ARUP

**Cook Cove Inlet Pty. Ltd.**

# Cooks Cove Planning Proposal (PP-2022-1748) Concept Infrastructure Design

## Wind shear and turbulence assessment

Reference: Wind

Rev.01 Report | 12/01/2023



Job number 252942-15

Arup Australia Pty. Ltd. | ABN 76 625 912 665

**Arup Australia Pty. Ltd.**
Level 5, 151 Clarence Street
Sydney
NSW 2000
Australia
arup.com

# Document Verification

| | |
|---|---|
| **Project title** | Cooks Cove Planning Proposal (PP-2022-1748) Concept Infrastructure Design |
| **Document title** | Wind shear and turbulence assessment |
| **Job number** | 252942-15 |
| **Document ref** | Wind |
| **File reference** | |

| **Revision** | **Date** | **Filename** | Cooks Cove_ARUP wind shear CFD REP_221224.docx | | |
|---|---|---|---|---|---|
| Rev.00 | 24 Dec 2022 | **Description** | Draft Report | | |
| | | | **Prepared by** | **Checked by** | **Approved by** |
| | | **Name** | Sina Hassanli | Graeme Wood | Graeme Wood |
| Rev.01 | 12 Jan 2023 | **Filename** | Cooks Cove_ARUP wind shear and turbulence CFD REP_230112.docx | | |
| | | **Description** | Minor updates | | |
| | | | **Prepared by** | **Checked by** | **Approved by** |
| | | **Name** | Graeme Wood | | Graeme Wood |
| | | **Filename** | | | |
| | | **Description** | | | |
| | | | **Prepared by** | **Checked by** | **Approved by** |
| | | **Name** | | | |

Issue Document Verification with Document ✓

# Executive Summary

Arup has been commissioned by Cook Cove Inlet to provide a quantitative assessment of the proposed Cooks Cove development on aircraft operations at Sydney Airport. The development is located within the NASF (2018) assessment zone for Runway 07, on the boundary for Runway 16R with the majority of the development outside the assessment zone, and outside the boundary for the remaining four runways. A numerical study of the proposed Cooks Cove development located to the west of Sydney Airport has been conducted to determine the effect of the proposed development on wind conditions along the approach flight path to Runways 16R and 07. A full-scale numeric model of the development site and surroundings was developed for the relevant assessment area. The impact of the proposed development was modelled along the flight paths to the relevant runways for four critical wind directions, in accordance with NASF (2018).

It is important to appreciate the difference between wind shear and mechanical turbulence, and some general discussion is included in Appendix A.2. This assessment has used National Airports Safeguarding Framework (NASF, 2018) Guideline B for building generated wind shear.

Numeric modelling was conducted with appropriate approach boundary layer conditions representative of a suburban environment. The modelled wind flow had appropriate turbulence characteristics as defined in Standards Australia (2011). Stability of the boundary layer across the computational domain has been demonstrated.

Wind conditions along the centreline plane of Runways 16R and 07 were extracted from the numerical model for four incident wind directions, with and without the Cooks Cove development to quantify the wind speeds required to exceed the relevant wind shear and turbulence criteria, and to illustrate the change in wind conditions.

The assessment has shown that the 3 s gust wind speed required to exceed the NASF (2018) **along-flight criterion** is greater than the wind speed that airport operational criterion for both runways. The minimum measured value was 35 kt in Case 3 between Ch 600-700 and height of 40-45 m. This location is on the 3° glideslope for aircraft landing at the Runway threshold.

For the **cross-flight criterion**, the required 3 s gust wind speed measured at the anemometer to exceed the criterion was always in excess of the 20 kt operational cross-wind speed control. The lowest wind speed with the proposed development was 28 kt in Case 3 in the same location as the lowest along-flight wind speed. The 28 kt wind speed is the same as the operational cross-flight wind speed for this incident wind direction. This is caused by the proposed trapezoidal building to the south of the proposed Cooks Cove development.

For the **turbulence criterion**, in none of the simulated cases, the 3 s gust wind speed at the anemometer required to exceed turbulence criterion at the runway exceed the operational threshold of 20 kt. Cooks Cove development caused a slight increase in the turbulence levels along the flight paths. For winds at 45° to Runway 07, the lowest measured wind speed required measured at 10 m anemometer height was 23 kt at 600 m before the threshold at a height of 60 m. This is below the operational wind speed of 28 kt for winds from this direction. The change in wind speed would occur for about 13 hours per annum. Operationally for strong winds from the north-east quadrant, aircraft would typically be landing on the parallel Runways 34L and 34R.

The impact of Cooks Cove development on Runway 16R was small, with all turbulence results in excess of the 22 kt operational limit for winds from this direction.

## Table of Contents



## Tables



## Figures

## Appendices

# 1. Client provided content

## 1.1 Introduction

This report has been prepared, on behalf of Cook Cove Inlet Pty. Ltd., to support the public exhibition and assessment of the Cooks Cove Planning Proposal (PP-2022-1748), which was issued a Gateway Determination by the Department of Planning and Environment on 5 August 2022. The proposal seeks to amend Bayside Local Environmental Plan 2021 (BLEP 2021) to rezone and insert planning controls for certain land known as Cooks Cove within the BLEP 2021.

The Cooks Cove Planning Proposal aims to facilitate the long-planned transformation of 36.2 ha of underutilised and strategically important land at Arncliffe, located to the north of the M5 Motorway and adjacent the western foreshore of the Cooks River. The project seeks a renewed focus on delivering a contemporary logistics and warehousing precinct within a well-connected location, surrounded by enhanced open space provisions. The site forms part of the broader Bayside West 2036 Precincts and generally comprises the footprint of the former Kogarah Golf Club, now in part occupied by a temporary M6 Stage 1 construction compound.

## 1.2 Cooks Cove Master Plan 2022

The Cooks Cove Master Plan 2022, as prepared by Hassell, represents an optimised and refined reference scheme, to guide best practice design and the preparation of detailed planning controls to achieve an attractive precinct with high amenity. Key features of the Cooks Cove Master Plan are:

- A net development zone of approximately 15 ha with up to 343,250 $m^2$ Gross Floor Area (GFA) comprising
  - 290,000 $m^2$ of multi-level logistics and warehousing;
  - 20,000 $m^2$ for hotel and visitor accommodation uses;
  - 22,350 $m^2$ for commercial office uses;
  - 10,900 $m^2$ of retail uses;
- Multi-level logistics with building heights generally up to 5 storeys (approx. 48 m)
- A retail podium with commercial office and hotel above, up to a total of 12 storeys (approx. 51 m)
- Built form of a scale and composition which caters for the generation of approximately 3,300 new jobs
- A surrounding open space precinct including:
  - a highly activated waterfront including the Fig Tree Grove outdoor dining and urban park precinct,
  - extension of the Bay to Bay Regional cycle link, ‘Foreshore Walk’, including active and passive recreational uses, together with environmental enhancements, and
  - master planned and Council-owned ‘Pemulwuy Park’ – with an agreed embellishment outcome of passive open space and environmental enhancements to be delivered in stages post construction of the M6 Stage 1 Motorway.
- Complementary on and off-site infrastructure to be delivered by way of State and Local Voluntary Planning Agreements.


**Figure 1: Proposed Cooks Cove Master Plan 2022 – Source: Hassell**

## 1.3 Proposed Planning Controls

The Planning Proposal Justification Report, as prepared by Ethos Urban, details the intention to insert new planning provisions covering the Cooks Cove development zone and adjoining lands, through the amendment of the BLEP 2021, accordingly removing this same area from State Environmental Planning Policy (Precincts—Eastern Harbour City) 2021 (formerly Sydney Regional Environmental Plan No. 33 – Cooks Cove).

Specifically, the Planning Proposal will:

- Seek new land use zones within the development zone, including a primary SP4 Enterprise zone across the majority of the Kogarah Golf Course freehold land, RE1 Public Recreation foreshore and passive open space zones and elements of SP2 Infrastructure.
- Impose an overall maximum building height of RL51 m with appropriate transitions to respond to aviation controls within limited sections of the site.
- Limit gross floor area (GFA) to the south of Marsh Street to 340,000 $m^2$, with a further 1.25:1 Floor Space Ratio (circa 3,250 $m^2$ of GFA) to the north of Marsh Street, to achieve the overall intended logistics, commercial, retail and short-term accommodation land uses.
- Other additional permitted uses and site-specific planning provisions.

- Reclassification of Lot 14 DP213314 and Lot 1 DP108492 (Council owned and the subject of Charitable Trusts), initially from ‘community’ to ‘operational’ to ensure appropriate access, improve utility of public open space and to create contiguous boundaries. Following rezoning and subdivision it is subsequently intended that Council reclassify residue RE1 parcels as ‘community’ by resolution.

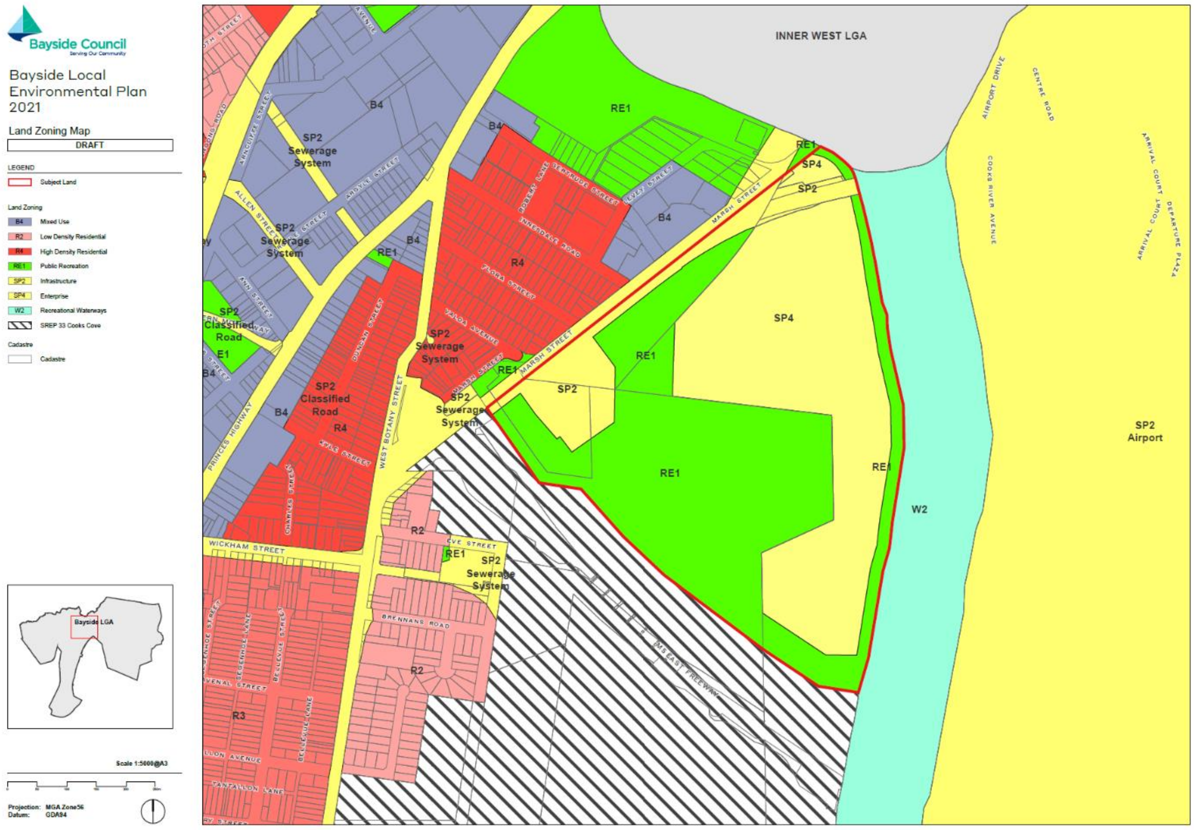



**Figure 2: Proposed Draft Bayside LEP 2021 Zoning Map – Source: Ethos Urban**

The proposal is in response to Bayside West Precincts 2036 – Arncliffe, Banksia and Cooks Cove (released August 2018) and the subsequent Ministerial Directions under s9.1 of the EP&A Act, being Local Planning Directions 1.11 Implementation of Bayside West Precincts 2036 Plan and 1.12 Implementation of Planning Principles for the Cooks Cove Precinct.

## 1.4 Site Description

### Cooks Cove

Cooks Cove is located in the suburb of Arncliffe within the Bayside Council Local Government Area (LGA). The site is located to the west of the Cooks River, approximately 10 km south of the Sydney Central Business District (CBD). The site enjoys adjacency to key trade-related infrastructure being immediately west of Sydney Kingsford Smith International Airport, and approximately 6 km west of Port Botany.

Cooks Cove is strategically located within close proximity to a number of railway stations including Banksia, Arncliffe, Wolli Creek, and the International Airport Terminal, which vary in distance from the site between 700 m and 1.1 km. The M5 Motorway, providing regional connectivity to the Sydney Metropolitan area, runs in an east-west direction immediately to the south of the site. The M8 and M6 Motorways are, and will be, constructed in tunnels approximately 60 m beneath the adjoining Bayside Council 'Trust' lands. The Sydney Gateway project, presently under construction to the immediate north of Cooks Cove and Sydney Airport, will substantially improve future accessibility to the St Peters interchange and the wider M4/M5 WestConnex network, via toll free connections, as well as the Domestic Airport and Port Botany.

The Cooks Cove Development Zone is located to the north of the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS) and is generally bound by the Cooks River to the east and Marsh Street to the north and west. The site is approximately 36.2 ha and is owned and managed by a number of landowners, both public and private. Surrounding development includes the Sydney Airport International Terminal precinct, Mercure Sydney Airport, an area of low density dwellings presently transitioning to medium-high density residential flat buildings, recreation and open space facilities, and road and airport related infrastructure.

### Kogarah Golf Club

Kogarah Golf Club was established in 1928, with the Club occupying the land subject to the Planning Proposal boundary since 1955. At this time, the Cooks River was reconfigured to its current alignment to accommodate the expansion of Sydney Airport. The land presents a highly modified environment, with relatively flat topography, gently moulded fairways and greens, separated by strips of vegetation and man-made water bodies. The golf course clubhouse, car park, and maintenance facilities are located in the northern corner of the site, adjacent the Cooks River. Access is provided via Levey Street. The members of Kogarah Golf Club will relocate from the site in May 2024 to new playing facilities.

### Arncliffe Motorway Operations Complex

The temporary construction compound for the WestConnex M8 and M6 Stage 1 Motorway tunnelling works was originally established in June 2016. The temporary construction facility occupies approximately 7.5 ha and is expected to remain until 2025. At this time the facility will reduce to 1.5 ha to accommodate the permanent Arncliffe Motorway Operations Complex, located in the western corner of the site, adjacent Marsh Street. The complex will house ventilation and water treatment plant and maintenance equipment for both the M6 and M8 sub-grade motorways.

### Easements and Affectations

The Sydney Desalination Plant pipeline runs through the development zone, north-south adjacent the Cooks River. The pipe has a diameter of 1.8 m and sits within an easement of 6-9 m in width. From south to north the pipeline is constructed in a combination of trench and above ground with mounded cover and then transitions to micro-tunnel and typical depth of circa 11 m. The Moomba to Sydney Pipeline, containing ethane gas, follows a similar general alignment north-south adjacent the Cooks River. The pipe has a nominal 225 mm diameter, within an easement generally 5 m wide and with the pipe located at a depth of 1.2-2.3 m.

# 2. Wind Shear and Turbulence Assessment

## 2.1 Introduction

Arup has been engaged by Cook Cove Inlet to quantify the impact of the proposed Cooks Cove development on aircraft operations at Sydney Airport. A development of this size and proximity to the runways has the potential to cause adverse wind conditions during aircraft landing by increasing wind shear and building induced turbulence. This report quantifies the impact of the development on aircraft operations based on standard airport operating procedures.

The proposed Cooks Cove development is located to the west of Sydney Airport, Figure 3, illustrating the proximity to the runways and the NASF Guideline B wind assessment zones. It is evident the multi-building development is entirely within the assessment zone for Runway 07, but predominantly outside the assessment zone for Runway 16R, Figure 3. The proposed development consists of various stages, with the final completed form shown in Figure 4.

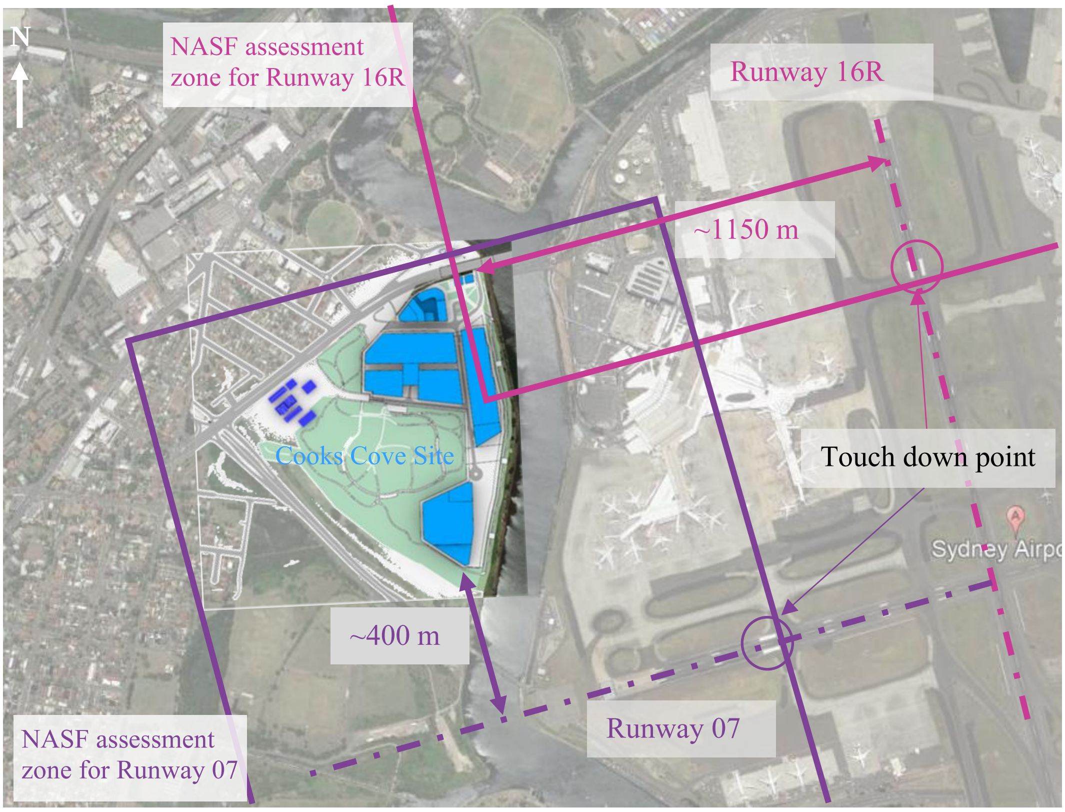



Figure 3: Aerial view showing site location and NASF assessment zones for Runway 16R and 07

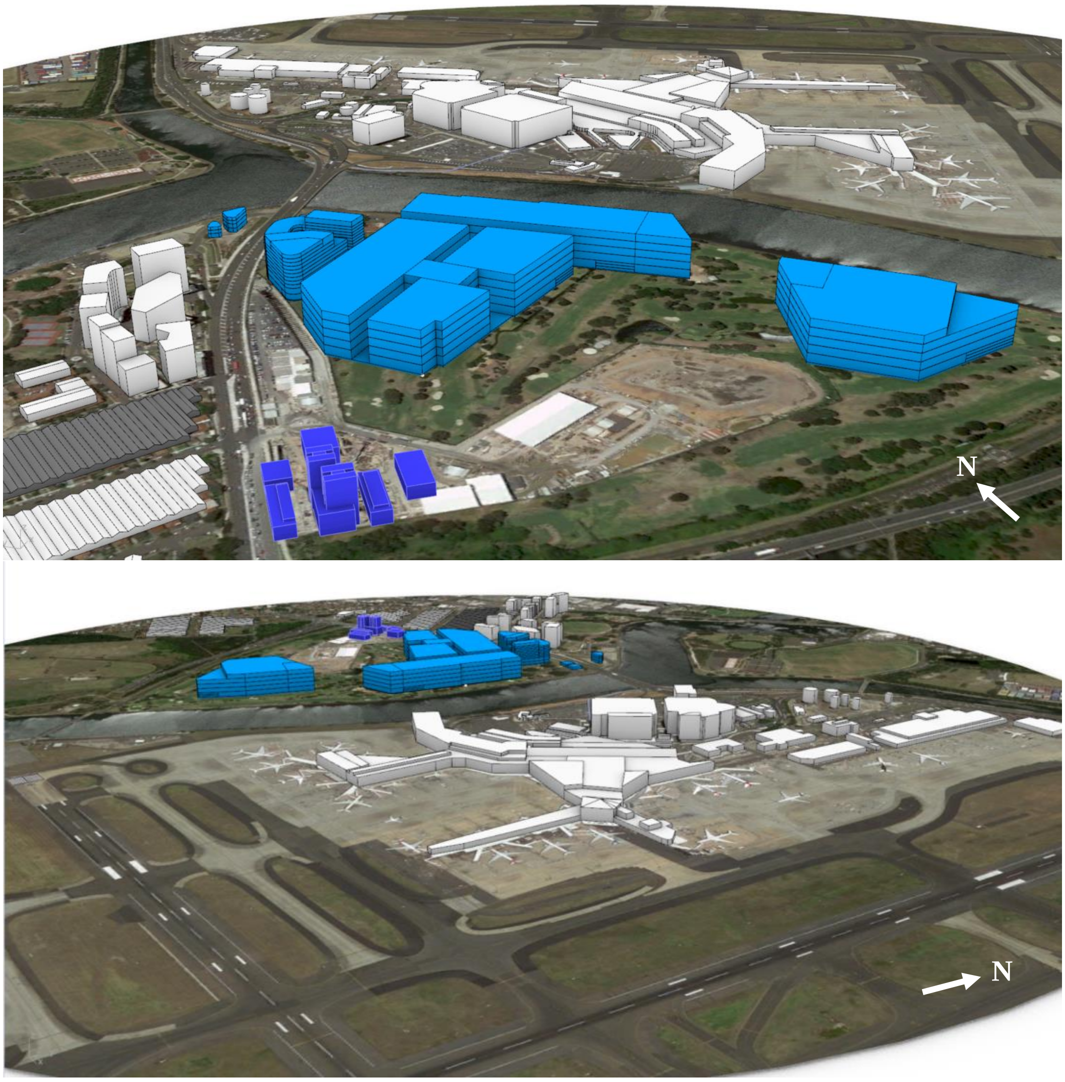



**Figure 4: Perspective of site in final configuration from SW (T) and SE (B)**

A full-scale numerical model of the Cooks Cove development and surrounds was developed for the study. The model is based on the existing built form of the surroundings and does not include potential future developments in the area; either in the Sydney Airport International terminal precinct, or in the surrounding suburban area.

In accordance with NASF (2018), four wind directions were investigated as shown in Figure 5, representing critical cases for landing aircraft for wind shear and turbulence. Since the development is completely within the assessment zone for Runway 07, three wind directions were considered. Case 1 is orthogonal to Runways 07 to investigate a pure cross-flight wind direction. The other directions are in increments of 22.5° producing a headwind for landing aircraft. Due to the distance of the development from Runway 16R and the presence of the large terminal buildings between the site and the runway, the fourth wind scenario assesses the critical case for aircraft landing on Runway 16R. In accordance with NASF (2018), the results presented herein extend before and after the runway threshold by 900 and 400 m respectively, and up to a height of 60 m above ground level.

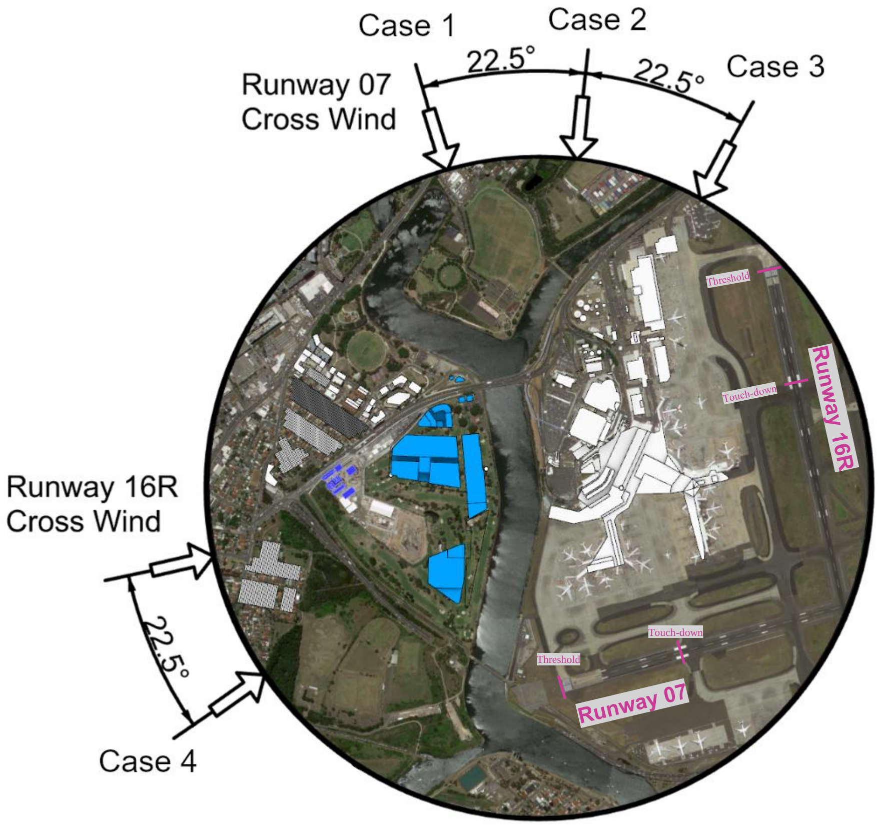



**Figure 5: Simulated wind directions for the proposed Cooks Cove development shown in light blue**

It is understood that the general operating requirements at Sydney Airport limit a 3 second gust cross-flight component to 10.3 m/s (20 kt) with a pilot discretionary limit of 12.9 m/s (25 kt), and a tail-wind of 2.6 m/s (5 kt). For winds at 45° to the runway, the measured wind speed in the wind direction would have to be 28 and 35 kt to cause a 20 or 25 kt component of wind speed in the pure cross-wind direction. For 22.5° this would be 21.6 and 27.1 kt, respectively. When these guideline limits are exceeded, alternate operational modes would be imposed as discussed in Section 2.3. It is understood that for operational efficiency, Sydney Airport maintains the use of the parallel runways for as long as possible. The wind gust duration provided by AirServices Australia and the Bureau of Meteorology is a “3-second average”. The sampling frequency of the data is unknown, which could have a minor influence on the results presented herein. Landing aircraft are decelerating and moving slower at a shallower slope than aircraft taking off, and are therefore more susceptible to changes in the relative wind speed between the aircraft and the wind thereby influencing the lift characteristics.

There are six anemometers located around the airport near the threshold to each runway. When the gust wind speed is higher than the measured readings, the operating runway may be changed. For this study, it has been assumed that only one anemometer is used for the assessment of the wind speed, and that is located in a similar turbulent environment to the landing aircraft. The typical approach speed of aircraft is between about 36 and 77 m/s (70 and 150 kt), which is significantly higher than operational wind speeds for the runways.

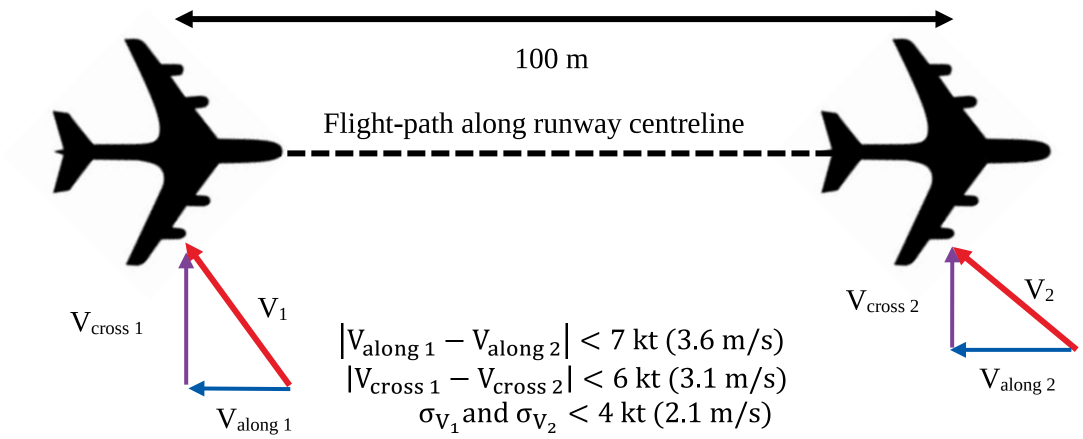
Arup has performed a numerical Computational Fluid Dynamics (CFD) study to quantify the wind speeds and turbulence characteristics along the glide path of landing aircraft. The results have been assessed against NASF (2018) wind shear and turbulent criteria to determine whether the impact on aircraft operations is deemed acceptable.

## 2.2 Assessment Criteria

The criteria used in this assessment is the National Airports Safeguarding Framework (NASF) Principles (2012) and Guidelines B (NASF 2018).

Landing aircraft are decelerating and travel at a lower speed than departing aircraft. Consequently, they are more susceptible to changes in the relative wind speed and turbulence. Departing aircraft are generally accelerating, and ascend more steeply than landing aircraft descend, further reducing their susceptance to local changes in wind conditions. The point of most interest for aircraft operations is therefore on the immediate approach to the touchdown point, below an elevation of 60 m, and the subsequent deceleration along the runway.

Based on the NASF (2018) guidelines, there are two mechanisms of concern for aircraft operations: wind shear and turbulence. Wind shear is the difference in the mean wind speed between two locations, whereas turbulence is a measure of the temporal fluctuations in the wind at the same location. There are two wind shear, and one turbulence criteria described in NASF (2018). From discussions with NLR, CASA, and DITRD&C, our interpretative sketch of the intended use of the NASF criteria is presented in Figure 6.




$$|V_{along\ 1} - V_{along\ 2}| < 7\ \text{kt}\ (3.6\ \text{m/s})$$
$$|V_{cross\ 1} - V_{cross\ 2}| < 6\ \text{kt}\ (3.1\ \text{m/s})$$
$$\sigma_{V_1} \text{ and } \sigma_{V_2} < 4\ \text{kt}\ (2.1\ \text{m/s})$$

Figure 6: Interpretative sketch of NLR criteria

In this work, wind shear is quantified for both along-flight and cross-flight wind directions by sampling wind speeds 100 m apart as outlined in the NASF guidelines, and turbulence is reported as the standard deviation in wind speed at any given location. A 20 m horizontal distance step is taken to ensure no flow feature is missed between a distance of 100 m and highest values for wind shear and turbulence in a 100m horizontal distance is reported.

It is important to note that wind speed and turbulence are discussed in terms of statistics. These statistics are combined with the operating procedures to quantify the potential probability of impact on airport operations.

In addition to this approach, a comparative study has been completed to show the difference in the wind conditions at the airport with and without the Cooks Cove development. If no significant change is shown between the CFD models, then the development would be deemed to not unduly impact aircraft operations from the existing condition. Any negative change in wind conditions has been combined with the historic wind climate for the airport to quantify the amount of time that operations would be impacted.

## 2.3 Aircraft Operations

The modes of operation at Sydney Airport are described in Figure 7 and Table 1 outlining the runways that could be impacted by the Cooks Cove development in the various modes of aircraft operation. From discussions with Sydney Airport regarding operational efficiency, the use of the parallel runways is critical to maintain the volume of traffic, therefore modes 9 and 10 are preferred.

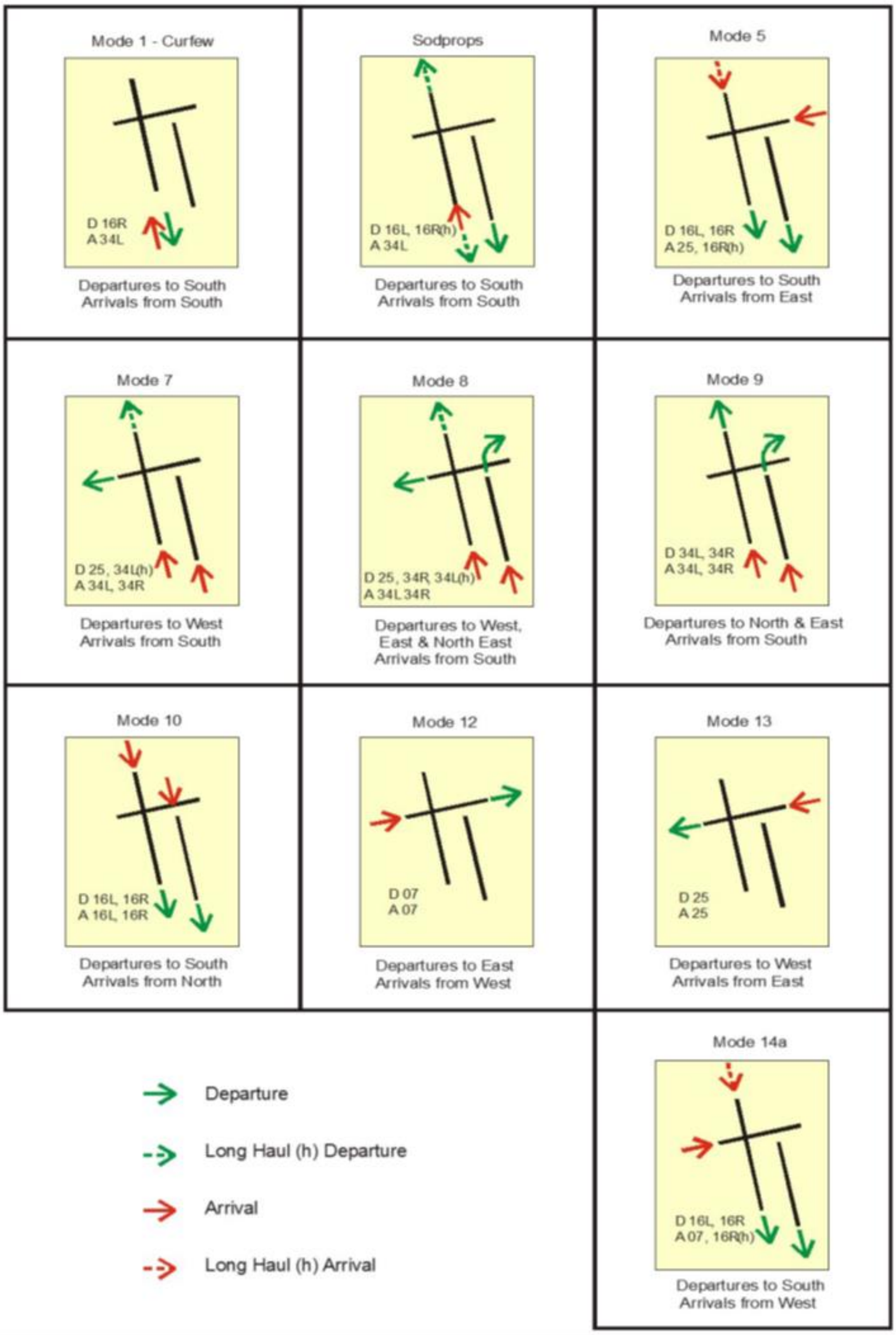



**Figure 7: Sydney Airport operational modes**

**Table 1: Potential impact of Cooks Cove development on landing aircraft modes**

| Mode | Operation | Impacts Runway 07 | Impacts Runway 16R |
|---|---|---|---|
| 1 | Curfew operation | No | No |
| Sodprops | Low volume traffic | No | No |
| 5 | Noise sharing | No | Yes |
| 7 | Noise sharing | No | No |
| 8 | Not used | No | No |
| 9 | Noise sharing and wind | No | No |
| 10 | Noise sharing and wind | No | Yes |
| 12 | Wind from east quadrant | Yes | No |
| 13 | Wind from west quadrant | No | No |
| 14a | Noise sharing | Yes | Yes |

Generally, the greatest effect of a structure on a landing aircraft is during a cross-wind perpendicular to the runway coming directly over the proposed development. Runway 07 would be most affected when Mode 12 is initiated, which would occur during strong winds from the east quadrant. For the Cooks Cove development to have an impact on the wind conditions for aircraft landing on Runway 07, the wind would have to be coming from the north-east quadrant otherwise the parallel runways would be preferred operationally. Similarly, the greatest impact of the proposed development on landings to Runway 16R would occur during strong winds from the south-west, affecting Modes 5, 10, and 14a. Runways 07 and 16R have been considered in the study, as the remaining runways are outside the zone of influence specified in NASF (2018), and during standard operating procedures are considered too remote from the proposed development to have an influence.

## 2.4 Methodology

Computational Fluid Dynamics (CFD) was used to quantify the along- and cross-flight wind speeds, and turbulence across the entire flow field; in particular along the vertical flight plane at both runway centrelines for the four wind directions.

A hex-dominant computational mesh comprising approximately 12 million cells was used to discretise the domain, Figure 8. The grid resolution is finer close to the ground plane where the shear stresses are greater, increasing in cell size with distance from the ground. Given the assessment criteria only requires the mean, and standard deviation of wind speed, the steady-state Reynolds Averaged Navier-Stokes (RANS) equations with the standard k-ω SST turbulence model were employed.

The equations for pressure, momentum, and turbulence quantities were discretised to second order accuracy to reduce the impact of numerical diffusion. Convergence was determined by monitoring the pressure, wind speed, and turbulence along the glideslope to both runways.

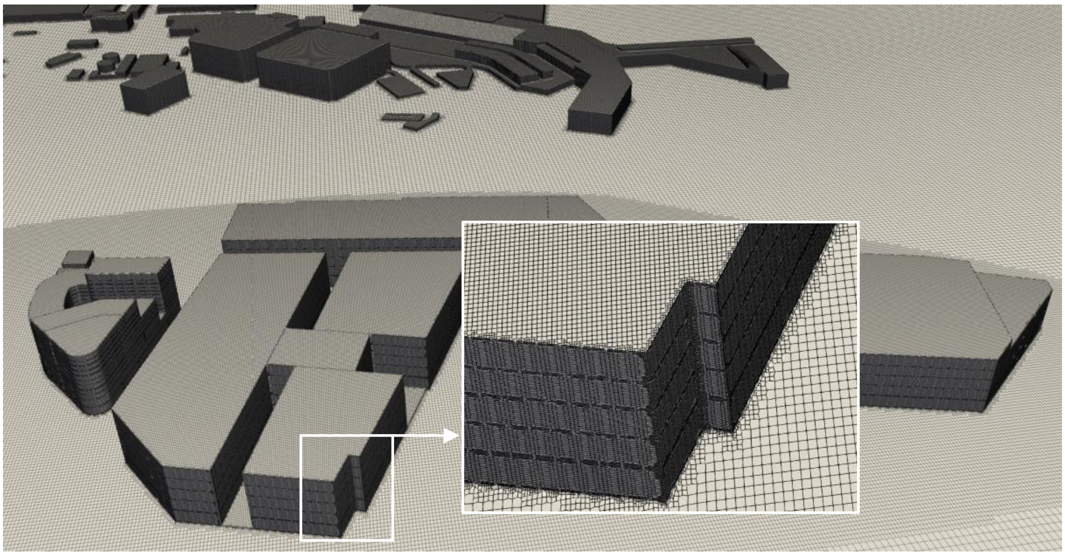


Figure 8: Mesh resolution

## 2.5 Atmospheric Boundary Layer Calibration

As discussed in Section 2.2, turbulence is quantified as the standard deviation of wind speed. The standard turbulence model used in this work allows for the extraction of the standard deviation of wind speed at every point in the simulation. This value is used to compare the wind conditions with the assessment criteria.

The turbulence at any location is a function of the natural turbulence in the wind generated by the upwind topography and terrain, and from the surrounding buildings. This is often overlooked in CFD studies where only turbulence generated by the upwind buildings is captured. To capture the effect of the upwind topography and terrain on turbulence, an Atmospheric Boundary Layer (ABL) profile matched to the local climate and terrain was used at the inlet of the domain. This ABL captures the effect of upwind terrain and topography without explicitly modelling it; similar to the approach used in wind tunnel testing. To ensure the ABL does not decay significantly throughout the computational domain, calibration studies were performed on an empty domain with various mesh and simulation boundary conditions.

The modelled wind speed and turbulence intensity profiles at the inlet and the edge to Cooks Cove site in an empty computational domain is presented in Figure 9, for the approach over suburban terrain, as defined in Standards Australia (2021) as Terrain Category 3 (TC3). Note there are some minor discrepancies between the modelled wind speed and turbulence intensity profiles compared with the profiles in Standards Australia (2021), and the CFD at the inlet and the entry of the Cooks Cove region in the empty domain. Nevertheless, the determinacies are within an acceptable range of 10% from AS/NZS 1170.2 profiles and show a relatively stable boundary layer across the domain. This approach ensures that the correct levels of “background” turbulence are accounted for in the assessment and the small turbulence decay closer to the ground is accounted for in the post-processing stage with appropriate correction factors.

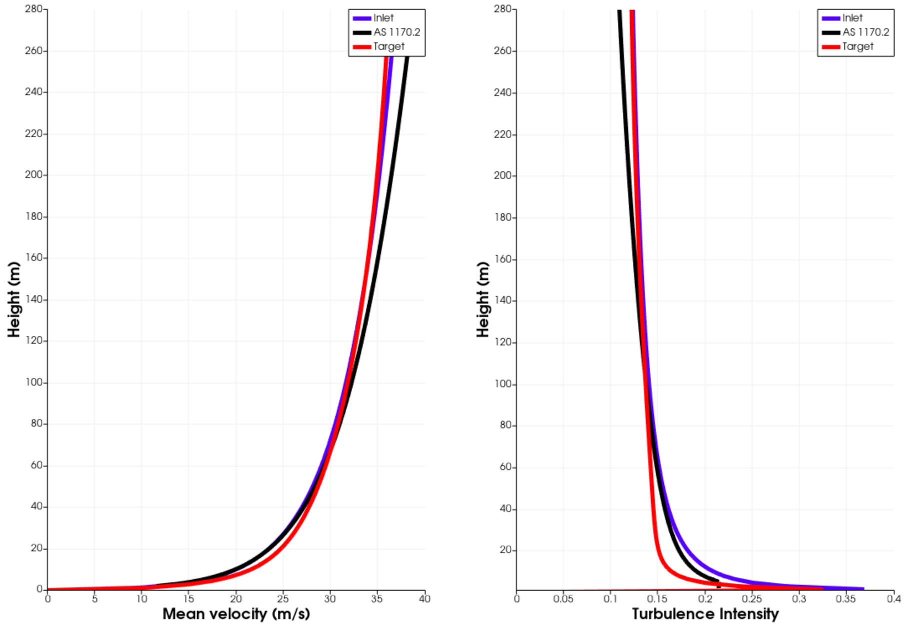



**Figure 9: Atmospheric boundary layer wind seed ratio (L) and turbulence intensity profile (R)**

With standard approach profiles for mean wind speed and turbulence, the natural wind conditions have the potential to cause wind shear and turbulence issues for landing aircraft. The peak 3 s gust wind speed, measured at an anemometer location at a height of 10 m in similar approach conditions, required to exceed the NASF (2018) wind shear and turbulence criteria would be greater than 100 kt and about 30 kt respectively at runway plane. The 3 s gust wind speed at anemometer height to exceed the turbulence criterion in various surface roughness conditions is presented in Figure 10. It is evident that the turbulence criterion in the natural flow is more critical than the wind shear criterion. The differences in the turbulence structure between natural wind and building induced turbulence is not assessed in Nieuwpoort (2010) or NASF (2018).

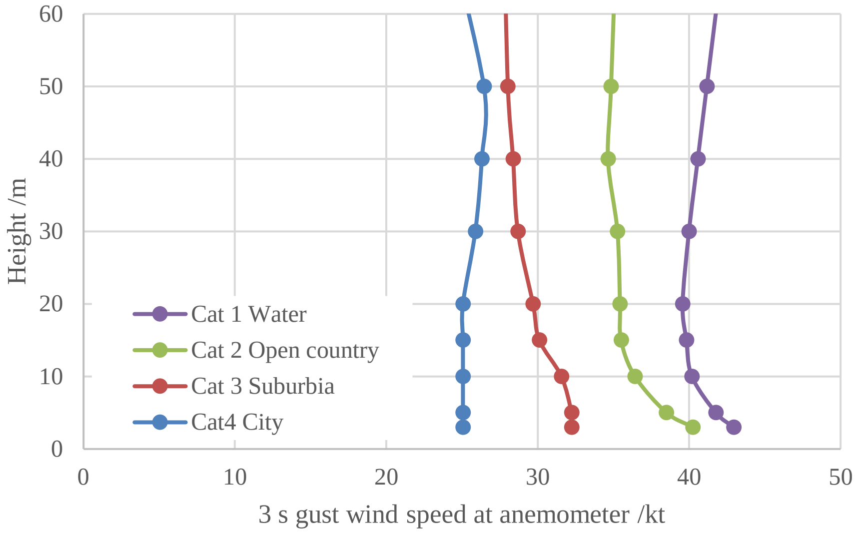



**Figure 10: Required 3 s gust at anemometer height for wind conditions to exceed 4 kt turbulence criterion**

## 2.6 Results

The velocity and turbulence contour plots at a representative horizontal plane 20 m above the runway threshold for the four cases are presented in Figure 11 and Figure 12, respectively.

### Wind shear

It can be seen in Case 1 with a pure cross-wind to Runway 07, that the largest gradient of wind speed along the runway as a result of the proposed Cooks Cove development would happen about 200 m before the threshold. It is evident the impact of the International Terminal building on the wind shear between the threshold and touchdown points with and without the proposed Cooks Cove development.

In Case 2, the wind has to travel a greater distance from the Cooks Cove development to the runway centreline extension and therefore the impact decreases. In addition, the alignment of the buildings, in particular the location of the proposed southern building closest to the runway is in the wake of upstream buildings thereby decreasing the impact of this building on the wind shear along the glideslope.

In Case 3, the southern building closest to the runway is more exposed and is only partially shielded by the upstream buildings. This results in a measurable building induced wind shear impacting about 700 m before the threshold.

The wind shear from the proposed Cooks Cove development in Case 4 where winds are 22.5° from the pure cross-wind direction to Runway 16R, is largely dissipated as a result of the significant distance from the runway and the presence of Sydney Airport terminal buildings downstream. Therefore, the building-induced wind shear impact of the proposed development is relatively small at Runway 16R.

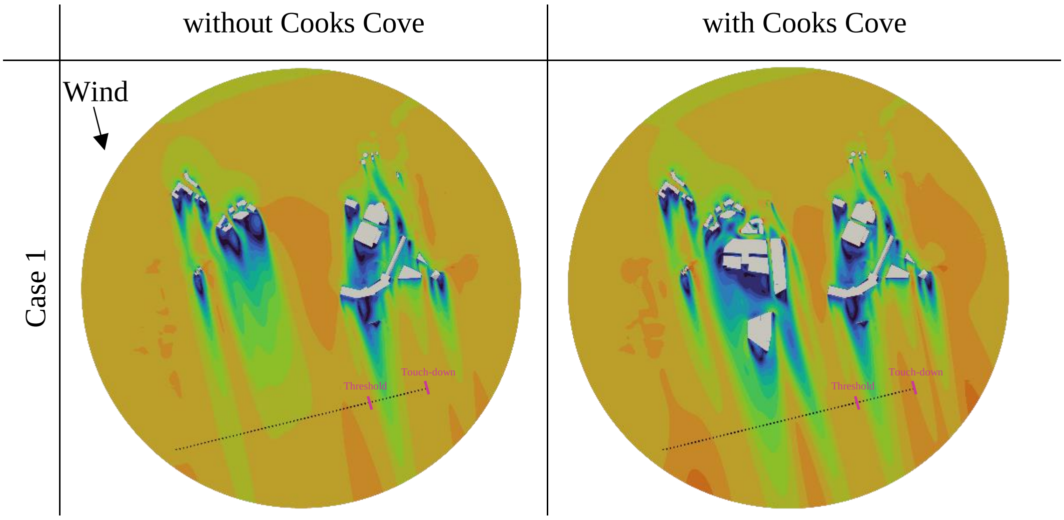



**Figure 11: Mean wind speed on horizontal plane 20 m above threshold for 4 cases with and without Cooks Cove development (cont)**

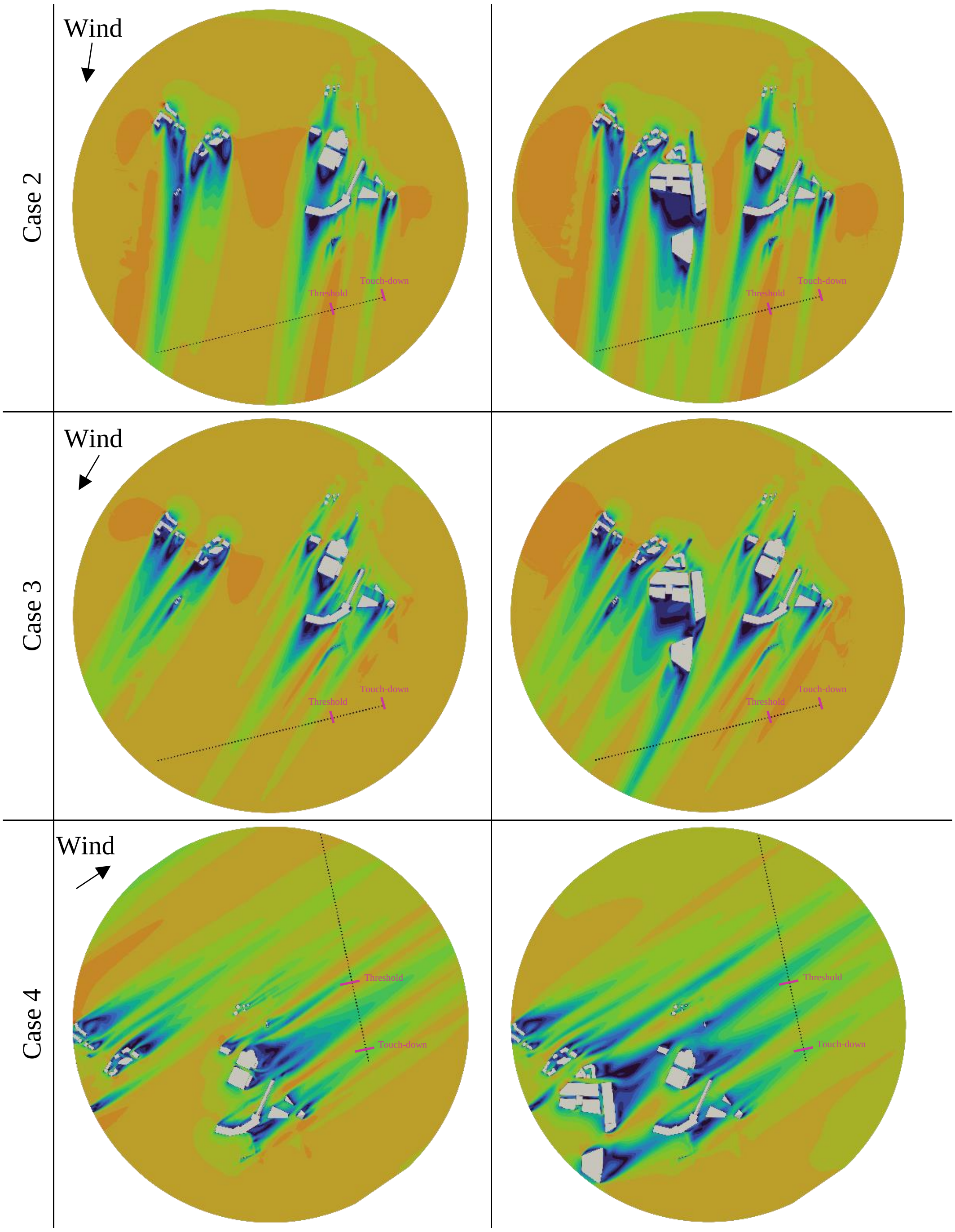



**Figure 11: Mean wind speed on horizontal plane 20 m above threshold for 4 cases with and without Cooks Cove development**

## Turbulence

In Case1, with the wind perpendicular to Runway 07, Figure 12, the proposed development impacts an area about 500 m before the threshold, primarily due to the proximity of the southern building. This area is already affected by the buildings to the north of the site without Cooks Cove development; however, the impact is less severe as the impact of the wake diminishes with greater distance from the runway. The region between threshold and touchdown point is impacted by the Sydney Airport terminal buildings hence the turbulence close to landing is similar to existing conditions.

In Case 2, the wake region characterised by high turbulence travels a greater distance from the buildings to the extension of the runway centreline, hence its magnitude is reduced compared with Case 1, and impacts further from the threshold. The Sydney Airport terminal buildings have a similar impact on the wind conditions with and without the Cooks Cove development.

In Case 3, as discussed in the previous section, the proposed southern building closest to the runway is partially exposed thereby generating turbulence that would impact the runway centreline approximately 600 to 700 m before the threshold.

In Case 4, the wake region of the proposed development extends to the Runway 16R; however due to the large distance, the turbulence is more dissipated producing only marginally impacts at higher elevations approximately 60 m above the local ground and 100-400 m behind the threshold as shown in Table 6.

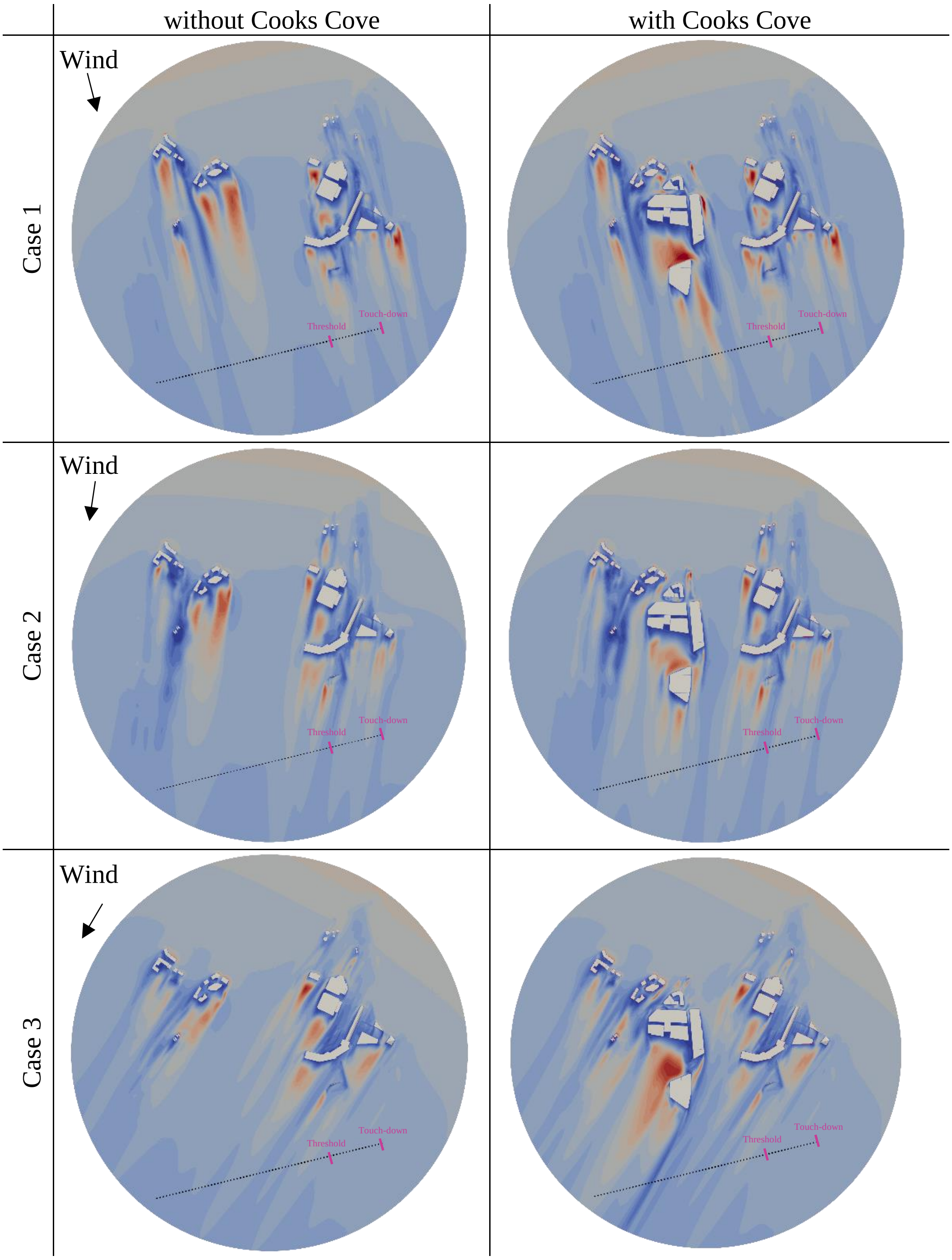



**Figure 12: Turbulence at horizontal plane at 20 m above threshold for 4 cases with and without Cooks Cove development (cont.)**

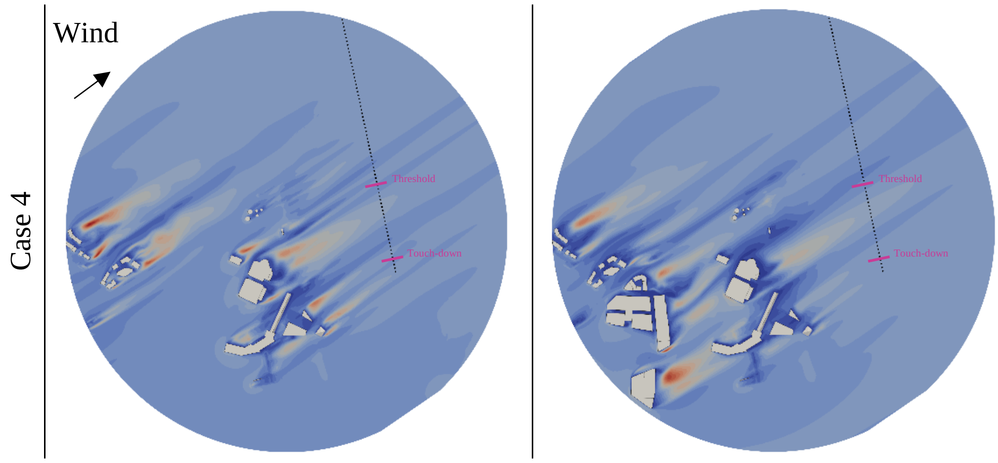



**Figure 12: Turbulence at horizontal plane at 20 m above threshold for 4 cases with and without Cooks Cove development**

## 2.7 Discussion

The 3 s gust wind speed at the anemometer location required to exceed the NASF (2018) criteria are presented in Table 3 to Table 6 in Appendix A.3. These tables present condensed data with each value representing the most critical measured from a finer array with horizontal by vertical resolution of 20 by 1 m along the glideslope plane. In these tables, the grey highlighted cells represent the 3° glideslope to the runway touchdown point, the grey text represents points under the 3° glideslope to the runway threshold, and yellow and orange text represents results with the required 3 s gust wind speed at anemometer height to be lower than 28 and 25 kt respectively to exceed the criteria. It is worth clarifying that lower values in the table represent more critical conditions as it means that the criterion would be exceeded at a lower gust wind speed at the anemometer location.

There is no case that exceeds the current 20 kt cross-wind operational wind speed (i.e. no measurement below than 20 kt in the tables, or 22 kt when the wind is at 22.5° to the cross-runway direction), but there are instances where the pure cross-wind drops to 23 kt approaching the 20 kt operational limit. For winds at 45° to the Runway, there are locations where the turbulence results are lower than the operational criterion of 28 kt both in the existing and proposed configurations.

In summary, the greatest impact of the Cooks Cove development is during a pure cross-wind to Runway 07, where the required 3 s gust wind speed at an anemometer in similar roughness characteristics to exceed the turbulence criterion level is 23 kt occurring approximately 100 to 200 m before the threshold at a height of 40 to 60 m above ground level. This wind speed is above the operation criteria, hence the runway would not be operational. During such a strong cross-wind, operational procedures would preference aircraft landing on Runways 34L and 34R.

An estimate of the amount of time difference per annum caused by the Cooks Cove development has been conducted. This assessment was carried out for both the minimum wind speed between the configurations, as this would be the most frequent to occur, and the largest change in wind speeds at a specific location causing an adverse effect on the wind conditions. To determine the minimum wind speed from Table 3 to Table 5, the cells with ±1 kt change in the wind speed were excluded as it was within the numerical computation rounding error. Moreover, the low wind speed cells affected by Sydney Airport terminal buildings were excluded from analysis. The results are presented in Table 2.

**Table 2: Maximum amount of time caused by changes in turbulent wind conditions**

| Scenario | | Minimum Wind Speed | | | Greatest Change | | |
|---|---|---|---|---|---|---|---|
| | | Without Cooks Cove (kt) | With Cooks Cove (kt) | No. Hours Difference | Without Cooks Cove (kt) | With Cooks Cove (kt) | No. Hours Difference |
| Runway 07 | Case 1 | 26 | 23 | 2 | 29 | 23 | <2 |
| | Case 2 | 26 | 24 | <4 | 30 | 25 | <1 |
| | Case 3 | 29 | 23 | 13 | 29 | 23 | 13 |
| Runway 16R | Case 4 | 30 | 28 | <3 | 33 | 28 | <3 |

The maximum total number of hours of difference in a year that the wind speeds could cause exceedance of the turbulence criterion was 13 hours for Case 3. The lowest wind speed for this direction remined in excess of the cross-flight operational wind speed. For this wind direction, Sydney Airport operations would prefer landing on Runways 34L and 34R. Please note that the timings are not necessarily consecutive. In Case 2, where winds 22.5° from perpendicular to the runway, the difference in the number of hours of exceedance increases to around 4 hours while the affected area and turbulence magnitude is reduced, Table 4. In Case 3, the difference in exceedance hours jumps to 13 hours due to the prevailing wind direction from north-east in Sydney. However, due to the location of the proposed Cooks Cove development and the greater travel distance for building-induced turbulence, the affected area is before the threshold (~600-700m) and impacting a smaller zone around 60 m above local ground level affecting aircraft landing between the threshold and touchdown points, Table 5. In Case 4 where wind is 22.5° from the cross-wind direction to Runway 16R, the lowest wind speed with the proposed development is 28 kt which above the 22 kt operational threshold for this wind angle. Although not exceeding the operational criteria, the number of hours per annum that the proposed development has an adverse impact is below 3 hours.

# References


Civil Aviation Authority (2021), Manual of Air Traffic Services – Part 1, CAP 493.

ICAO (International Civil Aviation Authority), 2005, Manual on low-level wind shear.

NASF, 2012, Managing the risk of building generated windshear and turbulence at airports, Guideline B.

NASF, 2018, Managing the risk of building generated windshear and turbulence at airports, Guideline B.

Nieuwpoort, A.M.H., J.H.M. Gooden, & J.L. de Prins, 2010, Wind criteria due to obstacles at and around airports, National Aerospace Laboratory, NLR-TP-2010-312.

Peterka, J.A., R.N. Meroney, and K.M. Kothari, 1985, Wind Flow Patterns About Buildings, Journal of Wind Engineering and Industrial Aerodynamics, Vol. 21, pp.21-38.

# A.1 Climate Analysis

The wind frequency and direction information measured by the Bureau of Meteorology anemometer at a standard height of 10 m at Sydney Airport from 1995 to 2021 have been used in this analysis. The arms of the wind rose point in the direction from where the wind is coming from. The directional wind speeds measured here are considered representative of the wind conditions at the site.

It is evident from Figure 13 that strong prevailing winds are organised into three main groups which centre at about the north-east, south, and west directions. Strong summer winds occur mainly from the north-east and south quadrant. Winds from the south are associated with large synoptic frontal systems and generally provide the strongest gusts during summer.

Winter and early spring strong winds typically occur from the west quadrants. West quadrant winds provide the strongest winds affecting the area throughout the year and tend to be associated with large scale synoptic events that can be hot or cold depending on inland conditions.

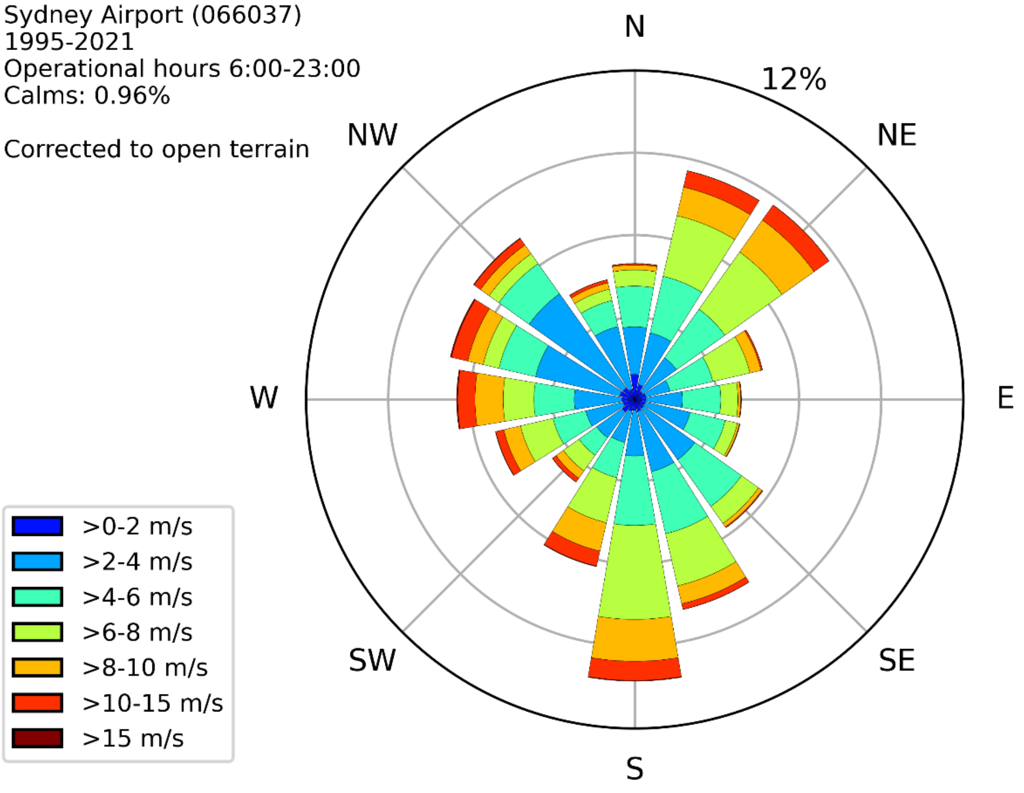



**Figure 13: Wind rose for operational hours**

## A.2 Discussion on wind shear and mechanical turbulence

Paragraph 2.2.1 from ICAO (2005) states:

'In the explanation of wind shear given in Chapter 1, the changes in wind speed and/or direction concern changes in the mean (or prevailing) wind from one reference point in space to another. Short-term fluctuations of the wind about a mean direction and/or speed are normally referred to as "variations" from the prevailing wind. Such variations of the wind, individually at least, are temporary, like eddies; while eddies clearly involve wind shear; because they are on a much smaller scale than an aircraft, they tend to affect the aircraft as bumpiness or turbulence. The scale on which the wind shear operates, in relation to the overall size of the aircraft concerned, is therefore of fundamental importance.'

From the above, it can be appreciated that wind shear is based on a difference in mean wind speed between two locations, whereas turbulence is the variation in wind speed and direction at a location with respect to time.

The "variations" mentioned above are generally called turbulence in the wind engineering community and will be used in this document. Turbulence can be quantified with the standard deviation of wind speed at a location with time. This does not give an indication of the size of, or energy level associated with the gusts. A spectral analysis would be required to extract the frequency structure of the gusts from which a measure of the size could be inferred. This is beyond the scope of the current discussion, and would be impractical to monitor full-scale.

To emphasise the difference between wind shear and turbulence, a brief discussion on the driving mechanisms involved in generating turbulence, and low level wind shear in the form of a thunderstorm downburst is included. Low level in wind engineering terms is defined as below about 500 m.

The typical atmospheric boundary layer created by large synoptic wind events is created by friction at the ground surface, and therefore changes from the ground up. The boundary layer typically extends about 500 to 1000 m above ground level. Increasing friction caused by ground objects causes a decrease in the near ground mean wind speed and an increase in turbulence. During strong wind events, the ratio of mean wind speed at 500 m to that at 10 m is typically about 1.6 for winds over open terrain (scattered trees and uncut grass), and 2.1 times for winds over suburbia. The mean wind speed at 500 m over open terrain is about 10% higher than that over suburbia. During strong wind events, turbulence intensity ratios between 500 m and 10 m are typically about 0.4, with winds over suburbia having about 1.3 times the turbulence intensity of those created over open country terrain. Turbulence intensity is defined as the standard deviation normalised by the local mean wind speed. It should be noted that at lower wind speeds, less than 10 m/s, the standard deviation and hence turbulence intensity values can increase.

To develop ICAO (2005) defined moderate and strong wind shear in open country terrain from 40 m to 10 m above ground level, the mean wind speed at 10 m would have to be in excess of 18 m/s (36 kt), and 33 m/s (66 kt) respectively. However, paragraph 5.2.8 of ICAO (2005) indicates that an aircraft could withstand a wind shear of 1.67 m/s per s (3 kt/s); for an aircraft landing in open country terrain with a ground speed of 55 m/s on a 3° glide slope, this would relate to a mean wind speed at a height of 10 m of approximately 75 m/s (150 kt), which would evidently never occur.

Turbulence intensity is wind speed dependent and the lower the mean wind speed the higher the turbulence intensity. However, once the mean wind speed exceeds about 10 m/s, (20 kt) the turbulence statistics become relatively less sensitive to wind speed. At the lower wind speeds, turbulence intensity is not considered a significant issue to aircraft safety, as the change in relative air speed between the aircraft and the wind is negligible. Turbulence is also a function of the meteorological event; local pressure driven winds such as a summer onshore wind will contain much smoother flow than winds associated with a large frontal system, even if they come from the same direction. This report only deals with developed atmospheric boundary layer flows and does not deal with meteorological events such as frontal systems and thunderstorm events, which cannot be practically modelled.

It is evident from the above, and an appreciation of the different surrounding terrain roughness that the existing wind conditions at an Airport are diverse depending on wind speed and direction. Determining the cause of any wind related pilot complaints based on isolated meteorological data would be exceptionally difficult; especially if it could be proven there were a lack of complaints during similar wind event days. It would be considered necessary to investigate the number of similar meteorological events and determine whether similar complaints were received on those days. Discussions with pilots would also be considered important to determine the frequency and severity of turbulent events.

The most likely cause of low-level wind shear at the Airport is caused by a frontal system, thunderstorm downdraft, or some form of temperature inversion. A mechanism for generating low level wind shear in thunderstorms is created by a descending column of cold air reaching the ground, then being turned by the ground plane, Figure 14. These events are called thunderstorm downbursts and have a central diameter of between 400 m and 4 km. The dashed white line starting on the left of Figure 14 at an elevation 1 k ft (300 m) is a typical glide slope for a landing aircraft. The concern for aviation is that a landing aircraft initially experiences a significant headwind in excess of 20 m/s (40 kt), which changes into a tailwind after passing through the centre of the descending column of air where the wind is coming vertically downward. The headwind causes the aircraft to rise, whereby the pilot will lower the throttle causing the aircraft to descend back to the glide slope, but then tailwind causes a reduction in lift causing the aircraft to land short of the runway. Thunderstorm downburst events typically last for only a few minutes and therefore have the spatial and temporal size to create localised wind shear.

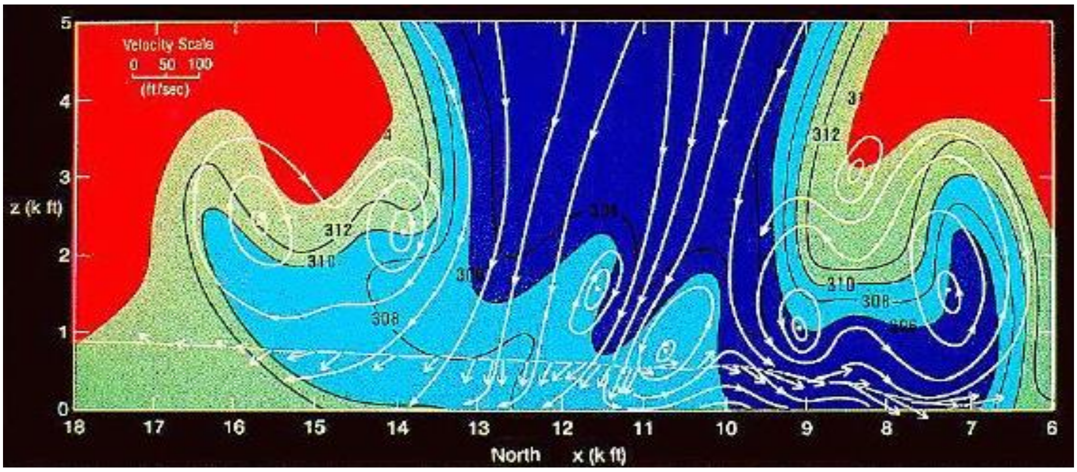



**Figure 14: Radar image of a thunderstorm downburst**

The wind flow patterns over a building Figure 15, are completely different in that there will be recirculation zones near the windward wall and roof edge, and in the immediate lee of the building.

The typical extent of these recirculation zones relative to the height of the structure, h, is illustrated conservatively in Figure 15; for instance Peterka et al. (1985) describe the downstream recirculation zone extending 2 to 6 times the height of the structure. These regions are not fixed but fluctuate in time thereby increasing downstream turbulence, but wind shear would only be experienced in the recirculation zones. As the distance increases from the structure the flow pattern will resort to the undisturbed state. This distance is a function of the geometry of the building, and the roughness of the surrounding terrain, but the mean velocity and turbulence intensity at roof height would be expected to be within 10% of the free stream conditions at 10 times the height of the structure downwind from the building. The building will influence the wind pattern to a distance larger than this, but the magnitude of any change would be slight. The frequency of turbulence shed from the building would be expected to be fairly high and the spatial extend of a similar size to a large aircraft, therefore any effect would be expected to be of short duration.

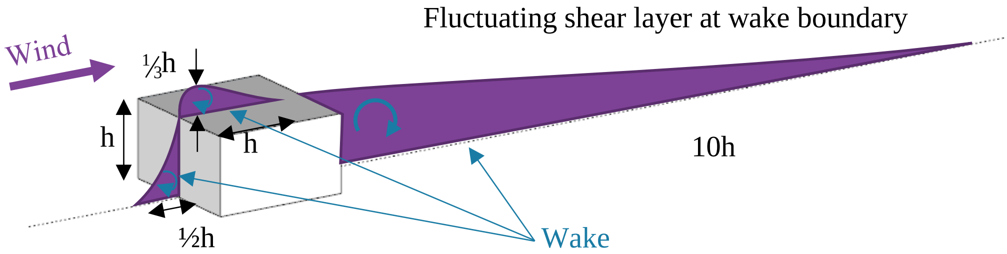



**Figure 15: Sketch of the flow pattern over an isolated structure**

It is evident from the above that the wind shear situation for flow over a structure is completely different to that for a thunderstorm. Unless the aircraft were to fly directly through one of the small wake regions, which are probably smaller in spatial extent than the aircraft itself, it would not experience any wind shear. The only concern would be if a large building were constructed right next to the runway and there were no provisions for using another runway during strong cross-wind events.

For oblique wind directions, flow around a large isolated regular structure has the potential to generate strong vortices that can extend for a significant distance downwind. These vortices have the potential to impact aircraft operations.

The wind flow pattern behind a group of buildings is significantly more complicated as the flow pattern is based on the compound shape. There is no method to analyse these complex flow pattern and physical or numerical modelling has to be adopted.

This discussion is in agreement with the ICAO Manual which in section 3.2.2 states:

'…This means that while the buildings are comparatively low, they present a wide and solid barrier to the prevailing surface wind flow. The wind flow is diverted around and over the buildings causing the surface wind to vary along the runway. Such horizontal wind shear, which is normally very localised, shallow and turbulent, is of particular concern to light aircraft operating into smaller aerodromes, but has also been known to affect larger aircraft.'

# A.3 Detailed Results

## Table 3. Case 1 - 3 s gust wind speeds in knots required to exceed specified criteria along Runway 07 (Operational limit of 20 kt)

### Case 1 Without Proposed Cook Cove Development

**Along-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 35_30 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 30_25 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 25_20 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 20_15 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 15_10 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 10_5 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |

**Cross-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | 82 | >100 | >100 | >100 | >100 | >100 | 46 | 52 | 76 |
| 55_50 | >100 | >100 | >100 | 91 | 73 | >100 | >100 | >100 | >100 | >100 | 41 | 47 | 65 |
| 50_45 | >100 | >100 | >100 | 83 | 66 | >100 | >100 | >100 | >100 | >100 | 37 | 42 | 59 |
| 45_40 | >100 | >100 | >100 | 76 | 60 | >100 | >100 | >100 | >100 | >100 | 34 | 38 | 54 |
| 40_35 | >100 | >100 | 95 | 69 | 54 | >100 | >100 | >100 | >100 | >100 | 31 | 36 | 51 |
| 35_30 | >100 | 94 | 85 | 64 | 50 | >100 | >100 | >100 | >100 | >100 | 30 | 34 | 49 |
| 30_25 | >100 | 85 | 77 | 58 | 45 | >100 | >100 | >100 | >100 | >100 | 29 | 33 | 49 |
| 25_20 | 99 | 76 | 70 | 53 | 41 | >100 | >100 | >100 | >100 | 86 | 29 | 32 | 50 |
| 20_15 | 78 | 67 | 62 | 47 | 37 | >100 | >100 | >100 | >100 | 70 | 28 | 31 | 53 |
| 15_10 | 54 | 51 | 49 | 38 | 32 | >100 | >100 | 98 | 68 | 51 | 28 | 30 | 63 |
| 10_5 | 48 | 46 | 44 | 36 | 30 | 84 | 89 | 79 | 59 | 46 | 27 | 29 | >100 |

**Turbulence**

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 30 | 29 | 27 | 27 | 27 | 26 | 26 | 26 | 28 | 29 | 28 | 23 | 23 | 28 |
| 55 | 30 | 29 | 28 | 27 | 27 | 26 | 26 | 26 | 28 | 29 | 28 | 23 | 23 | 28 |
| 50 | 30 | 30 | 28 | 27 | 27 | 26 | 26 | 26 | 28 | 29 | 29 | 23 | 24 | 29 |
| 45 | 31 | 30 | 28 | 28 | 28 | 26 | 26 | 27 | 29 | 30 | 29 | 24 | 24 | 29 |
| 40 | 31 | 30 | 28 | 28 | 28 | 27 | 26 | 27 | 29 | 30 | 29 | 24 | 24 | 29 |
| 35 | 31 | 30 | 28 | 28 | 29 | 27 | 27 | 27 | 29 | 30 | 29 | 25 | 25 | 30 |
| 30 | 32 | 31 | 29 | 28 | 29 | 28 | 28 | 28 | 30 | 31 | 29 | 26 | 26 | 30 |
| 25 | 32 | 31 | 29 | 29 | 30 | 29 | 28 | 29 | 30 | 31 | 30 | 27 | 27 | 31 |
| 20 | 32 | 32 | 30 | 30 | 31 | 30 | 29 | 29 | 31 | 31 | 30 | 28 | 28 | 31 |
| 15 | 32 | 32 | 31 | 31 | 32 | 31 | 30 | 31 | 31 | 32 | 31 | 30 | 30 | 31 |
| 10 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 |
| 5 | 31 | 31 | 32 | 31 | 31 | 34 | 33 | 32 | 32 | 32 | 32 | 32 | 34 | 31 |

### Case 1 With Proposed Cook Cove Development

**Along-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 35_30 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 30_25 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 25_20 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 20_15 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 15_10 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 10_5 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |

**Cross-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | 52 | 43 | 67 | 66 | 36 | 66 | >100 | 40 | 49 | 54 |
| 55_50 | >100 | >100 | >100 | 47 | 40 | 63 | 58 | 31 | 53 | >100 | 36 | 44 | 49 |
| 50_45 | >100 | >100 | >100 | 44 | 37 | 61 | 51 | 28 | 45 | >100 | 33 | 41 | 45 |
| 45_40 | >100 | >100 | >100 | 41 | 35 | 61 | 46 | 26 | 40 | >100 | 31 | 39 | 43 |
| 40_35 | >100 | >100 | 98 | 39 | 33 | 62 | 41 | 24 | 38 | >100 | 30 | 37 | 41 |
| 35_30 | >100 | >100 | 89 | 38 | 31 | 64 | 38 | 23 | 36 | >100 | 29 | 36 | 41 |
| 30_25 | >100 | 90 | 80 | 36 | 30 | 67 | 36 | 23 | 36 | >100 | 29 | 36 | 41 |
| 25_20 | 99 | 82 | 73 | 35 | 29 | 68 | 35 | 23 | 36 | >100 | 29 | 36 | 43 |
| 20_15 | 79 | 70 | 64 | 33 | 28 | 68 | 35 | 23 | 38 | >100 | 29 | 37 | 47 |
| 15_10 | 54 | 51 | 50 | 31 | 26 | 70 | 36 | 22 | 44 | 67 | 30 | 37 | 60 |
| 10_5 | 48 | 45 | 46 | 29 | 25 | 65 | 45 | 21 | 71 | 59 | 29 | 36 | >100 |

**Turbulence**

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 30 | 29 | 28 | 27 | 25 | 24 | 24 | 24 | 23 | 28 | 28 | 23 | 23 | 28 |
| 55 | 30 | 29 | 28 | 27 | 25 | 24 | 24 | 24 | 23 | 28 | 28 | 23 | 23 | 28 |
| 50 | 30 | 30 | 28 | 27 | 25 | 24 | 24 | 23 | 23 | 28 | 28 | 23 | 23 | 29 |
| 45 | 31 | 30 | 28 | 28 | 26 | 24 | 24 | 23 | 23 | 28 | 28 | 23 | 24 | 29 |
| 40 | 31 | 30 | 28 | 28 | 26 | 25 | 24 | 23 | 23 | 28 | 29 | 24 | 24 | 29 |
| 35 | 31 | 30 | 29 | 28 | 27 | 25 | 24 | 23 | 24 | 29 | 29 | 25 | 25 | 29 |
| 30 | 32 | 31 | 29 | 28 | 28 | 26 | 25 | 24 | 25 | 29 | 29 | 26 | 26 | 30 |
| 25 | 32 | 31 | 29 | 29 | 29 | 27 | 26 | 24 | 26 | 29 | 29 | 27 | 27 | 30 |
| 20 | 32 | 31 | 30 | 30 | 30 | 29 | 28 | 25 | 27 | 30 | 30 | 28 | 29 | 30 |
| 15 | 32 | 32 | 31 | 31 | 32 | 31 | 30 | 27 | 29 | 30 | 30 | 29 | 31 | 31 |
| 10 | 32 | 32 | 32 | 32 | 32 | 33 | 33 | 28 | 32 | 31 | 31 | 31 | 33 | 31 |
| 5 | 31 | 31 | 32 | 32 | 32 | 38 | 34 | 30 | 34 | 33 | 32 | 32 | 34 | 31 |

## Table 4. Case 2 - 3 s gust wind speeds in knots required to exceed specified criteria along Runway 07 (Operational limit of 22 kt)

### Case 2 Without Proposed Cook Cove Development

**Along-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 35_30 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 30_25 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 25_20 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 20_15 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 15_10 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 80 | >100 | 95 |
| 10_5 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 75 | >100 | 90 |

**Cross-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | 74 | >100 | >100 | >100 | >100 | >100 | >100 | 76 | 82 | 89 | >100 | >100 | >100 |
| 55_50 | 69 | >100 | >100 | >100 | >100 | >100 | >100 | 63 | 70 | 77 | >100 | >100 | 93 |
| 50_45 | 65 | >100 | >100 | >100 | >100 | >100 | 99 | 55 | 62 | 69 | >100 | >100 | 76 |
| 45_40 | 61 | >100 | >100 | >100 | >100 | >100 | 89 | 49 | 56 | 64 | >100 | >100 | 64 |
| 40_35 | 59 | >100 | >100 | >100 | >100 | >100 | 80 | 45 | 55 | 62 | 97 | >100 | 57 |
| 35_30 | 58 | >100 | >100 | >100 | >100 | >100 | 73 | 41 | 56 | 63 | 81 | >100 | 49 |
| 30_25 | 57 | >100 | >100 | >100 | >100 | >100 | 68 | 39 | 56 | 65 | 69 | 92 | 45 |
| 25_20 | 58 | >100 | >100 | >100 | >100 | >100 | 63 | 37 | 58 | 74 | 58 | 83 | 41 |
| 20_15 | 60 | >100 | >100 | >100 | >100 | 99 | 57 | 35 | 64 | 94 | 48 | 66 | 38 |
| 15_10 | 71 | 77 | 84 | 81 | 74 | 66 | 47 | 32 | 81 | >100 | 38 | 48 | 33 |
| 10_5 | 90 | 65 | 69 | 66 | 62 | 57 | 43 | 31 | 71 | >100 | 35 | 42 | 32 |

**Turbulence**

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 26 | 28 | 28 | 28 | 29 | 29 | 29 | 27 | 24 | 25 | 30 | 29 | 27 | 26 |
| 55 | 26 | 28 | 28 | 28 | 29 | 29 | 29 | 27 | 24 | 25 | 30 | 29 | 27 | 26 |
| 50 | 26 | 28 | 28 | 28 | 30 | 30 | 29 | 27 | 24 | 25 | 30 | 29 | 27 | 26 |
| 45 | 27 | 28 | 28 | 29 | 30 | 30 | 30 | 27 | 25 | 26 | 30 | 29 | 27 | 26 |
| 40 | 28 | 29 | 28 | 29 | 30 | 30 | 30 | 28 | 25 | 26 | 30 | 29 | 28 | 26 |
| 35 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 28 | 26 | 27 | 30 | 29 | 28 | 27 |
| 30 | 29 | 29 | 29 | 30 | 31 | 31 | 31 | 28 | 27 | 28 | 30 | 29 | 28 | 27 |
| 25 | 31 | 30 | 30 | 30 | 31 | 31 | 31 | 29 | 28 | 29 | 30 | 29 | 29 | 28 |
| 20 | 32 | 30 | 30 | 31 | 31 | 31 | 31 | 30 | 29 | 29 | 30 | 29 | 30 | 29 |
| 15 | 32 | 31 | 31 | 31 | 32 | 31 | 31 | 31 | 30 | 30 | 31 | 30 | 31 | 31 |
| 10 | 33 | 32 | 32 | 32 | 31 | 31 | 31 | 32 | 32 | 30 | 30 | 31 | 31 | 32 |
| 5 | 33 | 32 | 32 | 31 | 31 | 31 | 31 | 31 | 34 | 31 | 30 | 30 | 31 | 31 |

### Case 2 With Proposed Cook Cove Development

**Along-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 35_30 | 97 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 30_25 | 94 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 25_20 | 93 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 20_15 | 93 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 93 | >100 | >100 |
| 15_10 | 99 | >100 | 99 | >100 | >100 | >100 | >100 | 98 | >100 | >100 | 74 | >100 | 92 |
| 10_5 | >100 | >100 | 94 | >100 | >100 | >100 | >100 | 94 | >100 | >100 | 69 | >100 | 87 |

**Cross-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | 48 | 99 | 70 | >100 | >100 | >100 | >100 | 60 | 76 | 87 | >100 | >100 | >100 |
| 55_50 | 45 | 93 | 64 | >100 | 86 | >100 | >100 | 50 | 65 | 77 | >100 | >100 | 92 |
| 50_45 | 42 | 88 | 59 | >100 | 71 | 88 | 99 | 45 | 58 | 70 | >100 | >100 | 75 |
| 45_40 | 40 | 85 | 55 | >100 | 62 | 78 | 86 | 41 | 54 | 66 | >100 | >100 | 64 |
| 40_35 | 39 | 84 | 53 | 93 | 57 | 71 | 76 | 37 | 52 | 65 | 94 | >100 | 55 |
| 35_30 | 38 | 85 | 49 | 81 | 55 | 68 | 69 | 35 | 52 | 65 | 78 | >100 | 48 |
| 30_25 | 38 | 87 | 47 | 72 | 55 | 67 | 63 | 33 | 53 | 68 | 66 | 95 | 44 |
| 25_20 | 38 | 83 | 46 | 65 | 54 | 65 | 59 | 32 | 54 | 77 | 55 | 86 | 40 |
| 20_15 | 39 | 74 | 43 | 58 | 52 | 60 | 55 | 31 | 59 | 78 | 46 | 69 | 37 |
| 15_10 | 45 | 56 | 38 | 49 | 45 | 49 | 47 | 29 | 70 | 84 | 36 | 49 | 33 |
| 10_5 | 75 | 50 | 36 | 45 | 42 | 45 | 44 | 28 | >100 | >100 | 33 | 43 | 31 |

**Turbulence**

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 24 | 25 | 27 | 25 | 26 | 27 | 27 | 27 | 24 | 25 | 29 | 29 | 27 | 26 |
| 55 | 24 | 26 | 27 | 25 | 26 | 26 | 27 | 27 | 24 | 25 | 30 | 29 | 27 | 26 |
| 50 | 25 | 26 | 27 | 25 | 25 | 26 | 27 | 27 | 24 | 25 | 30 | 29 | 27 | 26 |
| 45 | 25 | 26 | 27 | 25 | 26 | 26 | 27 | 27 | 24 | 26 | 30 | 29 | 27 | 26 |
| 40 | 26 | 27 | 28 | 25 | 26 | 26 | 27 | 27 | 25 | 26 | 30 | 29 | 28 | 26 |
| 35 | 27 | 27 | 28 | 26 | 26 | 27 | 27 | 27 | 25 | 27 | 30 | 29 | 28 | 26 |
| 30 | 28 | 28 | 29 | 26 | 27 | 27 | 27 | 28 | 26 | 28 | 30 | 29 | 28 | 27 |
| 25 | 29 | 29 | 29 | 27 | 27 | 28 | 28 | 28 | 27 | 28 | 30 | 29 | 29 | 28 |
| 20 | 30 | 30 | 30 | 28 | 29 | 29 | 30 | 29 | 29 | 28 | 31 | 29 | 30 | 29 |
| 15 | 32 | 31 | 31 | 30 | 30 | 30 | 31 | 31 | 30 | 29 | 31 | 30 | 30 | 30 |
| 10 | 33 | 31 | 31 | 32 | 31 | 32 | 33 | 32 | 33 | 30 | 30 | 30 | 31 | 32 |
| 5 | 35 | 30 | 30 | 33 | 33 | 34 | 33 | 33 | 35 | 31 | 29 | 30 | 31 | 31 |

## Table 5. Case 3 - 3 s gust wind speeds in knots required to exceed specified criteria along Runway 07 (Operational limit of 28 kt)

### Case 3 Without Proposed Cook Cove Development

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 35_30 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 97 | >100 | >100 | >100 | >100 |
| 30_25 | >100 | >100 | >100 | 97 | 99 | >100 | >100 | >100 | 86 | >100 | >100 | >100 | >100 |
| 25_20 | >100 | >100 | >100 | 90 | 91 | >100 | >100 | >100 | 77 | >100 | >100 | >100 | >100 |
| 20_15 | >100 | >100 | >100 | 82 | 82 | >100 | 98 | >100 | 67 | >100 | >100 | >100 | >100 |
| 15_10 | >100 | >100 | >100 | 68 | 69 | >100 | 73 | 97 | 56 | >100 | 99 | 80 | >100 |
| 10_5 | 94 | 88 | 94 | 63 | 64 | >100 | 66 | 84 | 52 | >100 | 84 | 71 | 96 |

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 92 | >100 | >100 | >100 | >100 |
| 35_30 | >100 | >100 | >100 | 89 | 90 | >100 | >100 | >100 | 82 | >100 | >100 | >100 | >100 |
| 30_25 | >100 | >100 | >100 | 84 | 82 | >100 | >100 | >100 | 73 | >100 | >100 | >100 | >100 |
| 25_20 | >100 | >100 | >100 | 77 | 75 | >100 | >100 | >100 | 66 | >100 | >100 | >100 | >100 |
| 20_15 | >100 | >100 | >100 | 70 | 67 | >100 | 85 | >100 | 58 | >100 | >100 | >100 | >100 |
| 15_10 | 97 | 90 | 96 | 58 | 56 | >100 | 63 | 95 | 49 | >100 | 94 | 71 | 92 |
| 10_5 | 81 | 76 | 81 | 53 | 52 | >100 | 57 | 80 | 46 | >100 | 79 | 63 | 78 |

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 30 | 29 | 29 | 29 | 27 | 27 | 28 | 29 | 27 | 26 | 27 | 28 | 28 | 28 |
| 55 | 30 | 30 | 29 | 29 | 27 | 27 | 28 | 29 | 27 | 26 | 27 | 28 | 28 | 28 |
| 50 | 30 | 30 | 30 | 29 | 27 | 27 | 28 | 29 | 27 | 26 | 28 | 29 | 28 | 28 |
| 45 | 30 | 30 | 30 | 30 | 27 | 27 | 29 | 30 | 28 | 26 | 28 | 29 | 28 | 28 |
| 40 | 31 | 30 | 30 | 30 | 27 | 27 | 29 | 30 | 28 | 27 | 28 | 29 | 29 | 29 |
| 35 | 31 | 31 | 30 | 30 | 28 | 27 | 29 | 30 | 28 | 27 | 28 | 29 | 29 | 29 |
| 30 | 31 | 31 | 30 | 31 | 28 | 28 | 30 | 30 | 28 | 27 | 29 | 30 | 29 | 29 |
| 25 | 31 | 31 | 31 | 31 | 29 | 29 | 30 | 30 | 29 | 28 | 29 | 30 | 29 | 30 |
| 20 | 32 | 31 | 31 | 31 | 30 | 30 | 31 | 30 | 30 | 29 | 30 | 31 | 30 | 30 |
| 15 | 32 | 32 | 32 | 32 | 31 | 31 | 32 | 31 | 31 | 30 | 31 | 31 | 30 | 31 |
| 10 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 32 | 31 | 31 | 31 | 31 | 31 | 31 |
| 5 | 31 | 31 | 31 | 31 | 32 | 33 | 31 | 31 | 31 | 32 | 30 | 30 | 31 | 30 |

### Case 3 With Proposed Cook Cove Development

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | 72 | 45 | 77 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | 64 | 41 | 54 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | 59 | 37 | 49 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | 56 | 35 | 42 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | 54 | 35 | 39 | >100 | 99 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 35_30 | >100 | 53 | 35 | 36 | >100 | 93 | >100 | >100 | 87 | >100 | >100 | >100 | >100 |
| 30_25 | >100 | 53 | 36 | 35 | >100 | 89 | >100 | >100 | 77 | >100 | >100 | >100 | >100 |
| 25_20 | >100 | 52 | 37 | 35 | >100 | 89 | >100 | >100 | 68 | >100 | >100 | >100 | >100 |
| 20_15 | >100 | 51 | 38 | 37 | >100 | 91 | >100 | >100 | 60 | >100 | >100 | >100 | >100 |
| 15_10 | 95 | 48 | 39 | 40 | >100 | >100 | 81 | >100 | 51 | >100 | 99 | 78 | >100 |
| 10_5 | 82 | 46 | 39 | 54 | 94 | >100 | 71 | 86 | 48 | >100 | 84 | 69 | 91 |

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | 53 | 32 | 44 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 55_50 | >100 | 51 | 30 | 35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 50_45 | >100 | 51 | 28 | 33 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 |
| 45_40 | >100 | 52 | 28 | 31 | >100 | >100 | >100 | >100 | 96 | >100 | >100 | >100 | >100 |
| 40_35 | >100 | 54 | 28 | 31 | >100 | 98 | >100 | >100 | 86 | >100 | >100 | >100 | >100 |
| 35_30 | >100 | 58 | 29 | 32 | >100 | 93 | >100 | >100 | 76 | >100 | >100 | >100 | >100 |
| 30_25 | >100 | 63 | 28 | 32 | 94 | 90 | >100 | >100 | 68 | >100 | >100 | >100 | >100 |
| 25_20 | >100 | 70 | 28 | 34 | 86 | 90 | >100 | >100 | 61 | >100 | >100 | >100 | >100 |
| 20_15 | >100 | 78 | 27 | 38 | 76 | 94 | 98 | >100 | 55 | >100 | >100 | 97 | >100 |
| 15_10 | >100 | 76 | 24 | 46 | 64 | >100 | 69 | >100 | 46 | 93 | 94 | 68 | 86 |
| 10_5 | >100 | 67 | 23 | 42 | 59 | >100 | 62 | 96 | 43 | 79 | 79 | 60 | 74 |

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 26 | 28 | 24 | 23 | 28 | 26 | 27 | 29 | 28 | 26 | 27 | 28 | 28 | 28 |
| 55 | 26 | 28 | 24 | 24 | 28 | 26 | 28 | 29 | 28 | 26 | 27 | 28 | 28 | 28 |
| 50 | 26 | 28 | 25 | 25 | 28 | 27 | 28 | 30 | 28 | 26 | 27 | 29 | 28 | 28 |
| 45 | 26 | 28 | 25 | 26 | 28 | 27 | 28 | 30 | 28 | 26 | 27 | 29 | 28 | 28 |
| 40 | 26 | 28 | 26 | 26 | 28 | 27 | 28 | 30 | 28 | 27 | 28 | 29 | 29 | 29 |
| 35 | 26 | 29 | 27 | 27 | 29 | 28 | 29 | 30 | 29 | 27 | 28 | 30 | 29 | 29 |
| 30 | 27 | 29 | 28 | 29 | 29 | 29 | 30 | 30 | 29 | 27 | 29 | 30 | 29 | 29 |
| 25 | 27 | 29 | 29 | 31 | 31 | 30 | 30 | 30 | 29 | 28 | 29 | 30 | 29 | 30 |
| 20 | 28 | 30 | 30 | 32 | 32 | 31 | 31 | 30 | 30 | 29 | 30 | 31 | 30 | 30 |
| 15 | 29 | 30 | 31 | 34 | 35 | 32 | 32 | 31 | 31 | 30 | 31 | 31 | 30 | 31 |
| 10 | 30 | 31 | 32 | 36 | 37 | 34 | 32 | 32 | 31 | 31 | 31 | 30 | 31 | 31 |
| 5 | 30 | 30 | 32 | 37 | 37 | 34 | 31 | 31 | 30 | 32 | 30 | 30 | 30 | 30 |

## Table 6. Case 4 - 3 s gust wind speeds in knots required to exceed specified criteria along Runway 16R (Operational limit of 22 kt)

### Case 1 Without Proposed Cook Cove Development

**Along-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 62 | 66 | 79 | 84 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 97 | >100 | 57 | 63 | 66 | 73 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 73 | >100 | 53 | 61 | 57 | 65 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 62 | 94 | 51 | 60 | 52 | 59 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 55 | 81 | 50 | 60 | 48 | 55 |
| 35_30 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 50 | 73 | 48 | 59 | 46 | 52 |
| 30_25 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 46 | 67 | 47 | 58 | 45 | 51 |
| 25_20 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 43 | 63 | 46 | 57 | 45 | 51 |
| 20_15 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 41 | 59 | 46 | 56 | 47 | 50 |
| 15_10 | >100 | >100 | >100 | >100 | 93 | 83 | >100 | 37 | 52 | 44 | 53 | 52 | 47 |
| 10_5 | >100 | >100 | >100 | >100 | 89 | 80 | 96 | 36 | 49 | 43 | 51 | 76 | 45 |

**Cross-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 50 | 54 | 60 | 71 |
| 55_50 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 85 | >100 | 46 | 51 | 50 | 61 |
| 50_45 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 63 | 96 | 42 | 50 | 44 | 54 |
| 45_40 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 54 | 81 | 40 | 50 | 39 | 49 |
| 40_35 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 47 | 70 | 39 | 50 | 36 | 46 |
| 35_30 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 42 | 64 | 37 | 50 | 35 | 43 |
| 30_25 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 39 | 60 | 36 | 51 | 34 | 41 |
| 25_20 | >100 | >100 | >100 | >100 | >100 | >100 | >100 | 36 | 57 | 35 | 52 | 34 | 39 |
| 20_15 | >100 | >100 | >100 | >100 | 92 | 86 | >100 | 34 | 55 | 34 | 52 | 34 | 38 |
| 15_10 | >100 | >100 | 95 | >100 | 77 | 73 | 93 | 31 | 48 | 32 | 50 | 38 | 36 |
| 10_5 | >100 | >100 | 91 | >100 | 75 | 70 | 88 | 30 | 45 | 31 | 49 | 56 | 35 |

**Turbulence**

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 33 | 32 | 32 | 31 | 31 | 33 | 33 | 34 | 30 | 32 | 26 | 25 | 33 | 30 |
| 55 | 33 | 32 | 32 | 31 | 31 | 32 | 33 | 33 | 30 | 31 | 26 | 25 | 33 | 30 |
| 50 | 33 | 32 | 32 | 31 | 31 | 32 | 33 | 33 | 29 | 30 | 26 | 25 | 33 | 30 |
| 45 | 33 | 32 | 32 | 31 | 31 | 32 | 33 | 32 | 29 | 30 | 26 | 26 | 33 | 29 |
| 40 | 33 | 32 | 32 | 31 | 31 | 32 | 32 | 32 | 29 | 30 | 26 | 26 | 34 | 30 |
| 35 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 30 | 30 | 27 | 27 | 34 | 30 |
| 30 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 31 | 31 | 28 | 28 | 34 | 30 |
| 25 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 32 | 31 | 29 | 30 | 33 | 31 |
| 20 | 32 | 32 | 32 | 33 | 33 | 33 | 32 | 32 | 33 | 32 | 31 | 32 | 33 | 32 |
| 15 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 35 | 33 | 32 | 34 | 34 | 34 |
| 10 | 33 | 33 | 33 | 34 | 33 | 33 | 34 | 34 | 33 | 32 | 35 | 37 | 34 | 35 |
| 5 | 33 | 33 | 34 | 35 | 34 | 34 | 35 | 33 | 33 | 31 | 36 | 37 | 33 | 36 |

### Case 1 With Proposed Cook Cove Development

**Along-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | 93 | >100 | 78 | 49 | 80 | 85 | >100 | >100 | 98 |
| 55_50 | >100 | >100 | >100 | >100 | 85 | 92 | 77 | 47 | 77 | 82 | >100 | >100 | 89 |
| 50_45 | >100 | >100 | >100 | >100 | 79 | 85 | 77 | 45 | 75 | 82 | 97 | 87 | 80 |
| 45_40 | >100 | >100 | >100 | >100 | 74 | 80 | 77 | 44 | 73 | 82 | 86 | 77 | 73 |
| 40_35 | >100 | >100 | >100 | >100 | 69 | 76 | 77 | 43 | 71 | 82 | 77 | 71 | 68 |
| 35_30 | >100 | >100 | >100 | >100 | 64 | 73 | 78 | 42 | 70 | 83 | 73 | 67 | 64 |
| 30_25 | >100 | >100 | >100 | >100 | 60 | 72 | 79 | 41 | 70 | 85 | 68 | 64 | 60 |
| 25_20 | >100 | >100 | >100 | >100 | 57 | 67 | 81 | 40 | 70 | 87 | 64 | 63 | 58 |
| 20_15 | >100 | >100 | >100 | >100 | 53 | 62 | 81 | 39 | 72 | 82 | 61 | 64 | 56 |
| 15_10 | >100 | 93 | 91 | >100 | 49 | 55 | 72 | 38 | 72 | 73 | 55 | 71 | 52 |
| 10_5 | >100 | 85 | 82 | >100 | 47 | 53 | 68 | 38 | 68 | 68 | 53 | 97 | 50 |

**Cross-Flight**

| | 900_800 | 800_700 | 700_600 | 600_500 | 500_400 | 400_300 | 300_200 | 200_100 | 100_0 | 0_-100 | -100_-200 | -200_-300 | -300_-400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60_55 | >100 | >100 | >100 | >100 | 78 | 84 | 62 | 42 | 57 | 61 | >100 | >100 | 83 |
| 55_50 | >100 | >100 | >100 | >100 | 72 | 77 | 60 | 40 | 56 | 62 | 91 | 87 | 74 |
| 50_45 | >100 | >100 | >100 | >100 | 67 | 71 | 59 | 39 | 55 | 62 | 75 | 71 | 66 |
| 45_40 | >100 | >100 | >100 | >100 | 63 | 66 | 58 | 38 | 55 | 64 | 66 | 61 | 61 |
| 40_35 | >100 | >100 | >100 | >100 | 60 | 63 | 57 | 37 | 55 | 67 | 60 | 54 | 56 |
| 35_30 | >100 | >100 | >100 | >100 | 57 | 61 | 57 | 37 | 53 | 67 | 57 | 50 | 52 |
| 30_25 | >100 | >100 | >100 | >100 | 54 | 60 | 56 | 36 | 52 | 62 | 52 | 48 | 49 |
| 25_20 | >100 | >100 | >100 | >100 | 51 | 60 | 56 | 36 | 52 | 57 | 50 | 47 | 47 |
| 20_15 | >100 | 96 | >100 | >100 | 48 | 62 | 55 | 36 | 52 | 53 | 47 | 48 | 44 |
| 15_10 | >100 | 73 | 74 | 96 | 44 | 57 | 49 | 35 | 55 | 48 | 44 | 52 | 41 |
| 10_5 | 91 | 67 | 67 | 85 | 43 | 54 | 47 | 35 | 73 | 45 | 42 | 57 | 39 |

**Turbulence**

| | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 0 | -100 | -200 | -300 | -400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 33 | 33 | 31 | 31 | 31 | 28 | 28 | 29 | 28 | 28 | 26 | 25 | 30 | 28 |
| 55 | 33 | 33 | 31 | 31 | 31 | 29 | 28 | 29 | 28 | 29 | 25 | 25 | 30 | 28 |
| 50 | 33 | 33 | 32 | 31 | 31 | 29 | 29 | 30 | 29 | 30 | 25 | 25 | 30 | 28 |
| 45 | 33 | 33 | 32 | 32 | 32 | 29 | 29 | 30 | 30 | 30 | 26 | 25 | 30 | 29 |
| 40 | 33 | 33 | 32 | 32 | 32 | 30 | 30 | 31 | 31 | 30 | 26 | 26 | 30 | 29 |
| 35 | 33 | 33 | 32 | 32 | 32 | 31 | 30 | 32 | 32 | 31 | 26 | 27 | 31 | 29 |
| 30 | 33 | 33 | 32 | 32 | 32 | 32 | 31 | 33 | 33 | 31 | 27 | 28 | 31 | 30 |
| 25 | 33 | 33 | 33 | 33 | 32 | 33 | 32 | 33 | 34 | 32 | 29 | 29 | 32 | 31 |
| 20 | 33 | 33 | 33 | 33 | 33 | 34 | 33 | 33 | 36 | 33 | 30 | 31 | 32 | 32 |
| 15 | 33 | 33 | 33 | 33 | 33 | 35 | 33 | 33 | 37 | 33 | 32 | 33 | 33 | 34 |
| 10 | 32 | 32 | 32 | 33 | 33 | 34 | 32 | 32 | 39 | 34 | 33 | 35 | 34 | 35 |
| 5 | 32 | 31 | 32 | 33 | 33 | 34 | 32 | 32 | 39 | 34 | 34 | 34 | 33 | 37 |

# A.4 Referenced Drawings and 3d Models

The following files were used to create the CFD model:

| | | | |
|---|---|---|---|
| 016462_CooksCove_Buildings.3dm | 16/11/2022 11:09 AM | Rhino 3-D Model | 2,642 KB |
| 016462_CooksCove_SiteModel.3dm | 16/11/2022 11:15 AM | Rhino 3-D Model | 265,930 KB |
| 016462_VentilationStacks.3dm | 15/11/2022 9:24 AM | Rhino 3-D Model | 565,700 KB |