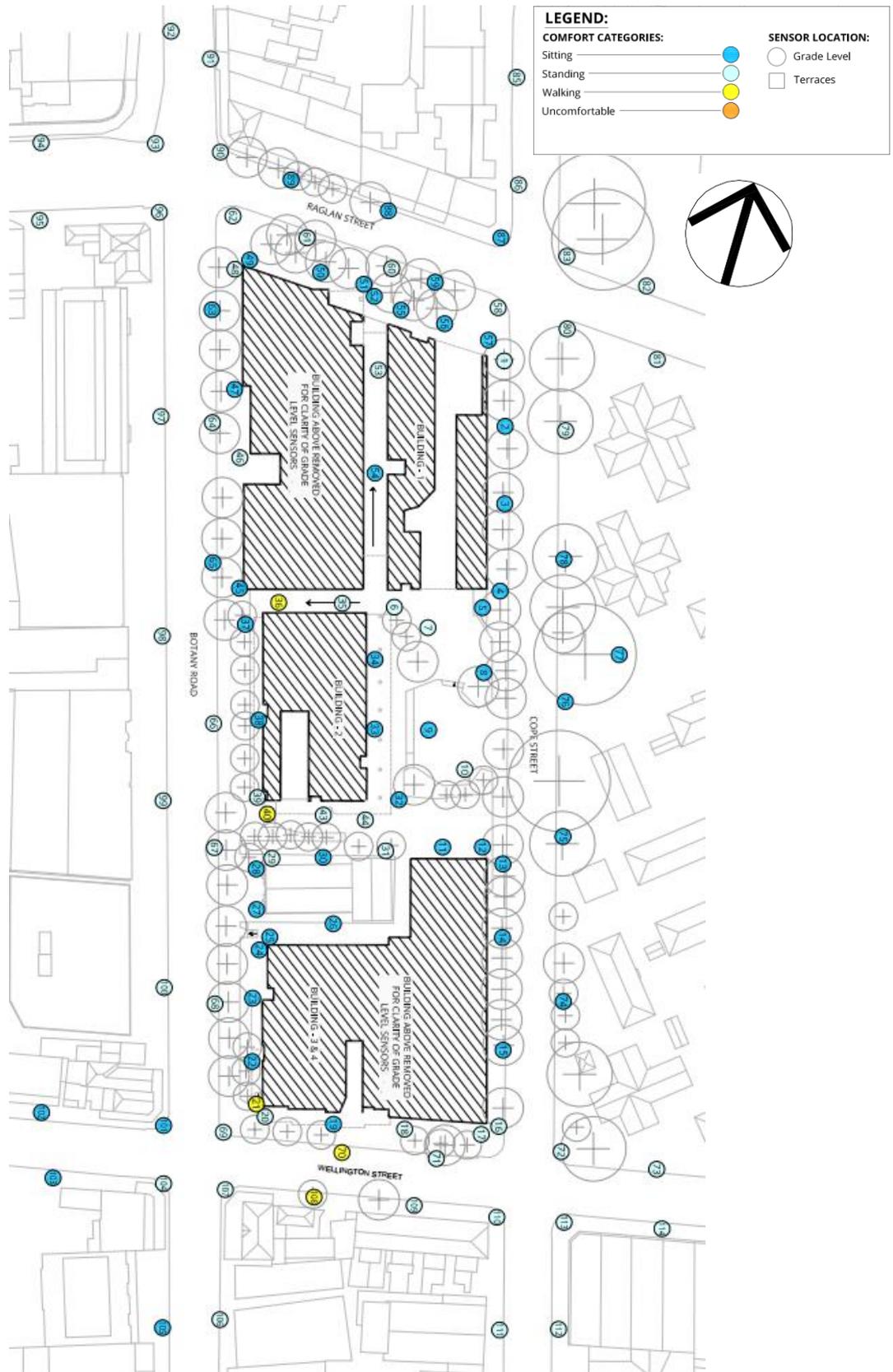


Figure 14 – Detailed Design, including Mature Mitigation, Ground Level Wind Comfort Results – Summer Period

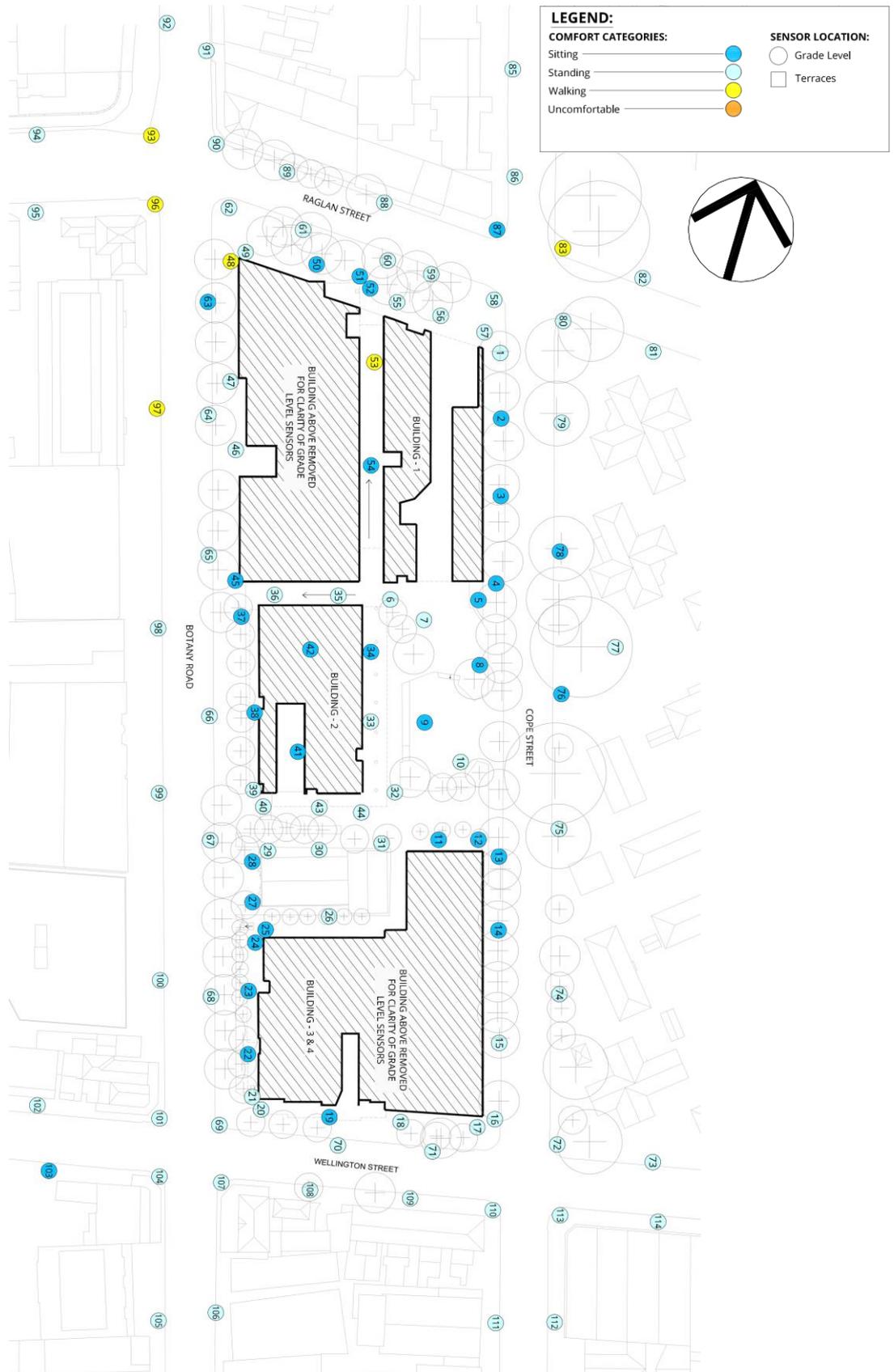


Figure 15 – Detailed Design, including Mature Mitigation, Ground Level Wind Comfort Results – Winter Period

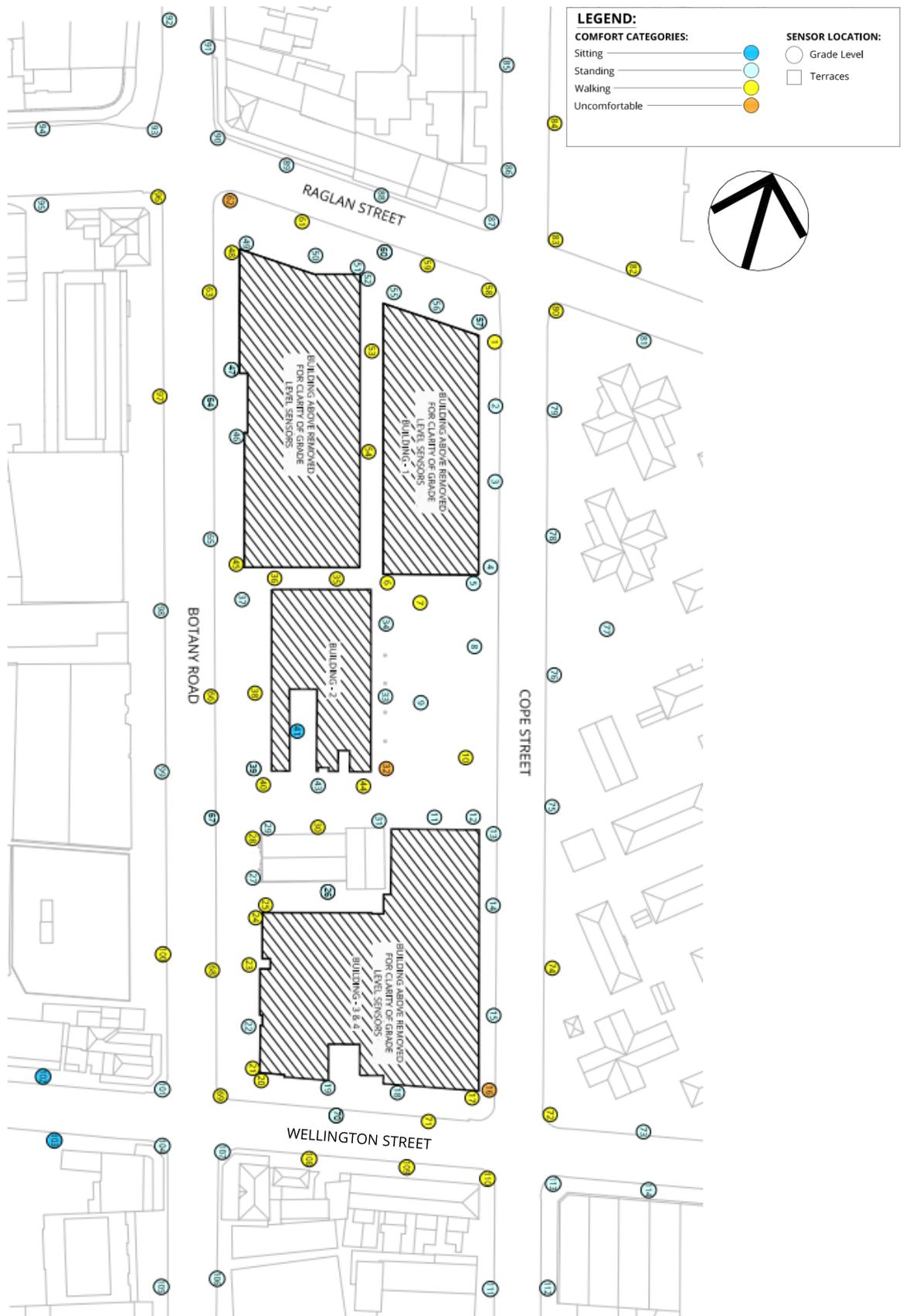


Figure 16 – Amended Design Ground Level Wind Comfort Results – Annual

8.2 Elevated Outdoor Areas

8.2.1 Building 1 (Northern Precinct)

The rooftop terrace areas located on Levels 9 and 13 of Building 1 are generally exposed to the prevailing winds given the elevated location of these terraces.

Level 9 is expected to experience uncomfortable wind conditions throughout the year with impact from the southerly and westerly winds. Testing was therefore undertaken with the inclusion of screening (1.8m in height) along the perimeter of the two terrace spaces. The south-eastern corner terrace was generally found to experience conditions suitable for standing or sitting, while the corner area was suitable for walking due to localised side-stream effects. The south-western terrace was found to have areas suitable for standing on the western aspect, however conditions for walking on the southern area and uncomfortable conditions for parts of the year at the corner were found. This was due to the westerly winds impacting this area. The south-western terrace area has been changed to a non-trafficable location and as such no treatment measures have been considered for this location.

The Level 13 rooftop terrace is somewhat exposed to the north-easterly and southerly winds, however benefited from shielding of the westerly winds. The expected localised screening around the perimeter of the terrace space will help to ensure that standing conditions are provided throughout the year.

8.2.2 Building 2 (Central Precinct)

An outdoor childcare space is noted on Level 1 and 2 on the northern aspect of Building 2. Early testing had indicated that this area could be exposed to the prevailing winds. As such the current design has included screening around the perimeter of the outdoor space as well as hit-and-miss rooftop canopy elements. This will help to ensure that conditions will satisfy the sitting and standing conditions throughout the year, being suitable for the intended childcare facility.

The rooftop terrace on Level 22 is noted to generally be suitable for walking conditions in the summer months with the majority of the area suitable for standing during the winter period. Landscaping in the form of hedges planting is noted to be proposed throughout this space which will provide further wind mitigation for users.

8.2.3 Buildings 3 and 4 (Southern Precinct)

The terrace space on Level 2 of Building 3 and Level 14 of Building 4 benefit from significant shielding from the subject development and localised porous screening around the terrace space respectively. As such both areas are expected to experience conditions equivalent to standing or better throughout the year. Any noted landscaping for these spaces will only further enhance conditions.

LEGEND:

COMFORT CATEGORIES:

- Sitting ●
- Standing ●
- Walking ●
- Uncomfortable ●

SENSOR LOCATION:

- Grade Level
- Terraces

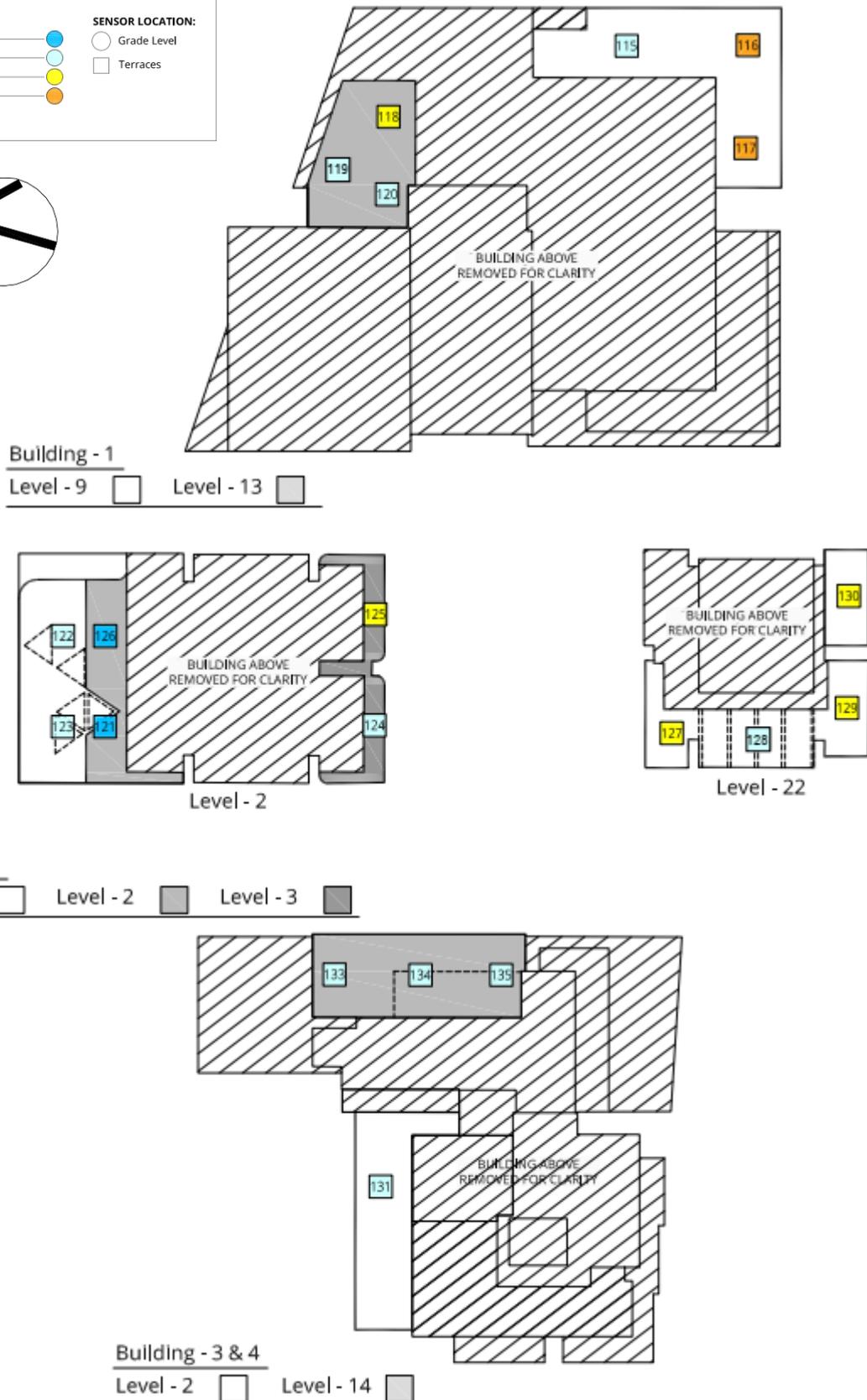
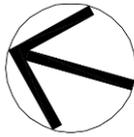


Figure 17 – Detailed Design Terrace Areas Wind Comfort Results – Summer Period

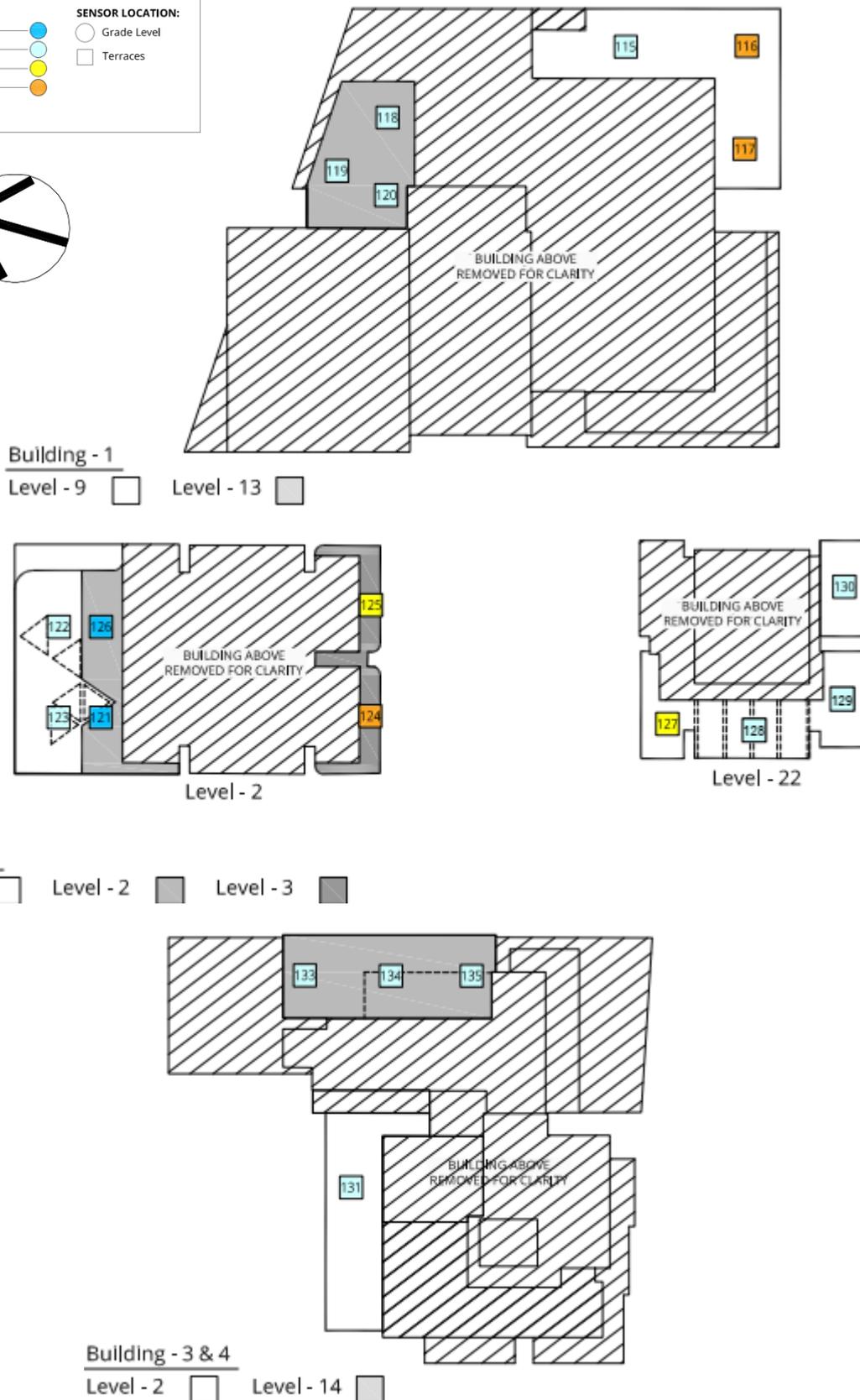
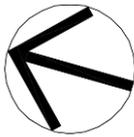


Figure 18 – Detailed Design Terrace Areas Wind Comfort Results – Winter Period

LEGEND:

COMFORT CATEGORIES:

- Sitting ●
- Standing ●
- Walking ●
- Uncomfortable ●

SENSOR LOCATION:

- Grade Level
- Terraces

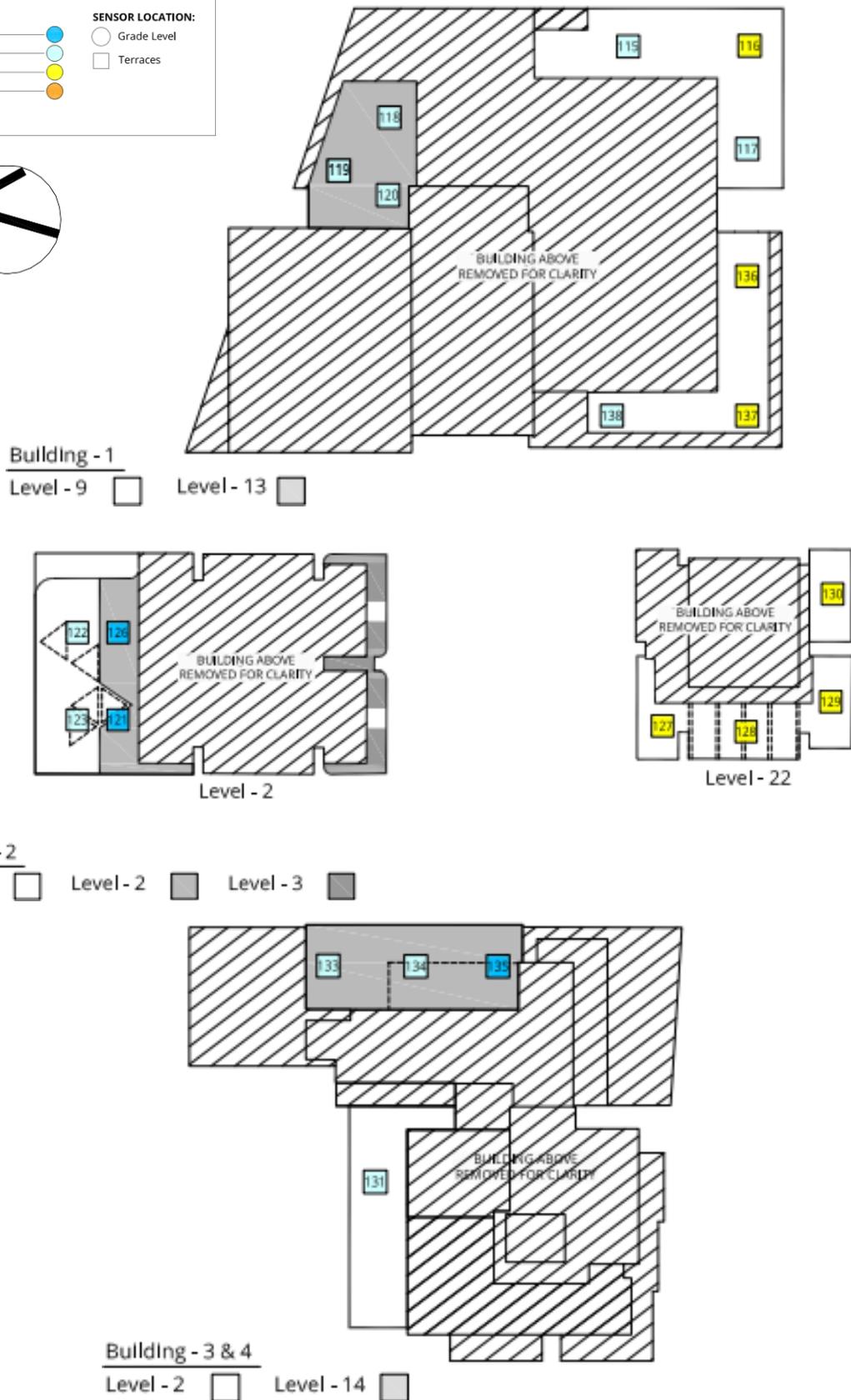
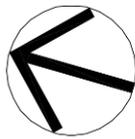


Figure 19 – Detailed Design, including Mitigation, Terrace Areas Wind Comfort Results – Summer Period

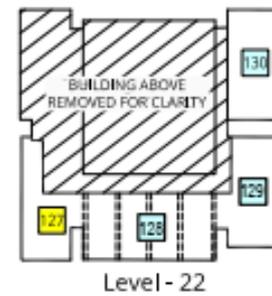
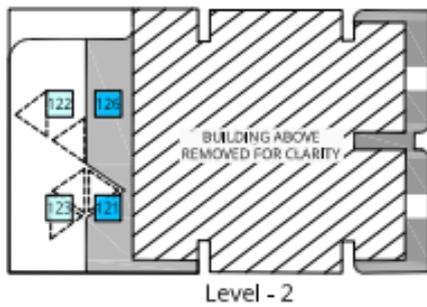
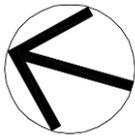
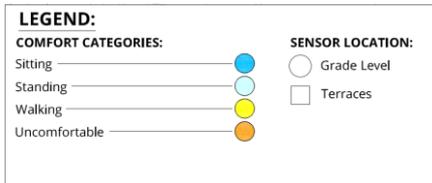


Figure 20 – Detailed Design, including Mitigation, Terrace Areas Wind Comfort Results – Winter Period

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
1	Amended Design	Annual	69	91	97	Walking	20.9	Pass
	Detailed Design	Summer	68	92	98	Walking	20.6	Pass
		Winter	71	90	96	Walking		
	Detailed Design + Initial Mitigation	Summer	90	99	100	Standing	13.3	Pass
		Winter	89	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	91	99	100	Standing	13.9	Pass
Winter		89	99	100	Standing			
2	Amended Design	Annual	82	97	100	Standing	17.8	Pass
	Detailed Design	Summer	81	96	99	Standing	17.7	Pass
		Winter	83	97	100	Standing		
	Detailed Design + Initial Mitigation	Summer	99	100	100	Sitting	10.6	Pass
		Winter	98	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	8.1	Pass
Winter		100	100	100	Sitting			
3	Amended Design	Annual	86	99	100	Standing	15.1	Pass
	Detailed Design	Summer	83	98	100	Standing	15.6	Pass
		Winter	84	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	96	100	100	Sitting	12.2	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	7.0	Pass
Winter		100	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
4	Amended Design	Annual	82	98	100	Standing	16.4	Pass
	Detailed Design	Summer	75	96	100	Standing	16.6	Pass
		Winter	84	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	93	100	100	Standing	12.4	Pass
		Winter	95	98	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	8.5	Pass
Winter		100	100	100	Sitting			
5	Amended Design	Annual	84	99	100	Standing	16.1	Pass
	Detailed Design	Summer	74	96	100	Standing	17.8	Pass
		Winter	84	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	98	100	100	Sitting	11.5	Pass
		Winter	98	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	95	97	100	Sitting	12.0	Pass
Winter		99	100	100	Sitting			
6	Amended Design	Annual	78	90	96	Walking	22.3	Pass
	Detailed Design	Summer	79	95	99	Standing	18.6	Pass
		Winter	78	92	98	Walking		
	Detailed Design + Initial Mitigation	Summer	90	100	100	Standing	12.9	Pass
		Winter	92	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	84	97	100	Standing	15.8	Pass
Winter		85	97	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
7	Amended Design	Annual	78	92	98	Walking	21.5	Pass
	Detailed Design	Summer	78	95	99	Standing	19.7	Pass
		Winter	80	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	90	100	100	Standing	13.9	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	85	99	100	Standing	15.4	Pass
Winter		89	99	100	Standing			
8	Amended Design	Annual	82	98	100	Standing	15.8	Pass
	Detailed Design	Summer	80	99	100	Standing	15	Pass
		Winter	85	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	95	100	100	Sitting	12.7	Pass
		Winter	93	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	97	100	Sitting	11.8	Pass
Winter		96	100	100	Sitting			
9	Amended Design	Annual	82	98	100	Standing	17.5	Pass
	Detailed Design	Summer	79	98	100	Standing	19.2	Pass
		Winter	80	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	89	100	100	Standing	14.5	Pass
		Winter	89	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	10.7	Pass
Winter		97	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
10	Amended Design	Annual	73	91	98	Waking	21.2	Pass
	Detailed Design	Summer	71	93	98	Walking	21.3	Pass
		Winter	74	91	98	Walking		
	Detailed Design + Initial Mitigation	Summer	87	97	100	Standing	18.5	Pass
		Winter	84	96	100	Standing		
	Detailed Design + Mature Mitigation	Summer	88	98	100	Standing	16.8	Pass
Winter		91	98	100	Standing			
11	Amended Design	Annual	83	97	100	Standing	17.9	Pass
	Detailed Design	Summer	80	97	100	Standing	17.6	Pass
		Winter	84	97	100	Standing		
	Detailed Design + Initial Mitigation	Summer	97	100	100	Sitting	12.1	Pass
		Winter	98	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	5.2	Pass
Winter		100	100	100	Sitting			
12	Amended Design	Annual	89	100	100	Standing	13.9	Pass
	Detailed Design	Summer	86	100	100	Standing	13.9	Pass
		Winter	90	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	100	100	100	Sitting	9.3	Pass
		Winter	100	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	8.7	Pass
Winter		100	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety		
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	m/s	Rating
% of Time			≥95%	≥95%	≥95%				
Location	Configuration	Season	%	%	%				
13	Amended Design	Annual	85	99	100	Standing	14.3	Pass	
	Detailed Design	Summer	78	99	100	Standing	14.9	Pass	
		Winter	88	99	100	Standing			
	Detailed Design + Initial Mitigation	Summer	98	100	100	Sitting	10.6	Pass	
		Winter	99	100	100	Sitting			
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	8.5	Pass	
Winter		100	100	100	Sitting				
14	Amended Design	Annual	88	100	100	Standing	14.4	Pass	
	Detailed Design	Summer	81	99	100	Standing	15	Pass	
		Winter	90	99	100	Standing			
	Detailed Design + Initial Mitigation	Summer	99	100	100	Sitting	10.3	Pass	
		Winter	100	100	100	Sitting			
	Detailed Design + Mature Mitigation	Summer	99	100	100	Sitting	10.3	Pass	
Winter		100	100	100	Sitting				
15	Amended Design	Annual	83	98	100	Standing	16.5	Pass	
	Detailed Design	Summer	81	99	100	Standing	14.4	Pass	
		Winter	91	100	100	Standing			
	Detailed Design + Initial Mitigation	Summer	95	98	100	Sitting	12.1	Pass	
		Winter	100	100	100	Sitting			
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	13.8	Pass	
Winter		97	100	100	Sitting				

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
16	Amended Design	Annual	69	86	94	Uncomfortable	22.7	Pass
	Detailed Design	Summer	62	85	96	Walking	20.1	Pass
		Winter	76	92	97	Walking		
	Detailed Design + Initial Mitigation	Summer	80	95	98	Standing	16.6	Pass
		Winter	86	97	99	Standing		
	Detailed Design + Mature Mitigation	Summer	80	97	100	Standing	16.0	Pass
Winter		84	97	100	Standing			
17	Amended Design	Annual	81	94	99	Walking	19.7	Pass
	Detailed Design	Summer	76	93	98	Walking	20.4	Pass
		Winter	79	93	98	Walking		
	Detailed Design + Initial Mitigation	Summer	81	96	100	Standing	16.6	Pass
		Winter	85	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	85	98	100	Standing	16.2	Pass
Winter		84	97	100	Standing			
18	Amended Design	Annual	87	97	100	Standing	17.8	Pass
	Detailed Design	Summer	89	99	100	Standing	15.8	Pass
		Winter	87	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	89	100	100	Standing	13.3	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	84	98	100	Standing	14.4	Pass
Winter		88	99	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
19	Amended Design	Annual	87	98	100	Standing	17.8	Pass
	Detailed Design	Summer	88	100	100	Standing	13.9	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	96	100	100	Sitting	11.9	Pass
		Winter	96	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	96	100	100	Sitting	11.0	Pass
Winter		97	100	100	Sitting			
20	Amended Design	Annual	73	91	98	Walking	21.5	Pass
	Detailed Design	Summer	66	84	94	Uncomfortable	23.2	Pass
		Winter	69	85	93	Uncomfortable		
	Detailed Design + Initial Mitigation	Summer	77	95	99	Standing	19.0	Pass
		Winter	77	92	97	Walking		
	Detailed Design + Mature Mitigation	Summer	84	97	100	Standing	16.5	Pass
Winter		80	93	98	Walking			
21	Amended Design	Annual	74	91	97	Walking	22.3	Pass
	Detailed Design	Summer	76	91	97	Walking	21.1	Pass
		Winter	72	88	95	Walking		
	Detailed Design + Initial Mitigation	Summer	80	94	99	Walking	17.4	Pass
		Winter	79	94	99	Walking		
	Detailed Design + Mature Mitigation	Summer	84	97	100	Standing	17.7	Pass
Winter		80	93	98	Walking			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
22	Amended Design	Annual	86	99	100	Standing	15.1	Pass
	Detailed Design	Summer	85	99	100	Standing	16.5	Pass
		Winter	85	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	100	100	100	Sitting	10.3	Pass
		Winter	99	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	99	100	100	Sitting	12.7	Pass
Winter		95	97	100	Standing			
23	Amended Design	Annual	74	93	99	Walking	19.9	Pass
	Detailed Design	Summer	78	96	100	Standing	17.4	Pass
		Winter	81	97	100	Standing		
	Detailed Design + Initial Mitigation	Summer	94	100	100	Standing	12.1	Pass
		Winter	96	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	9.5	Pass
Winter		100	100	100	Sitting			
24	Amended Design	Annual	74	94	99	Walking	18.9	Pass
	Detailed Design	Summer	74	94	99	Walking	19	Pass
		Winter	79	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	87	100	100	Standing	14.3	Pass
		Winter	88	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	97	100	100	Sitting	11.6	Pass
Winter		95	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
25	Amended Design	Annual	68	88	96	Walking	22.6	Pass
	Detailed Design	Summer	69	91	97	Walking	21.5	Pass
		Winter	74	91	97	Walking		
	Detailed Design + Initial Mitigation	Summer	89	99	100	Standing	14.1	Pass
		Winter	88	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	96	100	100	Sitting	11.8	Pass
Winter		95	100	100	Sitting			
26	Amended Design	Annual	79	95	99	Standing	17.5	Pass
	Detailed Design	Summer	80	95	99	Standing	18.7	Pass
		Winter	86	96	100	Standing		
	Detailed Design + Initial Mitigation	Summer	88	100	100	Standing	13.1	Pass
		Winter	93	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	88	99	100	Standing	13.6	Pass
Winter		95	100	100	Sitting			
27	Amended Design	Annual	86	98	100	Standing	16.4	Pass
	Detailed Design	Summer	91	100	100	Standing	15.4	Pass
		Winter	87	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	95	100	100	Sitting	12.2	Pass
		Winter	96	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	97	100	100	Sitting	11.5	Pass
Winter		96	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
28	Amended Design	Annual	76	95	99	Standing	18.9	Pass
	Detailed Design	Summer	77	95	100	Standing	18.7	Pass
		Winter	78	94	99	Walking		
	Detailed Design + Initial Mitigation	Summer	95	100	100	Sitting	11.6	Pass
		Winter	96	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	11.3	Pass
Winter		97	100	100	Sitting			
29	Amended Design	Annual	75	96	100	Standing	16.9	Pass
	Detailed Design	Summer	77	97	100	Standing	17.1	Pass
		Winter	79	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	88	99	100	Standing	14.2	Pass
		Winter	85	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	87	99	100	Standing	14.8	Pass
Winter		84	97	100	Standing			
30	Amended Design	Annual	74	94	98	Walking	23.6	Pass
	Detailed Design	Summer	80	98	100	Standing	21.2	Pass
		Winter	78	93	98	Walking		
	Detailed Design + Initial Mitigation	Summer	89	99	100	Standing	15.7	Pass
		Winter	89	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	12.0	Pass
Winter		95	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety		
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	m/s	Rating
% of Time			≥95%	≥95%	≥95%				
Location	Configuration	Season	%	%	%				
31	Amended Design	Annual	77	96	100	Standing	17.6	Pass	
	Detailed Design	Summer	70	94	99	Walking	17.9	Pass	
		Winter	80	97	100	Standing			
	Detailed Design + Initial Mitigation	Summer	72	95	97	Standing	19.6	Pass	
		Winter	77	95	97	Standing			
	Detailed Design + Mature Mitigation	Summer	86	98	100	Standing	16.1	Pass	
Winter		86	98	100	Standing				
32	Amended Design	Annual	72	88	94	Uncomfortable	22.1	Pass	
	Detailed Design	Summer	79	96	99	Standing	19.8	Pass	
		Winter	76	91	97	Walking			
	Detailed Design + Initial Mitigation	Summer	82	97	100	Standing	17.4	Pass	
		Winter	81	95	97	Standing			
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	12.0	Pass	
Winter		95	100	100	Sitting				
33	Amended Design	Annual	92	100	100	Standing	13.3	Pass	
	Detailed Design	Summer	95	100	100	Sitting	12.4	Pass	
		Winter	95	100	100	Sitting			
	Detailed Design + Initial Mitigation	Summer	95	100	100	Sitting	11.1	Pass	
		Winter	96	100	100	Sitting			
	Detailed Design + Mature Mitigation	Summer	92	100	100	Standing	9.4	Pass	
Winter		97	100	100	Sitting				

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
34	Amended Design	Annual	90	100	100	Standing	13	Pass
	Detailed Design	Summer	95	100	100	Sitting	11.1	Pass
		Winter	97	100	100	Sitting		
	Detailed Design + Initial Mitigation	Summer	98	100	100	Sitting	9.4	Pass
		Winter	100	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	100	100	100	Sitting	8.1	Pass
Winter		100	100	100	Sitting			
35	Amended Design	Annual	76	90	97	Walking	20.6	Pass
	Detailed Design	Summer	78	93	98	Walking	21	Pass
		Winter	75	90	97	Walking		
	Detailed Design + Initial Mitigation	Summer	92	100	100	Standing	14.1	Pass
		Winter	89	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	85	99	100	Standing	14.0	Pass
Winter		85	97	100	Standing			
36	Amended Design	Annual	73	89	95	Walking	21.8	Pass
	Detailed Design	Summer	76	93	98	Walking	22.4	Pass
		Winter	73	87	94	Uncomfortable		
	Detailed Design + Initial Mitigation	Summer	89	98	100	Standing	16.9	Pass
		Winter	82	94	99	Walking		
	Detailed Design + Mature Mitigation	Summer	87	98	100	Standing	16.2	Pass
Winter		81	93	99	Walking			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
37	Amended Design	Annual	79	96	100	Standing	17.9	Pass
	Detailed Design	Summer	90	100	100	Standing	16	Pass
		Winter	86	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	96	100	100	Sitting	11.8	Pass
		Winter	96	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	97	100	100	Sitting	10.8	Pass
Winter		97	100	100	Sitting			
38	Amended Design	Annual	78	95	99	Standing	19.5	Pass
	Detailed Design	Summer	82	98	100	Standing	19	Pass
		Winter	80	96	99	Standing		
	Detailed Design + Initial Mitigation	Summer	98	100	100	Sitting	12.7	Pass
		Winter	96	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	99	100	100	Sitting	9.7	Pass
Winter		98	100	100	Sitting			
39	Amended Design	Annual	78	95	99	Standing	21.7	Pass
	Detailed Design	Summer	88	98	100	Standing	19.9	Pass
		Winter	81	94	98	Walking		
	Detailed Design + Initial Mitigation	Summer	99	100	100	Sitting	11.4	Pass
		Winter	97	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	13.7	Pass
Winter		90	100	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
40	Amended Design	Annual	75	92	97	Walking	24.5	Exceeds
	Detailed Design	Summer	78	97	100	Standing	20.7	Pass
		Winter	78	93	98	Walking		
	Detailed Design + Initial Mitigation	Summer	84	97	99	Standing	20.3	Pass
		Winter	78	91	97	Walking		
	Detailed Design + Mature Mitigation	Summer	90	99	100	Standing	17.9	Pass
Winter		83	94	99	Walking			
43	Amended Design	Annual	78	96	100	Standing	17.7	Pass
	Detailed Design	Summer	75	95	99	Standing	18.8	Pass
		Winter	79	93	99	Walking		
	Detailed Design + Initial Mitigation	Summer	82	96	100	Standing	16.6	Pass
		Winter	85	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	86	99	100	Standing	11.9	Pass
Winter		89	100	100	Standing			
44	Amended Design	Annual	64	88	97	Walking	20.2	Pass
	Detailed Design	Summer	62	89	97	Walking	19.7	Pass
		Winter	73	92	98	Walking		
	Detailed Design + Initial Mitigation	Summer	70	92	98	Walking	19.4	Pass
		Winter	79	94	99	Walking		
	Detailed Design + Mature Mitigation	Summer	88	97	100	Standing	14.9	Pass
Winter		86	97	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
45	Amended Design	Annual	76	94	99	Walking	19.4	Pass
	Detailed Design	Summer	81	97	100	Standing	18.9	Pass
		Winter	78	94	99	Walking		
	Detailed Design + Initial Mitigation	Summer	91	100	100	Standing	12.8	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	99	100	100	Sitting	11.4	Pass
Winter		96	100	100	Sitting			
46	Amended Design	Annual	84	98	100	Standing	16.3	Pass
	Detailed Design	Summer	86	99	100	Standing	15.2	Pass
		Winter	87	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	88	99	100	Standing	15.4	Pass
		Winter	86	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	13.5	Pass
Winter		90	100	100	Standing			
47	Amended Design	Annual	78	95	100	Standing	17.8	Pass
	Detailed Design	Summer	79	96	100	Standing	16.7	Pass
		Winter	83	94	100	Walking		
	Detailed Design + Initial Mitigation	Summer	99	100	100	Sitting	9.5	Pass
		Winter	100	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	11.6	Pass
Winter		95	97	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
48	Amended Design	Annual	69	88	97	Walking	21	Pass
	Detailed Design	Summer	65	85	94	Uncomfortable	21.6	Pass
		Winter	66	85	94	Uncomfortable		
	Detailed Design + Initial Mitigation	Summer	81	96	100	Standing	17.5	Pass
		Winter	79	95	100	Standing		
	Detailed Design + Mature Mitigation	Summer	81	95	99	Standing	15.7	Pass
Winter		80	95	100	Standing			
49	Amended Design	Annual	87	98	100	Standing	16.2	Pass
	Detailed Design	Summer	87	98	100	Standing	16.5	Pass
		Winter	87	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	85	94	97	Walking	18.7	Pass
		Winter	89	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	92	99	100	Standing	12.8	Pass
Winter		95	100	100	Sitting			
50	Amended Design	Annual	91	98	100	Standing	18.3	Pass
	Detailed Design	Summer	87	99	100	Standing	16.3	Pass
		Winter	88	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	91	99	100	Standing	14.0	Pass
		Winter	92	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	99	100	100	Sitting	9.9	Pass
Winter		99	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
51	Amended Design	Annual	84	98	100	Standing	17.4	Pass
	Detailed Design	Summer	88	99	100	Standing	18.4	Pass
		Winter	85	96	99	Standing		
	Detailed Design + Initial Mitigation	Summer	93	100	100	Standing	13.2	Pass
		Winter	93	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	98	100	100	Sitting	10.8	Pass
Winter		97	100	100	Sitting			
52	Amended Design	Annual	89	98	100	Standing	19.5	Pass
	Detailed Design	Summer	91	99	100	Standing	19.9	Pass
		Winter	85	96	99	Standing		
	Detailed Design + Initial Mitigation	Summer	95	100	100	Sitting	16.9	Pass
		Winter	89	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	98	100	100	Sitting	10.9	Pass
Winter		97	100	100	Sitting			
53	Amended Design	Annual	79	93	97	Walking	20	Pass
	Detailed Design	Summer	80	93	97	Walking	18.3	Pass
		Winter	88	97	100	Standing		
	Detailed Design + Initial Mitigation	Summer	83	94	99	Walking	16.8	Pass
		Winter	90	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	88	95	100	Standing	17.0	Pass
Winter		94	99	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
54	Amended Design	Annual	75	92	97	Walking	20.8	Pass
	Detailed Design	Summer	87	99	100	Standing	13.6	Pass
		Winter	96	100	100	Sitting		
	Detailed Design + Initial Mitigation	Summer	98	100	100	Sitting	9.4	Pass
		Winter	100	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	98	100	100	Sitting	10.0	Pass
Winter		100	100	100	Sitting			
55	Amended Design	Annual	92	98	100	Standing	17.7	Pass
	Detailed Design	Summer	93	100	100	Standing	14.8	Pass
		Winter	89	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	88	99	100	Standing	15.0	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	97	100	Sitting	11.5	Pass
Winter		99	100	100	Sitting			
56	Amended Design	Annual	88	99	100	Standing	15.5	Pass
	Detailed Design	Summer	90	99	100	Standing	16.6	Pass
		Winter	88	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	94	100	100	Standing	13.8	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	12.4	Pass
Winter		95	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
57	Amended Design	Annual	72	95	99	Standing	17.4	Pass
	Detailed Design	Summer	72	96	100	Standing	16.6	Pass
		Winter	78	96	99	Standing		
	Detailed Design + Initial Mitigation	Summer	92	100	100	Standing	11.9	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	12.0	Pass
Winter		95	100	100	Sitting			
58	Amended Design	Annual	68	92	99	Walking	18.8	Pass
	Detailed Design	Summer	65	92	98	Walking	18.5	Pass
		Winter	73	93	99	Walking		
	Detailed Design + Initial Mitigation	Summer	86	98	100	Standing	16.3	Pass
		Winter	86	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	15.9	Pass
Winter		89	98	100	Standing			
59	Amended Design	Annual	79	94	99	Walking	19.2	Pass
	Detailed Design	Summer	77	94	99	Walking	18.8	Pass
		Winter	78	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	87	98	100	Standing	17.2	Pass
		Winter	85	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	92	100	100	Standing	12.5	Pass
Winter		95	97	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
60	Amended Design	Annual	82	95	99	Standing	20	Pass
	Detailed Design	Summer	82	97	100	Standing	19.7	Pass
		Winter	80	94	99	Walking		
	Detailed Design + Initial Mitigation	Summer	83	97	100	Standing	19.3	Pass
		Winter	82	96	99	Standing		
	Detailed Design + Mature Mitigation	Summer	89	98	100	Standing	16.1	Pass
Winter		88	98	100	Standing			
61	Amended Design	Annual	81	94	99	Walking	21.1	Pass
	Detailed Design	Summer	85	97	100	Standing	21.4	Pass
		Winter	81	94	98	Walking		
	Detailed Design + Initial Mitigation	Summer	89	99	100	Standing	18.3	Pass
		Winter	86	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	15.2	Pass
Winter		91	99	100	Standing			
62	Amended Design	Annual	66	85	94	Uncomfortable	21.7	Pass
	Detailed Design	Summer	68	87	96	Walking	20.2	Pass
		Winter	69	87	96	Walking		
	Detailed Design + Initial Mitigation	Summer	79	95	98	Standing	17.2	Pass
		Winter	80	96	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	13.0	Pass
Winter		91	99	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
63	Amended Design	Annual	71	90	98	Walking	19.3	Pass
	Detailed Design	Summer	70	91	98	Walking	19	Pass
		Winter	73	92	99	Walking		
	Detailed Design + Initial Mitigation	Summer	85	98	100	Standing	14.8	Pass
		Winter	90	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	96	100	100	Sitting	10.4	Pass
Winter		97	100	100	Sitting			
64	Amended Design	Annual	75	95	100	Standing	17.6	Pass
	Detailed Design	Summer	77	96	100	Standing	17	Pass
		Winter	78	96	100	Standing		
	Detailed Design + Initial Mitigation	Summer	82	98	100	Standing	15.5	Pass
		Winter	83	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	85	98	100	Standing	13.8	Pass
Winter		87	99	100	Standing			
65	Amended Design	Annual	78	96	100	Standing	18.8	Pass
	Detailed Design	Summer	80	98	100	Standing	18.3	Pass
		Winter	79	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	92	100	100	Standing	13.1	Pass
		Winter	93	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	11.9	Pass
Winter		96	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
66	Amended Design	Summer	72	94	99	Walking	19.1	Pass
	Detailed Design	Summer	77	96	100	Standing	18.6	Pass
		Winter	77	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	85	99	100	Standing	16.0	Pass
		Winter	85	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	88	100	100	Standing	13.3	Pass
Winter		91	100	100	Standing			
67	Amended Design	Annual	75	95	99	Standing	19.4	Pass
	Detailed Design	Summer	76	97	100	Standing	18.7	Pass
		Winter	79	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	85	98	100	Standing	16.6	Pass
		Winter	86	98	98	Standing		
	Detailed Design + Mature Mitigation	Summer	89	99	100	Standing	15.9	Pass
Winter		90	99	100	Standing			
68	Amended Design	Annual	71	92	98	Walking	20.4	Pass
	Detailed Design	Summer	68	91	98	Walking	20.5	Pass
		Winter	77	94	99	Walking		
	Detailed Design + Initial Mitigation	Summer	72	94	99	Walking	19.3	Pass
		Winter	83	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	92	100	100	Standing	13.8	Pass
Winter		89	99	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
69	Amended Design	Annual	67	89	97	Walking	20.7	Pass
	Detailed Design	Summer	66	91	98	Walking	19.3	Pass
		Winter	72	90	97	Walking		
	Detailed Design + Initial Mitigation	Summer	82	99	100	Standing	15.5	Pass
		Winter	82	96	100	Standing		
	Detailed Design + Mature Mitigation	Summer	87	100	100	Standing	13.5	Pass
Winter		90	100	100	Standing			
70	Amended Design	Annual	79	95	99	Standing	20.2	Pass
	Detailed Design	Summer	85	99	100	Standing	19.1	Pass
		Winter	85	96	100	Standing		
	Detailed Design + Initial Mitigation	Summer	89	99	100	Standing	19.3	Pass
		Winter	86	96	99	Standing		
	Detailed Design + Mature Mitigation	Summer	86	98	100	Standing	20.8	Pass
Winter		82	93	97	Walking			
71	Amended Design	Annual	76	93	98	Walking	21.3	Pass
	Detailed Design	Summer	77	96	100	Standing	20.1	Pass
		Winter	77	92	99	Walking		
	Detailed Design + Initial Mitigation	Summer	90	99	100	Standing	18.8	Pass
		Winter	85	96	100	Standing		
	Detailed Design + Mature Mitigation	Summer	84	98	100	Standing	18.5	Pass
Winter		82	95	99	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
72	Amended Design	Annual	72	92	99	Walking	19.2	Pass
	Detailed Design	Summer	68	91	99	Walking	19.3	Pass
		Winter	77	94	99	Walking		
	Detailed Design + Initial Mitigation	Summer	76	97	100	Standing	16.5	Pass
		Winter	82	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	80	98	100	Standing	15.9	Pass
Winter		87	99	100	Standing			
73	Amended Design	Annual	81	96	100	Standing	18.9	Pass
	Detailed Design	Summer	81	97	100	Standing	18.5	Pass
		Winter	83	97	100	Standing		
	Detailed Design + Initial Mitigation	Summer	81	97	100	Standing	18.3	Pass
		Winter	83	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	88	100	100	Standing	13.9	Pass
Winter		89	100	100	Standing			
74	Amended Design	Annual	77	94	99	Walking	19.8	Pass
	Detailed Design	Summer	72	94	99	Walking	18.8	Pass
		Winter	84	96	100	Standing		
	Detailed Design + Initial Mitigation	Summer	75	95	99	Standing	17.9	Pass
		Winter	85	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	11.2	Pass
Winter		96	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
75	Amended Design	Annual	85	99	100	Standing	15.1	Pass
	Detailed Design	Summer	83	99	100	Standing	14.4	Pass
		Winter	89	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	87	100	100	Standing	14.1	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	90	100	100	Standing	12.8	Pass
Winter		95	100	100	Sitting			
76	Amended Design	Annual	78	96	100	Standing	18.1	Pass
	Detailed Design	Summer	81	98	100	Standing	16	Pass
		Winter	83	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	84	99	100	Standing	15.1	Pass
		Winter	87	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	98	100	100	Sitting	9.8	Pass
Winter		99	100	100	Sitting			
77	Amended Design	Annual	92	100	100	Standing	13.4	Pass
	Detailed Design	Summer	92	100	100	Standing	12.3	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	92	100	100	Standing	12.1	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	11.7	Pass
Winter		96	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
78	Amended Design	Annual	80	98	100	Standing	15.6	Pass
	Detailed Design	Summer	75	96	100	Standing	17.1	Pass
		Winter	82	97	100	Standing		
	Detailed Design + Initial Mitigation	Summer	76	96	99	Standing	17.4	Pass
		Winter	81	96	100	Standing		
	Detailed Design + Mature Mitigation	Summer	96	100	100	Sitting	10.7	Pass
Winter		98	100	100	Sitting			
79	Amended Design	Annual	80	96	99	Standing	18	Pass
	Detailed Design	Summer	80	98	100	Standing	17.9	Pass
		Winter	79	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	82	98	100	Standing	18.5	Pass
		Winter	79	95	99	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	17.0	Pass
Winter		88	98	100	Standing			
80	Amended Design	Annual	72	92	98	Walking	20.9	Pass
	Detailed Design	Summer	71	92	98	Walking	20.0	Pass
		Winter	75	93	99	Walking		
	Detailed Design + Initial Mitigation	Summer	73	93	98	Walking	20.7	Pass
		Winter	76	93	99	Walking		
	Detailed Design + Mature Mitigation	Summer	80	96	99	Standing	17.3	Pass
Winter		81	96	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
82	Amended Design	Annual	71	92	97	Walking	22.3	Pass
	Detailed Design	Summer	72	96	100	Standing	19.6	Pass
		Winter	75	93	98	Walking		
	Detailed Design + Initial Mitigation	Summer	73	96	99	Standing	22.5	Pass
		Winter	73	90	96	Walking		
	Detailed Design + Mature Mitigation	Summer	81	98	100	Standing	17.8	Pass
Winter		83	96	100	Standing			
83	Amended Design	Annual	71	93	99	Walking	21.3	Pass
	Detailed Design	Summer	69	96	100	Standing	20.5	Pass
		Winter	75	93	98	Walking		
	Detailed Design + Initial Mitigation	Summer	71	96	100	Standing	21.4	Pass
		Winter	75	92	98	Walking		
	Detailed Design + Mature Mitigation	Summer	70	95	100	Standing	16.6	Pass
Winter		77	95	100	Standing			
84	Amended Design	Annual	68	91	97	Walking	22.6	Pass
	Detailed Design	Summer	66	92	99	Walking	22	Pass
		Winter	71	89	96	Walking		
	Detailed Design + Initial Mitigation	Summer	67	93	99	Walking	22.8	Pass
		Winter	72	89	95	Walking		
	Detailed Design + Mature Mitigation	Summer	80	97	99	Standing	22.0	Pass
Winter		78	92	96	Walking			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
85	Amended Design	Annual	81	97	100	Standing	16.3	Pass
	Detailed Design	Summer	75	95	99	Standing	16.3	Pass
		Winter	86	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	76	96	99	Standing	15.9	Pass
		Winter	86	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	82	97	100	Standing	14.9	Pass
Winter		89	99	100	Standing			
86	Amended Design	Annual	87	99	100	Standing	13.9	Pass
	Detailed Design	Summer	84	99	100	Standing	13.8	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	86	100	100	Standing	13.4	Pass
		Winter	92	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	89	100	100	Standing	13.8	Pass
Winter		89	99	100	Standing			
87	Amended Design	Annual	85	99	100	Standing	15	Pass
	Detailed Design	Summer	83	99	100	Standing	14.4	Pass
		Winter	88	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	86	99	100	Standing	13.8	Pass
		Winter	90	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Standing	12.0	Pass
Winter		95	100	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety		
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	m/s	Rating
% of Time			≥95%	≥95%	≥95%				
Location	Configuration	Season	%	%	%				
88	Amended Design	Annual	80	96	99	Standing	19.9	Pass	
	Detailed Design	Summer	76	97	100	Standing	20.2	Pass	
		Winter	77	93	98	Walking			
	Detailed Design + Initial Mitigation	Summer	75	96	99	Standing	21.0	Pass	
		Winter	76	92	98	Walking			
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	12.8	Pass	
Winter		95	100	100	Sitting				
89	Amended Design	Annual	77	96	100	Standing	17.2	Pass	
	Detailed Design	Summer	74	95	99	Standing	17.6	Pass	
		Winter	78	95	99	Standing			
	Detailed Design + Initial Mitigation	Summer	76	96	99	Standing	17.3	Pass	
		Winter	80	95	99	Standing			
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	13.0	Pass	
Winter		97	100	100	Sitting				
90	Amended Design	Annual	80	96	100	Standing	19.3	Pass	
	Detailed Design	Summer	79	96	100	Standing	18.8	Pass	
		Winter	79	95	99	Standing			
	Detailed Design + Initial Mitigation	Summer	84	98	100	Standing	16.7	Pass	
		Winter	83	97	100	Standing			
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	15.7	Pass	
Winter		88	98	100	Standing				

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
91	Amended Design	Annual	88	99	100	Standing	15.4	Pass
	Detailed Design	Summer	88	98	100	Standing	14.9	Pass
		Winter	89	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	88	99	100	Standing	14.7	Pass
		Winter	89	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	86	98	100	Standing	14.6	Pass
Winter		87	98	100	Standing			
92	Amended Design	Annual	88	100	100	Standing	13.8	Pass
	Detailed Design	Summer	87	100	100	Standing	14.5	Pass
		Winter	87	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	88	100	100	Standing	14.1	Pass
		Winter	88	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	85	99	100	Standing	14.0	Pass
Winter		87	99	100	Standing			
93	Amended Design	Annual	77	96	100	Standing	15.4	Pass
	Detailed Design	Summer	73	95	100	Standing	15.7	Pass
		Winter	79	96	100	Standing		
	Detailed Design + Initial Mitigation	Summer	73	96	100	Standing	15.6	Pass
		Winter	79	96	100	Standing		
	Detailed Design + Mature Mitigation	Summer	73	95	100	Standing	15.5	Pass
Winter		80	96	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
94	Amended Design	Annual	88	100	100	Standing	14.9	Pass
	Detailed Design	Summer	86	100	100	Standing	14.7	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	87	100	100	Standing	14.3	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	84	99	100	Standing	15.0	Pass
Winter		89	99	100	Standing			
95	Amended Design	Annual	89	100	100	Standing	14.9	Pass
	Detailed Design	Summer	90	100	100	Standing	14.1	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	90	100	100	Standing	14.1	Pass
		Winter	90	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	90	100	100	Standing	14.2	Pass
Winter		89	99	100	Standing			
96	Amended Design	Annual	77	94	99	Walking	19.3	Pass
	Detailed Design	Summer	75	92	98	Walking	18.9	Pass
		Winter	78	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	78	93	97	Walking	19.5	Pass
		Winter	80	96	99	Standing		
	Detailed Design + Mature Mitigation	Summer	77	95	99	Standing	16.8	Pass
Winter		81	96	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
97	Amended Design	Annual	73	92	98	Walking	20.2	Pass
	Detailed Design	Summer	70	91	97	Walking	19.8	Pass
		Winter	75	94	99	Walking		
	Detailed Design + Initial Mitigation	Summer	73	91	97	Walking	19.6	Pass
		Winter	78	95	99	Standing		
	Detailed Design + Mature Mitigation	Summer	76	93	98	Walking	19.5	Pass
Winter		82	96	100	Standing			
99	Amended Design	Annual	78	97	100	Standing	17.2	Pass
	Detailed Design	Summer	76	98	100	Standing	16.4	Pass
		Winter	83	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	79	98	100	Standing	16.2	Pass
		Winter	85	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	80	98	100	Standing	16.0	Pass
Winter		87	99	100	Standing			
100	Amended Design	Annual	73	95	100	Standing	18.2	Pass
	Detailed Design	Summer	70	94	100	Walking	18.5	Pass
		Winter	79	96	100	Standing		
	Detailed Design + Initial Mitigation	Summer	71	95	100	Standing	18.1	Pass
		Winter	81	97	100	Standing		
	Detailed Design + Mature Mitigation	Summer	73	96	100	Standing	17.8	Pass
Winter		85	98	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
101	Amended Design	Annual	82	98	100	Standing	17	Pass
	Detailed Design	Summer	79	97	100	Standing	17.3	Pass
		Winter	86	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	86	99	100	Standing	15.2	Pass
		Winter	88	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	87	99	100	Standing	14.3	Pass
Winter		95	100	100	Sitting			
102	Amended Design	Annual	97	100	100	Sitting	10.8	Pass
	Detailed Design	Summer	97	100	100	Sitting	10.5	Pass
		Winter	99	100	100	Sitting		
	Detailed Design + Initial Mitigation	Summer	96	100	100	Sitting	10.5	Pass
		Winter	98	100	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	11.0	Pass
Winter		95	100	100	Sitting			
103	Amended Design	Annual	95	100	100	Sitting	13.1	Pass
	Detailed Design	Summer	96	100	100	Sitting	13	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	96	100	100	Sitting	12.7	Pass
		Winter	95	97	100	Sitting		
	Detailed Design + Mature Mitigation	Summer	96	100	100	Sitting	13.1	Pass
Winter		95	100	100	Sitting			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
104	Amended Design	Annual	89	100	100	Standing	13.6	Pass
	Detailed Design	Summer	86	100	100	Standing	13.8	Pass
		Winter	90	99	100	Standing		
	Detailed Design + Initial Mitigation	Summer	86	100	100	Standing	13.8	Pass
		Winter	89	99	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	13.4	Pass
Winter		91	100	100	Standing			
105	Amended Design	Annual	93	100	100	Standing	12.4	Pass
	Detailed Design	Summer	92	100	100	Standing	12.7	Pass
		Winter	93	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	93	100	100	Standing	12.5	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	89	100	100	Standing	11.4	Pass
Winter		95	100	100	Sitting			
106	Amended Design	Annual	91	100	100	Standing	13.9	Pass
	Detailed Design	Summer	92	100	100	Standing	14.1	Pass
		Winter	90	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	93	100	100	Standing	13.9	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	95	100	100	Sitting	14.8	Pass
Winter		89	99	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
107	Amended Design	Annual	79	97	100	Standing	18.2	Pass
	Detailed Design	Summer	80	97	100	Standing	17.6	Pass
		Winter	82	96	100	Standing		
	Detailed Design + Initial Mitigation	Summer	82	98	100	Standing	15.8	Pass
		Winter	86	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	86	99	100	Standing	15.1	Pass
Winter		87	99	100	Standing			
108	Amended Design	Annual	78	94	98	Walking	20	Pass
	Detailed Design	Summer	78	96	99	Standing	20.2	Pass
		Winter	76	91	97	Walking		
	Detailed Design + Initial Mitigation	Summer	80	96	100	Standing	19.7	Pass
		Winter	79	93	98	Walking		
	Detailed Design + Mature Mitigation	Summer	93	98	100	Standing	22.4	Pass
Winter		77	92	97	Walking			
109	Amended Design	Annual	72	91	98	Walking	22.8	Pass
	Detailed Design	Summer	71	92	98	Walking	21.9	Pass
		Winter	72	90	96	Walking		
	Detailed Design + Initial Mitigation	Summer	73	93	99	Walking	22.2	Pass
		Winter	74	91	97	Walking		
	Detailed Design + Mature Mitigation	Summer	74	95	100	Standing	15.8	Pass
Winter		81	97	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
110	Amended Design	Annual	74	94	99	Walking	19.7	Pass
	Detailed Design	Summer	72	95	100	Standing	18.6	Pass
		Winter	78	95	99	Standing		
	Detailed Design + Initial Mitigation	Summer	75	96	100	Standing	18.4	Pass
		Winter	79	95	98	Standing		
	Detailed Design + Mature Mitigation	Summer	78	97	100	Standing	16.0	Pass
Winter		85	98	100	Standing			
111	Amended Design	Annual	90	100	100	Standing	14.1	Pass
	Detailed Design	Summer	87	99	100	Standing	13.6	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	86	98	100	Standing	15.1	Pass
		Winter	94	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	84	98	100	Standing	14.6	Pass
Winter		90	100	100	Standing			
112	Amended Design	Annual	90	100	100	Standing	13.7	Pass
	Detailed Design	Summer	91	100	100	Standing	13.2	Pass
		Winter	93	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	91	98	100	Standing	13.2	Pass
		Winter	93	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	89	100	100	Standing	13.8	Pass
Winter		90	100	100	Standing			

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
113	Amended Design	Annual	81	98	100	Standing	16.2	Pass
	Detailed Design	Summer	82	98	100	Standing	15.8	Pass
		Winter	84	98	100	Standing		
	Detailed Design + Initial Mitigation	Summer	82	98	100	Standing	16.1	Pass
		Winter	84	98	100	Standing		
	Detailed Design + Mature Mitigation	Summer	81	98	100	Standing	15.8	Pass
Winter		83	98	100	Standing			
114	Amended Design	Annual	86	99	100	Standing	14.9	Pass
	Detailed Design	Summer	82	99	100	Standing	14.4	Pass
		Winter	89	100	100	Standing		
	Detailed Design + Initial Mitigation	Summer	84	99	100	Standing	14.5	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mature Mitigation	Summer	83	98	100	Standing	14.5	Pass
Winter		88	99	100	Standing			
115	Amended Design	Annual	89	100	100	Standing	12.9	Pass
	Detailed Design	Summer	83	99	100	Standing	13.6	Pass
		Winter	91	100	100	Standing		
	Detailed Design + Mitigation	Summer	89	100	100	Standing	12.0	Pass
Winter		95	100	100	Sitting			
116	Amended Design	Annual	67	88	96	Walking	24.1	Exceeds
	Detailed Design	Summer	61	84	93	Uncomfortable	26.3	Exceeds

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
	Detailed Design + Mitigation	Winter	72	89	94	Uncomfortable		
		Summer	72	92	98	Walking	21.8	Pass
		Winter	80	94	98	Walking		
117	Amended Design	Annual	66	87	93	Uncomfortable	26.3	Exceeds
	Detailed Design	Summer	62	85	93	Uncomfortable	25.8	Exceeds
		Winter	75	89	94	Uncomfortable		
	Detailed Design + Mitigation	Summer	73	96	100	Standing	16.8	Pass
Winter		89	96	100	Standing			
118	Amended Design	Annual	71	93	99	Walking	19.1	Pass
	Detailed Design	Summer	63	90	98	Walking	18.9	Pass
		Winter	79	96	100	Standing		
	Detailed Design + Mitigation	Summer	74	95	100	Standing	16.8	Pass
Winter		86	99	100	Standing			
119	Amended Design	Annual	74	93	99	Walking	19.2	Pass
	Detailed Design	Summer	70	93	100	Standing	17.2	Pass
		Winter	86	98	100	Standing		
	Detailed Design + Mitigation	Summer	75	95	98	Standing	18.3	Pass
Winter		90	99	100	Standing			
120	Amended Design	Annual	73	94	99	Walking	18.3	Pass
	Detailed Design	Summer	82	97	100	Standing	16	Pass
		Winter	90	99	100	Standing		

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%			
	Detailed Design + Mitigation	Summer	83	97	100	Standing	15.5	Pass
		Winter	90	99	100	Standing		
121	Amended Design	Annual	73	93	98	Walking	20.1	Pass
	Detailed Design	Summer	100	100	100	Sitting	7.9	Pass
		Winter	100	100	100	Sitting		
	Detailed Design + Mitigation	Summer	100	100	100	Sitting	8.1	Pass
		Winter	100	100	100	Sitting		
	122	Amended Design	Annual	65	88	95	Walking	24.0
Detailed Design		Summer	85	99	100	Standing	16.5	Pass
		Winter	85	98	100	Standing		
Detailed Design + Mitigation		Summer	86	99	100	Standing	15.9	Pass
		Winter	87	99	100	Standing		
123		Amended Design	Annual	65	85	93	Uncomfortable	24.7
	Detailed Design	Summer	88	99	100	Standing	16.4	Pass
		Winter	88	99	100	Standing		
	Detailed Design + Mitigation	Summer	89	99	100	Standing	16.6	Pass
		Winter	89	99	100	Standing		
	126	Amended Design	Annual	91	100	100	Standing	13.4
Detailed Design		Summer	97	100	100	Sitting	11.9	Pass
		Winter	97	100	100	Sitting		
Detailed Design		Summer	97	100	100	Sitting	11.2	Pass

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	Rating
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
	+ Mitigation	Winter	98	100	100	Sitting		
127	Amended Design	Annual	63	84	93	Uncomfortable	26.5	Exceeds
	Detailed Design	Summer	66	89	97	Walking	19.5	Pass
		Winter	74	93	99	Walking		
	Detailed Design + Mitigation	Summer	66	89	98	Walking	20.4	Pass
		Winter	72	92	98	Walking		
128	Amended Design	Annual	67	83	91	Uncomfortable	30.2	Exceeds
	Detailed Design	Summer	76	95	99	Standing	18.5	Pass
		Winter	79	95	99	Standing		
	Detailed Design + Mitigation	Summer	78	94	99	Walking	18.7	Pass
		Winter	78	95	99	Standing		
129	Amended Design	Annual	72	91	98	Walking	21.6	Pass
	Detailed Design	Summer	67	92	99	Walking	20	Pass
		Winter	78	95	99	Standing		
	Detailed Design + Mitigation	Summer	66	92	99	Walking	19.9	Pass
		Winter	79	95	99	Standing		
130	Amended Design	Annual	73	93	98	Walking	22.2	Pass
	Detailed Design	Summer	66	93	99	Walking	20.6	Pass
		Winter	82	96	100	Standing		
	Detailed Design + Mitigation	Summer	66	93	99	Walking	20.0	Pass
		Winter	82	96	100	Standing		

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety	
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	
% of Time			≥95%	≥95%	≥95%			
Location	Configuration	Season	%	%	%		m/s	Rating
131	Amended Design	Annual	86	99	100	Standing	16.6	Pass
	Detailed Design	Summer	83	97	100	Standing	16.1	Pass
		Winter	84	98	100	Standing		
	Detailed Design + Mitigation	Summer	83	97	100	Standing	16.2	Pass
		Winter	84	98	100	Standing		
	133	Amended Design	Annual	88	99	100	Standing	14.8
Detailed Design		Summer	88	100	100	Standing	15.4	Pass
		Winter	89	99	100	Standing		
Detailed Design + Mitigation		Summer	91	100	100	Standing	12.6	Pass
		Winter	93	100	100	Standing		
134		Amended Design	Annual	82	98	100	Standing	15.6
	Detailed Design	Summer	78	98	100	Standing	16.6	Pass
		Winter	84	98	100	Standing		
	Detailed Design + Mitigation	Summer	91	100	100	Standing	14.0	Pass
		Winter	91	100	100	Standing		
	135	Amended Design	Annual	88	99	100	Standing	14.2
Detailed Design		Summer	86	100	100	Standing	14.1	Pass
		Winter	91	100	100	Standing		
Detailed Design + Mitigation		Summer	96	100	100	Sitting	12.0	Pass
		Winter	96	100	100	Sitting		
136		Detailed Design	Summer	71	88	96	Walking	23.2

Wind Comfort Criteria			Sitting	Standing	Walking	Rating	Wind Safety		
GEM Wind Speed (m/s)			0-4	0-6	0-8		Gust Speed (>24m/s)	m/s	Rating
% of Time			≥95%	≥95%	≥95%				
Location	Configuration	Season	%	%	%				
	+ Mitigation	Winter	75	89	96	Walking			
137	Detailed Design	Summer	74	93	98	Walking	26.8	Exceed	
	+ Mitigation	Winter	70	85	92	Uncomfortable			
138	Detailed Design	Summer	90	99	100	Standing	14.7	Pass	
	+ Mitigation	Winter	87	99	100	Standing			

Table 5 – Occurrence Frequencies of Predicted Wind Speeds

9. Mitigation measures

The results of the wind tunnel study for the wind environment conditions within and around the Waterloo Metro Quarter precinct has been undertaken to understand the expected wind comfort conditions compared to the precinct requirements.

The wind tunnel study found that the inclusion of the awnings detailed on the architectural drawings and tree planting outlined in the landscape design enable the ground plane areas to satisfy the required wind comfort conditions for the precinct. As noted in Section 9, the tree planting considered to date as part of the wind tunnel study is the form expected at the time of planting and not a mature tree or final expected form of the landscaping throughout the precinct.

Testing for conditions associated with the elevated terrace spaces found that there was a localised exceedance of the recommended criteria. The south-western terrace area on Level 9 of Building 1 has been changed to a non-trafficable location and as such no treatment measures have been considered for this location. If the wind conditions for the terrace areas noted on Buildings 2, 3 and 4 are desired to be further improved, the following mitigation measures can be incorporated into the final design scheme to address the localised wind effects.

- Central Precinct (Building 2) – Level 22 Western Terrace
The Level 22 terrace is currently marginally exceeding the standing criteria. This is due to the elevated nature of the terrace on the building rooftop and the current design enabling this space to not be enclosed. This area has currently been modelled with quite open balustrades. The inclusion of impermeable balustrades (glass) of approximately 1.5m in height would provide localised protection to patrons, improving wind conditions on this terrace.
- Southern Precinct (Building 3) – Level 2 North-Western Terrace
The Level 2 terrace is currently satisfying standing conditions, however should sitting conditions be desired, it is recommended that the terrace over this space be further extended to the west to assist in breaking up the downwashed and side-stream winds at this corner.
- Southern Precinct (Building 4) – Level 14 Eastern Terrace
The location of this terrace on the rooftop means that localised recirculation of the prevailing winds will occur. The inclusion of a trellis or canopy structure over a portion of the terrace space will assist in reducing this recirculation and further improve conditions

10. Conclusion

Wind tunnel testing has been undertaken for the Waterloo Metro Quarter precinct with consideration for the built form design of the development as well as consideration for awning elements and precinct landscaping. It has been found that the majority of the precinct will satisfy the required wind comfort criteria for the precinct, this is while considering the precinct landscaping sizing and form at the time of opening of the precinct, which will still be quite young. As the tree planting grows to full maturity, these will further enhance the plantings ability to mitigate localised wind conditions throughout the precinct. Some localised additional mitigation measures have been discussed within the report to ensure all areas have been address for suitable wind comfort conditions.

11. Applicability of Results

The drawings and information listed below were received from Woods Bagot, Hassell, and Bates Smart. The findings presented in this report pertain to the proposed design as detailed in the architectural design drawings listed in the table below. Should there be any design changes that deviate from this list of drawings, the predictions presented may change. Therefore, if changes in the design are made, it is recommended that RWDI be contacted.

File Name	File Type	Date Received (dd/mm/yyyy)
Building 1 (Woods Bagot)		
WMQ-SITE-HAS-UD-MDL-0005	DWG	12/06/2020
WMQ-BLD1-WBG-AR-DRG-DA001-dwg[B]	DWG	28/07/2020
WMQ-BLD1-WBG-AR-DRG-DA002-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA003-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA091-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA092-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA100-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA100M-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA101-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA102-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA103-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA104-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA105-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA108-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA109-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA110-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA113-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA114-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA115-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA116-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA117-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA121-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA122-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA123-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA124-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA131-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA132-dwg[B]		
WMQ-BLD1-WBG-AR-DRG-DA133-dwg[B]		

File Name	File Type	Date Received (dd/mm/yyyy)
WMQ-BLD1-WBG-AR-DRG-DA134-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA141-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA142-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA143-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA144-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA145-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA146-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA147-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA148-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA149-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA190-dwg[B] WMQ-BLD1-WBG-AR-DRG-DA191-dwg[B]		
Building 2 (Hassell)		
WMQ-SITE-HAS-UD-MDL-0005	DWG	12/06/2020
WMQ-BLD2-HAS-AR-DRG-DA001 WMQ-BLD2-HAS-AR-DRG-DA002 WMQ-BLD2-HAS-AR-DRG-DA010 WMQ-BLD2-HAS-AR-DRG-DA011 WMQ-BLD2-HAS-AR-DRG-DA012 WMQ-BLD2-HAS-AR-DRG-DA013 WMQ-BLD2-HAS-AR-DRG-DA014 WMQ-BLD2-HAS-AR-DRG-DA015 WMQ-BLD2-HAS-AR-DRG-DA016 WMQ-BLD2-HAS-AR-DRG-DA017 WMQ-BLD2-HAS-AR-DRG-DA018 WMQ-BLD2-HAS-AR-DRG-DA019 WMQ-BLD2-HAS-AR-DRG-DA020 WMQ-BLD2-HAS-AR-DRG-DA021 WMQ-BLD2-HAS-AR-DRG-DA022 WMQ-BLD2-HAS-AR-DRG-DA023 WMQ-BLD2-HAS-AR-DRG-DA024 WMQ-BLD2-HAS-AR-DRG-DA025 WMQ-BLD2-HAS-AR-DRG-DA026 WMQ-BLD2-HAS-AR-DRG-DA027	DWG	29/07/2020

File Name	File Type	Date Received (dd/mm/yyyy)
WMQ-BLD2-HAS-AR-DRG-DA028		
WMQ-BLD2-HAS-AR-DRG-DA029		
WMQ-BLD2-HAS-AR-DRG-DA030		
WMQ-BLD2-HAS-AR-DRG-DA031		
WMQ-BLD2-HAS-AR-DRG-DA032		
WMQ-BLD2-HAS-AR-DRG-DA033		
WMQ-BLD2-HAS-AR-DRG-DA034		
WMQ-BLD2-HAS-AR-DRG-DA035		
WMQ-BLD2-HAS-AR-DRG-DA101		
WMQ-BLD2-HAS-AR-DRG-DA102		
WMQ-BLD2-HAS-AR-DRG-DA103		
WMQ-BLD2-HAS-AR-DRG-DA201		
WMQ-BLD2-HAS-AR-DRG-DA202		
WMQ-BLD2-HAS-AR-DRG-DA301		
WMQ-BLD2-HAS-AR-DRG-DA302		
WMQ-BLD2-HAS-AR-DRG-DA303		
WMQ-BLD2-HAS-AR-DRG-DA304		
WMQ-BLD2-HAS-AR-DRG-DA401		
WMQ-BLD2-HAS-AR-DRG-DA402		
WMQ-BLD2-HAS-AR-DRG-DA501		
WMQ-BLD2-HAS-AR-DRG-DA502		
WMQ-BLD2-HAS-AR-DRG-DA503		
WMQ-BLD2-HAS-AR-DRG-DA601		
WMQ-BLD2-HAS-AR-DRG-DA701		
WMQ-BLD2-HAS-AR-DRG-DA801		
WMQ-BLD2-HAS-AR-DRG-DA901		
WMQ-BLD2-HAS-AR-DRG-DA902		
Building 3 (Bates Smart)		
WMQ-SITE-HAS-UD-MDL-0005	DWG	12/06/2020
WMQ-BLD3-BSA-AR-DRG-DA100-dwg_G	DWG	28/07/2020
WMQ-BLD3-BSA-AR-DRG-DA100M-dwg_F		
WMQ-BLD3-BSA-AR-DRG-DA101-dwg_F		
WMQ-BLD3-BSA-AR-DRG-DA102-dwg_F		
WMQ-BLD3-BSA-AR-DRG-DA103-dwg_F		

File Name	File Type	Date Received (dd/mm/yyyy)
WMQ-BLD3-BSA-AR-DRG-DA106-dwg_F WMQ-BLD3-BSA-AR-DRG-DA116-dwg_D WMQ-BLD3-BSA-AR-DRG-DA123-dwg_F WMQ-BLD3-BSA-AR-DRG-DA124-dwg_F WMQ-BLD3-BSA-AR-DRG-DA125-dwg_F		
WMQ-BLD3-BSA-AR-DRG-DA140-dwg_C WMQ-BLD3-BSA-AR-DRG-DA141-dwg_C WMQ-BLD3-BSA-AR-DRG-DA142-dwg_C WMQ-BLD3-BSA-AR-DRG-DA143-dwg_C WMQ-BLD3-BSA-AR-DRG-DA150-dwg_E WMQ-BLD3-BSA-AR-DRG-DA151-dwg_F	DWG	29/07/2020
Building 4 (Bates Smart)		
WMQ-SITE-HAS-UD-MDL-0005	DWG	12/06/2020
WMQ-BLD4-BSA-AR-DRG-DA101-dwg_I WMQ-BLD4-BSA-AR-DRG-DA102-dwg_D WMQ-BLD4-BSA-AR-DRG-DA103-dwg_I WMQ-BLD4-BSA-AR-DRG-DA108-dwg_H WMQ-BLD4-BSA-AR-DRG-DA109-dwg_H WMQ-BLD4-BSA-AR-DRG-DA110-dwg_G	DWG	28/07/2020
WMQ-BLD4-BSA-AR-DRG-DA140-dwg_D WMQ-BLD4-BSA-AR-DRG-DA141-dwg_D WMQ-BLD4-BSA-AR-DRG-DA142-dwg_D WMQ-BLD4-BSA-AR-DRG-DA143-dwg_D WMQ-BLD4-BSA-AR-DRG-DA150-dwg_H WMQ-BLD4-BSA-AR-DRG-DA151-dwg_B WMQ-BLD4-BSA-AR-DRG-DA160-dwg_E WMQ-BLD4-BSA-AR-DRG-DA161-dwg_E WMQ-BLD4-BSA-AR-DRG-DA162-dwg_E WMQ-BLD4-BSA-AR-DRG-DA163-dwg_E	DWG	29/07/2020



12. Appendices

12.1 Appendix 1 – Wind Tunnel Model Photos



Figure A-1 – Wind Tunnel Model of Detailed Design (View from the South)

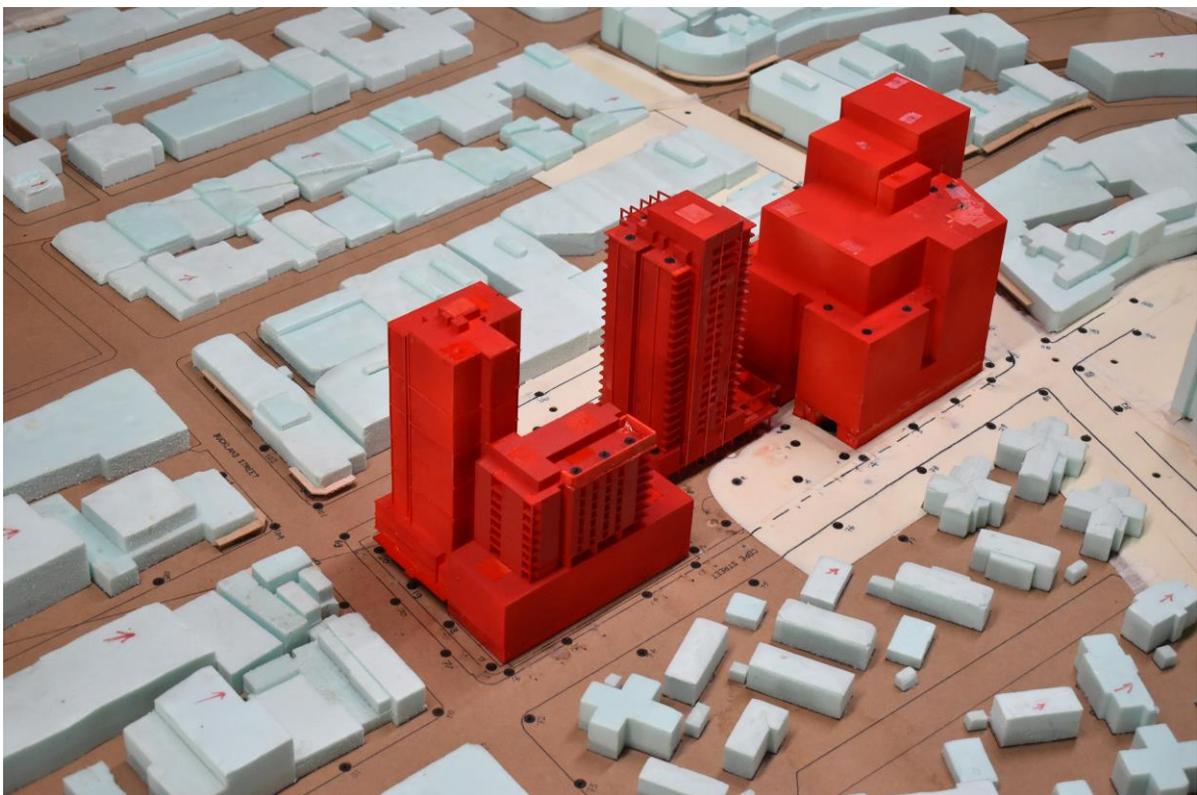


Figure A-2 – Wind Tunnel Model of Detailed Design (View from the South-East)

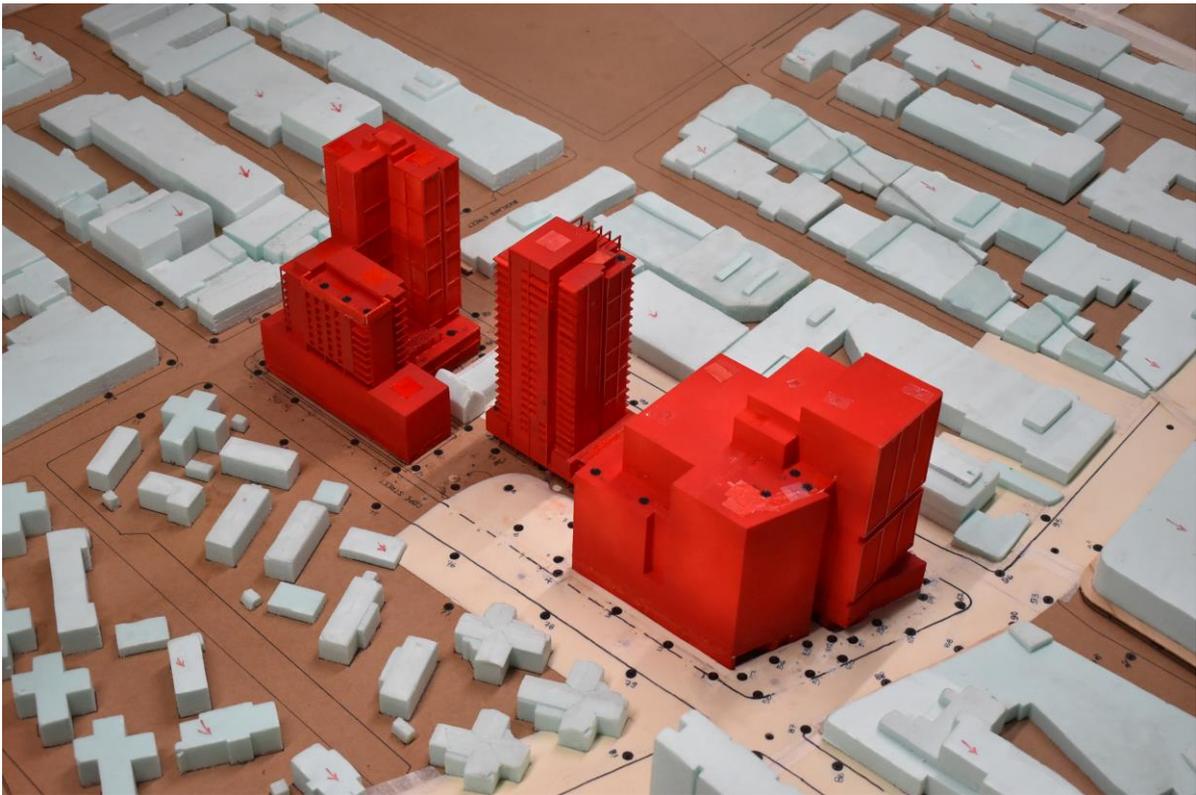


Figure A-3 – Wind Tunnel Model of Detailed Design (View from the North-East)

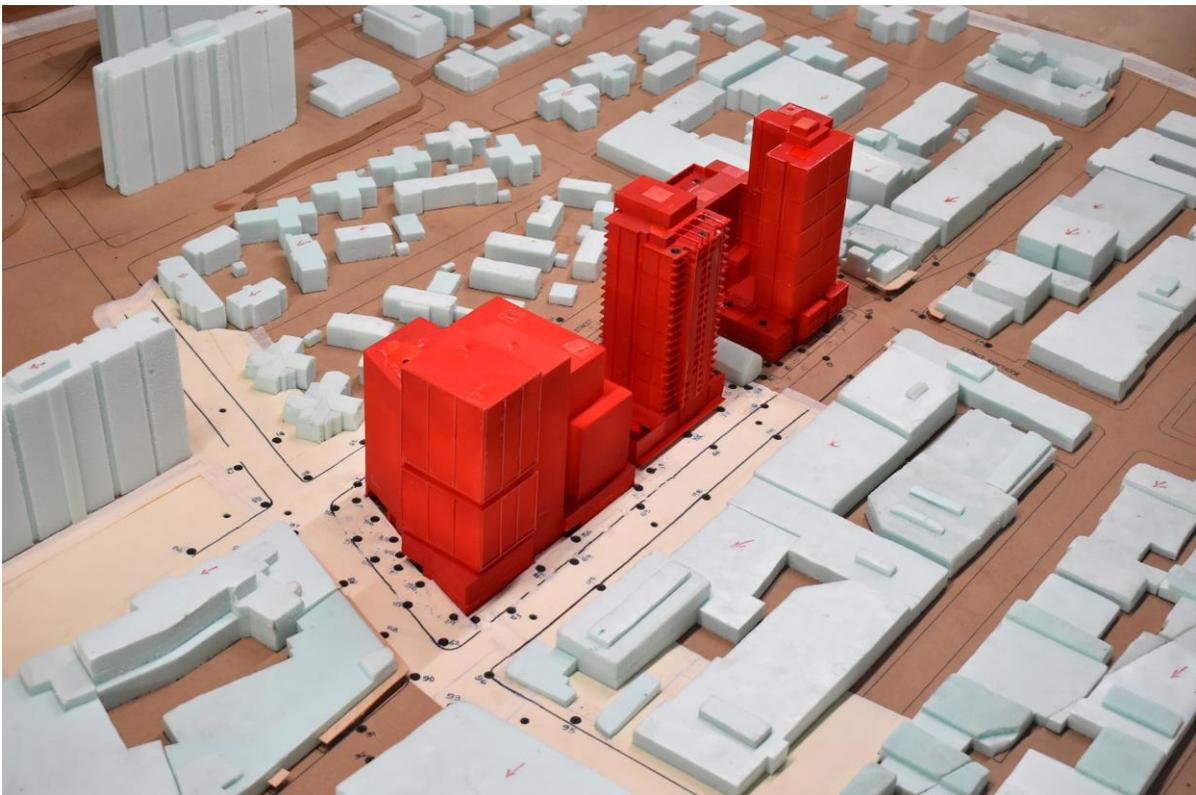


Figure A-4 – Wind Tunnel Model of Detailed Design (View from the North-West)



Figure A-5 – Wind Tunnel Model of Detailed Design with Initial Landscaping (View from the West)



Figure A-6 – Wind Tunnel Model of Detailed Design with Initial Landscaping (View from the North-East)

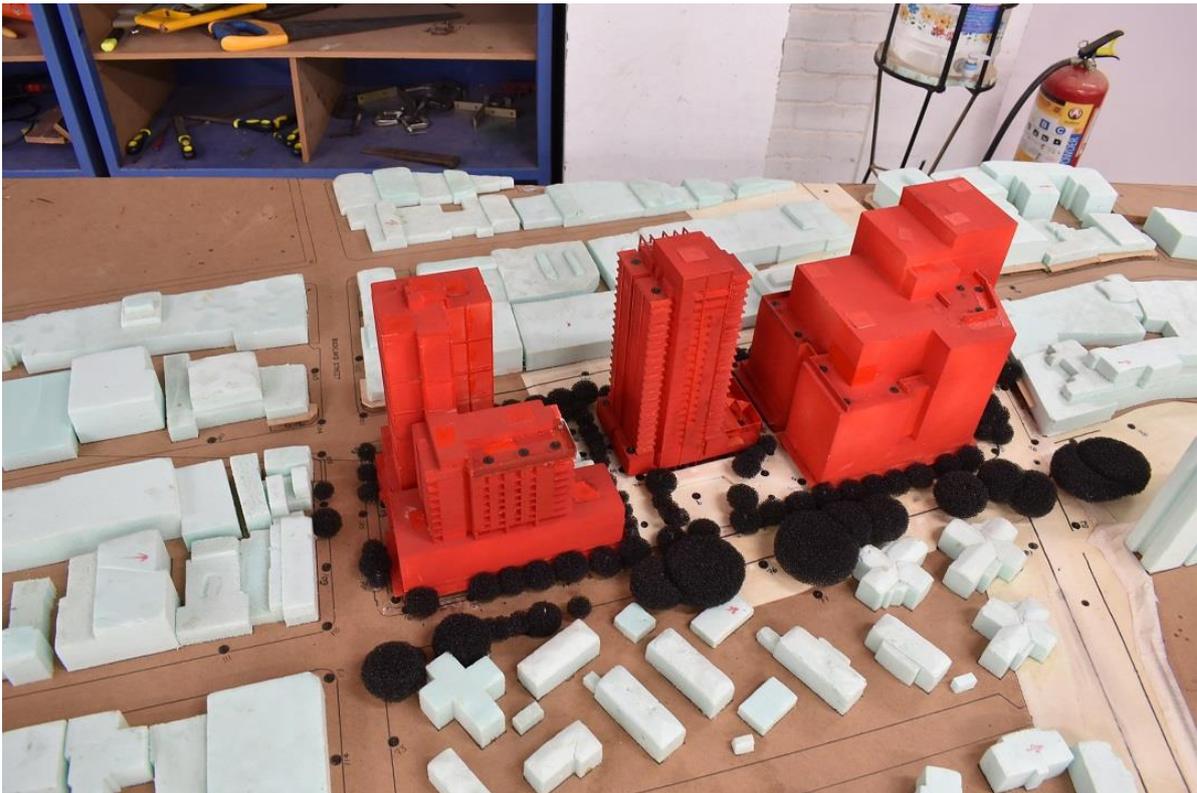


Figure A-7 – Wind Tunnel Model of Detailed Design with Mature Landscaping (View from the North-East)



Figure A-8 – Wind Tunnel Model of Detailed Design with Mature Landscaping (View from the North-East)