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Our ref: 062001-05

Dear Amanda

Re: Tallawarra B Power Station – Plume Symbol Amendment

This correspondence provides further advice regarding the plume symbol associated with the Tallawara B Power Station, following an enquiry from the Civil Aviation Safety Authority (CASA) as to the validity of the information being provided to pilots through current published aeronautical data.

1.1. Background

The Tallawarra B Power Station is approved with conditions.

Condition 1.6 required the submission of a report to the Secretary of the NSW Department of Planning and Environment (or delegate) which demonstrates that operation of an open cycle gas turbine plant will not have an adverse impact on aviation safety. The report was to be prepared in consultation with Shellharbour City Council, and its conclusions and recommendations were to have been agreed to by the Civil Aviation Safety Authority (CASA) prior to submission to the Secretary. The report was to be approved by the Secretary before commencement of construction of an open cycle plant.

Aviation Projects prepared the report *Tallawarra B OCGT Aeronautical Impact Assessment* (v1.1, 13 Feb 2020) (AIA), in consultation with Shellharbour City Council, that was subsequently agreed to by CASA and approved by the Secretary.

The AIA concluded as follows:

> *In light of the foregoing assessment, with plume characteristics as proposed, specifically a critical plume velocity of 6.1 m/s at or below 700 ft AMSL, Aviation Projects has concluded that there will be an acceptable level of aviation safety risk associated with the Tallawarra B OCGT, reduced to as low as reasonably practicable if the mitigations proposed herein are implemented.*

The assessment was based, in part, on guidance provided by CASA in Advisory Circular (AC) 139-05v3.0 *Plume rise assessments,* dated 03 January 2019.

The assessment methodology in that version of the AC relied on meeting a critical plume velocity at a nominated height as the key determinant of aviation risk.

The AIA was based on an early simplistic model of the plume dispersal device (PDD), which found that the vertical velocity of the plume gradually reduced with height from a maximum at the point of release. The critical plume height of 6.1 m/s was found to occur at 580 ft AMSL. The image at Figure 1, extracted from the report

prepared by Katestone – *Tallawarra B Power Station - Plume Rise Assessment Report*, February 2020 that was annexed to the AIA, illustrates the analysis.

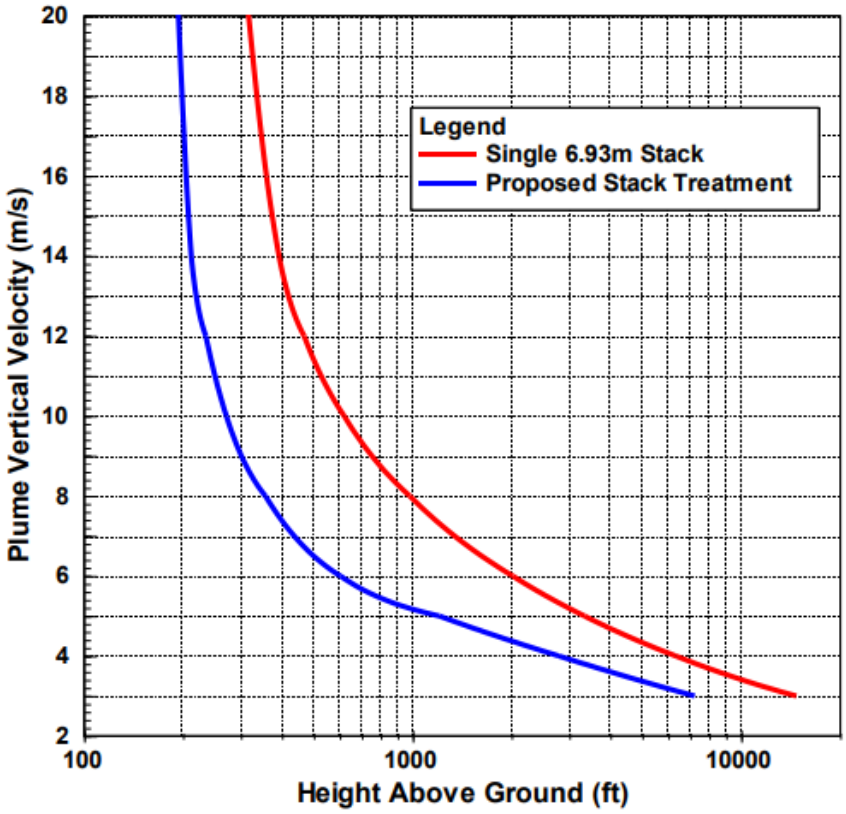

Figure 9 **Predicted plume vertical velocity vs height above ground for the unmitigated F Class stack (red line) and the proposed stack top diffuser (blue line) using the Spillane plume model**

Figure 1 Katestone Figure 9

Subsequently, the plume dispersal device (PDD) was modelled using a computational fluid dynamics model (CFD) including the final PDD design (version 3B).

The diagram at Figure 2, which is Figure 12 from CFD modelling conducted for EnergyAustralia (Stacey Agnew, July 2023) can be used to derive information that is comparable to Katestone Figure 9. Stacey Agnew Figure 12 shows elevation (above ground level (AGL)) on the vertical axis and velocity on the horizontal axis. Rather than average vertical velocity, the CFD model produces peak vertical velocity, which GHD and CASA agree can be used to calculate average velocity by dividing by 2.

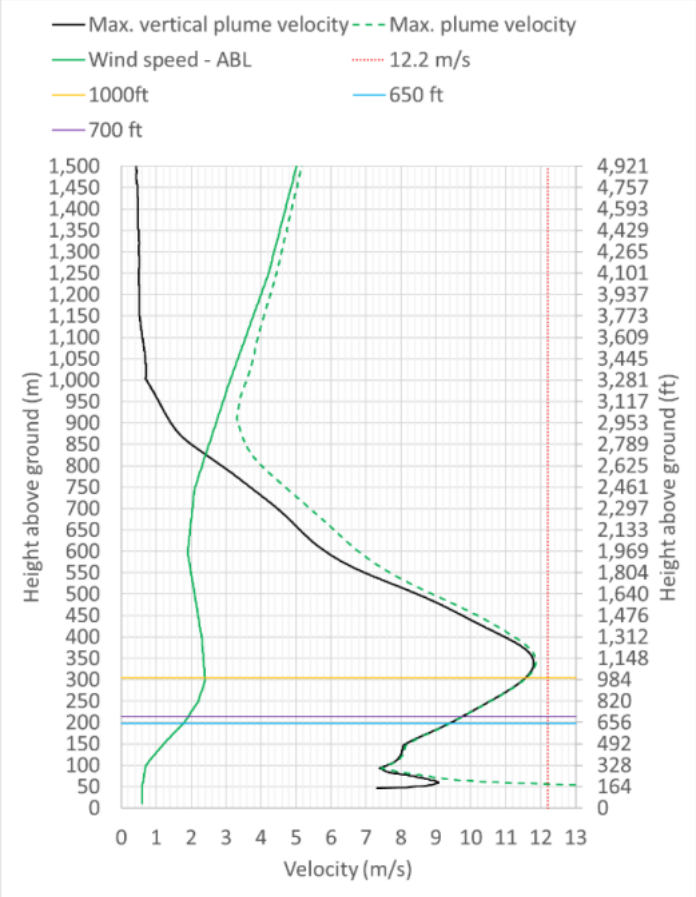

Figure 2 Stacey Agnew Figure 12 – initial meteorological case

Stacey Agnew (2023) found the peak vertical velocity of the plume to be transient, whereas the earlier PDD designs that were examined using CFD reached a steady state peak vertical velocity.

> *"...All simulation cases showed a transient plume behaviour, where such peak values persisted only for a few seconds. The time-averaged maximum plume rise velocities are in general lower than the transient peaks by about 1 m/s..."*

Stacey Agnew (2023) conducted CFD modelling of the final PDD design for three meteorological conditions:

- The initial case, which equated to a 99.85th percentile (may occur for 0.15% of the time) and was agreed to be a reasonable worst-case.
- The calm wind case, which was requested by CASA to represent plume rise under very light winds. This condition produced lower vertical velocities than the other two.
- The combined wind case, which was described by GHD's peer review (GHD, 2023) as the "worst-of-the-worst" possible wind condition and was also concluded by GHD to have a probability of occurrence of 2.3 x 10^{-5}.

It can be noted from Figure 2 that, unlike the simple reducing velocity trend in Katestone Figure 9, the maximum transient peak vertical velocity (black line) initially drops but at about 250 ft the velocity starts to increase with height, reaching its maximum of just below 11.8 m/s at around 1148 ft AGL.

This is because the PDD discharges through alternating horizontal and below-horizontal outlets. The plume therefore has no initial positive vertical velocity.

The PDD plume therefore rises due to buoyancy alone, which is a dynamic process that sees the plume divided into sub-plumes at the point of release with the sub-plumes rising due to their buoyancy then coalescing higher in the atmosphere. When the sub-plumes coalesce the resultant plume has greater buoyancy, which results in a higher vertical velocity after that point.

The maximum transient peak vertical velocity then reduces gradually with elevation. So, at no elevation does the maximum transient peak vertical velocity exceed 11.8 m/s according to the analysis.

Stacey Agnew (2023) found that the time-averaged peak vertical velocity for the initial case is 0.8 m/s less than the maximum. Therefore, the time-averaged peak vertical velocity does not exceed 11 m/s at any elevation AGL. Dividing this value by 2 gives an average vertical velocity of 5.5 m/s. This is less than CASA's critical velocity of 6.1m/s.

Whilst higher maximum peak vertical velocities are predicted for the combined wind case, the likelihood that power station operation would coincide with this meteorological condition was found by GHD (2023) to be significantly less than CASA's probability criterion for moderate turbulence of 1×10^{-5}.

The project approval requiring a plume velocity of 6.1 m/s at or below 700 ft AMSL has been met, based on this agreed methodology.

Under the methodology that existed at the time, it could have been argued, since the plume velocity wouldn't exceed 6.1 m/s, that a plume symbol was not required. The Department of Planning and Environment advised on 12 May 2023 that the project's version 3B design satisfied condition 1.6 of the project approval (subject to the provision of further evidence regarding the implementation of the aviation mitigation measures, performance guarantee test and Plume Validation Monitoring Program).

The approved aviation mitigation measures included alerting of pilots through the Aeronautical Information Package (AIP) – refer to the relevant content extracted from the AIA and copied below (author's bolding):

> *10.1 Alerting through AIP – ERSA, aeronautical charts*
>
> *Pilots can be alerted to the hazard through information published in the various elements of the Aeronautical Information Package (AIP) published by Airservices Australia. The various documents and proposed changes are listed below:*
>
> *ERSA FAC – a note could be included in Local Traffic Regulations to the effect that aircraft should avoid overflying the power station below 1000 ft when it is operating; and*
>
> ***Aeronautical charts – a plume symbol could be placed over the power station.***

On 13 April 2023, details of the plume (author's bolding) were provided to CASA (Louise Alberts, Senior Standards Officer (AIP/AIM), Air Navigation, Airspace and Aerodromes Branch):

> *Height of the plume (e.g. 2000FT AGL):* ***The plume velocity is less than 6.1 m/s at 700 ft AMSL.***

CASA then arranged publication of the plume symbol based on this and other relevant information. An extract of the Sydney Visual Navigation Chart (VNC) dated 30 November 2023, showing the plume symbol at Tallawarra B Power Station, is provided at Figure 3.

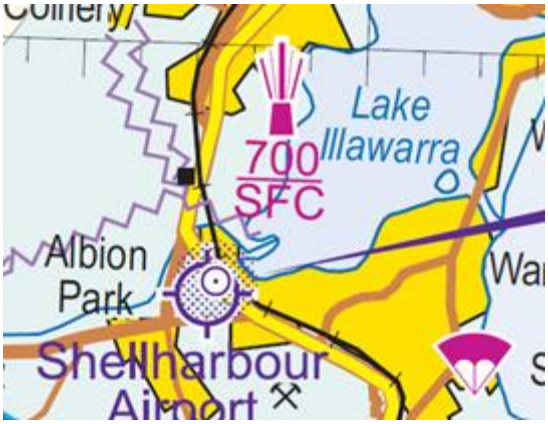

Figure 3 Extract of Sydney VNC showing plume symbol

1.2. Consideration of plume symbol amendment

CASA has since asked, in meetings with the Department of Planning and Environment and EnergyAustralia, if the plume symbol needs updating given that the current design would result in the plume velocity increasing with height. Specifically, it was interested to know whether the plume symbol should be amended to show 700 ft AMSL and another height to provide pilots with as much information as possible to avoid the fastest part of the plume.

The fastest part of the plume, of the three modelled meteorological conditions occurs in the combined meteorological scenario between approximately 900 ft and 1700 ft AMSL. Although, this has an estimated probability of substantially less than 1×10^{-5}.

Publishing these heights in conjunction with the plume symbol would likely be inconsistent with historical methodologies, and while providing additional information to pilots, may introduce confusion because of the non-standard representation.

Further, it is unknown if any of the other plumes for which a symbol has been published have a vertical velocity profile that slows down below 6.1 m/s above the critical plume height and then increases again - to just below 6.1 m/s.

In this case, all of the other known plume hazards with or without symbols would warrant checking to ensure consistent symbology and information is provided to pilots.

Another option would be to publish the heights between which the plume velocity could be within the range of >4.3 m/s (which is the trigger velocity for further assessment) to <6.1 m/s (critical plume velocity) - that would extend from the surface (exhaust stack height) to approximately 2300 ft. This range in heights would have an estimated probability of substantially less than 1×10^{-5}.

In technical terms, this approach to hazard identification would be aligned to relevant reference criteria and relatively informative for pilots. It would likely introduce an inconsistency given that most other plumes that exceed 4.3 m/s but remain <6.1 m/s are likely not highlighted with a plume symbol. Any proposal to introduce a non-standard symbology should be subject to CASA's determination, given that it has authority over the published data.

1.3. Summary of options

The following options are considered worthy of further consideration:

1. Remove the plume symbol, based on the plume velocity not exceeding 6.1 m/s. This could arguably be technically valid, but not the best option in the circumstances.
2. Leave the plume symbol annotation as is – i.e. SFC - 700 ft AMSL. This would correlate the published information with the condition of approval and design/performance requirements of the equipment, but not clearly identify the heights above the exhaust stack that represented the greatest, albeit acceptable, hazard.
3. Highlight the relevant part of the plume where the velocity exceeds a nominated criteria – either between 4.3 m/s and just below 6.1 m/s (i.e. SFC to 2300 ft AMSL) or the area of greatest velocity (900 ft AMSL – 1700 ft AMSL). This annotation would be non-standard and would require CASA determination.

1.4. Recommended amendment of plume symbol

It is recommended that the plume symbol and associated Additional Information is Shellharbour Airport's En Route Supplement (ERSA) facilities (FAC) page be amended to reflect the region of highest velocity plume, which remains below 6.1 m/s, is likely occur between 900 ft AMSL and 1700 ft AMSL.

If you wish to clarify or discuss the contents of this correspondence, please contact me on 0417 631 681.

Kind regards

Keith Tonkin

Managing Director

22 December 2023