Hunter Power Project

Revised Plume Rise Assessment for Final Design

Rev 2

9 September 2022

Snowy Hydro

Final

Hunter Power Project

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1	03/06/2022	Final draft	S Lakmaker	M Pickett	M Luger	K Ivanusic
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Contents

List of figures

List of tables

Executive Summary

The Hunter Power Project (the Project) was approved as SSI-12590060 by the then Minister for Planning and Public Spaces on 17 December 2021. The approved Project involves the development of a gas-fired power station comprising two open cycle gas turbine (OCGT) generators with a nominal capacity of up to 750 megawatts (MW), an electrical switchyard and associated supporting infrastructure. The gas turbines would primarily be fired on natural gas with the use of diesel fuel as a backup. The Project will operate as a “peak load” generation facility supplying electricity at short notice when there is a requirement in the National Electricity Market (NEM).

Since the Project’s approval, a main equipment supplier has been engaged by Snowy Hydro and the detailed design has progressed. Key changes to the project include a reduction in the maximum capacity of the power station to 660 MW and an increase in the height of the turbine exhaust stacks to 60 m.

The purpose of this Revised Plume Rise Assessment is to comply with Infrastructure Approval condition B19 that requires an updated plume rise assessment report based on the final generator design. The plume rise modelling has been carried out in accordance with CASA Advisory Circular titled “AC 139-05v3.0 - Plume Rise Assessments” (CASA, 2019). Modelling for a five year simulation period showed that the heights at which the plume vertical velocity falls below 6.1 m/s were 1,113 m AGL for gas operation and 1,057 m AGL for diesel operation.

The meteorological conditions which led to the maximum results was based on the assumption that two gas turbines were operating at a time of very light winds (0.1 m/s) on a winter day, a meteorological condition which occurred for one hour in the five year simulation period. For all other meteorological conditions experienced during the five year simulation period, the corresponding maximum heights were below 1,113 m AGL.

The modelling also showed that the frequency of the plume vertical velocity exceeding 6.1 m/s at 1,000 m AGL is 0.01% (or approximately 1 hour in a year) for 2 x OCGT units operating on gas.

These plume rise heights are consistent (in fact having a slightly lower impact) compared to the predictions in the Environmental Impact Statement (Jacobs, 2021).

1. Introduction

1.1 Project background

Snowy Hydro (the Proponent) has received approval for the development and operation of a new gas fired power station (the Project) to be located at the former Kurri Kurri aluminium smelter owned by Hydro Aluminium Kurri Kurri Pty Ltd (Hydro Aluminium), located in the small suburb of Loxford, just north of Kurri Kurri in NSW. The Proponent has engaged Jacobs to prepare this plume rise assessment based on the final plant design. This report represents the plume rise impact assessment to inform the potential hazards and risks due to the Project.

The Project involves the construction and operation of a power station and electrical switchyard, together with other associated infrastructure. The power station will have a capacity of up to approximately 750 megawatts (MW) which will be generated via two heavy duty gas turbines. Although primarily a gas fired power station, the facility will also be capable of operating on diesel (as a back-up) as required, if there were a constraint or unavailability in the natural gas network and there was a need to supply electricity to the National Electricity Market (NEM).

The Project will operate as a "peak load" generation facility supplying electricity at short notice when there is a requirement in the National Electricity Market. The major supporting infrastructure that is part of the Project will be a 132 kV electrical switchyard located within the Project Site. The Project will connect into existing 132 kV electricity transmission infrastructure located adjacent to the Project Site. A new gas lateral pipeline and gas receiving station will also be required and this will be developed by a third party.

Other ancillary elements of the Project include:

- Water storage tanks and other water management infrastructure
- Fire water storage and firefighting equipment such as hydrants and pumps
- Maintenance laydown areas
- Stormwater detention basin
- Diesel fuel storage tanks and truck unloading facilities
- Site access roads and car parking
- Office/administration, amenities, workshop/storage areas.

Construction activities commenced in May 2022 and the Project is intended to be operational by the end of 2023, with operations potentially commencing in mid-2023.

1.2 Purpose of this report

The Project was approved as SSI-12590060 by the then Minister for Planning and Public Spaces on 17 December 2021. The approved Project involves the development of a gas-fired power station comprising two open cycle gas turbine (OCGT) generators with a nominal capacity of up to 750 megawatts (MW), an electrical switchyard and associated supporting infrastructure. The gas turbines would primarily be fired on natural gas with the use of diesel fuel as a backup. The Project will operate as a "peak load" generation facility supplying electricity at short notice when there is a requirement in the National Electricity Market (NEM).

Since the Project's approval, a main equipment supplier has been engaged by Snowy Hydro and the detailed design has progressed. Key changes to the project include a reduction in the maximum capacity of the power station to 660 MW and an increase of the turbine exhaust stacks to 60 m.

The purpose of this Revised Plume Rise Assessment is to comply with Infrastructure Approval condition B19 that requires an updated plume rise assessment report based on the final generator design. Specifically, B19 states:

Prior to the commencement of installation of the gas turbines, the Proponent must provide an updated plume rise assessment report based on the final generator design to the satisfaction of the Secretary. The report must:

(a) Be prepared in consultation with the Civil Aviation Safety Authority, Department of Defence and RAAF Base Williamtown;

(b) Demonstrate that the critical plume extent is consistent with the predictions in the EIS; and

(c) Demonstrate that reasonable and feasible at source mitigation measures have been applied to further minimise the critical plume extent.

1.3 Compliance with above conditions

1.3.1 Consultation on draft report

As required by B19 (a) the draft report was sent to the Civil Aviation Safety Authority (CASA), Department of Defence and RAAF Base Williamtown on 8 June 2022. Correspondence is included in Appendix A.

Defence responded that the power station will not adversely impact upon civil or military flying operations at RAAF Base Williamtown/ Newcastle Airport if all mitigating measures identified in Defence correspondence to DPE dated 8 June 2021 are fully adhered to. All these earlier measures form part of the Infrastructure Approval conditions B19 and B20 and have been addressed.

CASA response stated that a critical plume height of 841 m AHD will not present any unacceptable impacts to the safely of aircraft operations in the vicinity of the site. CASA will work with the Department of Defence and Airservices Australia to determine what, if any, appropriate mitigation measures are required.

1.3.2 Plume extent consistent with predictions in EIS

As shown in Table 1.1 the plume height associated with the final design is lower than that assessed in the EIS. In particular, the modelling predicts that the height that the plume vertical velocity falls below 6.1 m/s (m AGL) would be 841 m for the final design against the 853 m predicted for the EIS.

Table 1.1: Height at which plume vertical velocity falls below 4.3, 6.1 and 10.6 m/s

Percent exceedance	Height at which plume vertical velocity falls below 4.3 m/s (m AGL)			Height at which plume vertical velocity falls below 6.1 m/s (m AGL)			Height at which plume vertical velocity falls below 10.6 m/s (m AGL)		
Scenario	EIS	Proposed final design (gas)	Proposed final design (diesel)	EIS	Proposed final design (gas)	Proposed final design (diesel)	EIS	Proposed final design (gas)	Proposed final design (diesel)
0%	1509	1480	1418	1144	1113	1057	291	302	276
0.05%	1316	1307	1260	938	917	873	255	264	240
0.1%	1258	1241	1181	853	841	778	239	251	228
0.2%	1162	1147	1098	766	755	702	225	229	214
0.3%	1096	1086	1040	718	706	656	214	226	203
0.5%	1024	1013	954	656	647	601	201	210	191
1%	888	872	822	557	555	514	177	189	176

Percent exceedance	Height at which plume vertical velocity falls below 4.3 m/s (m AGL)			Height at which plume vertical velocity falls below 6.1 m/s (m AGL)			Height at which plume vertical velocity falls below 10.6 m/s (m AGL)		
2%	743	736	691	456	456	425	155	167	153
3%	650	647	604	402	405	376	140	152	140
4%	587	585	544	361	364	339	132	141	137
5%	540	539	502	332	338	313	124	138	127
6%	502	502	469	312	316	294	115	127	125
7%	474	474	441	294	300	279	112	126	115
8%	449	450	419	280	286	267	110	117	114
9%	428	430	401	267	273	254	101	114	114
10%	410	412	383	256	262	245	99	114	113
20%	298	302	282	190	198	186	85	101	90
30%	245	251	235	159	168	159	74	89	89
40%	212	219	206	141	149	141	62	88	88
50%	191	198	187	126	137	130	61	78	78
60%	175	183	173	115	128	121	61	77	77
70%	161	169	160	106	120	113	60	77	77
80%	147	158	149	99	112	106	50	77	76
90%	133	144	138	87	104	98	49	76	76
100%	82	99	98	53	80	80	47	74	74

1.3.3 Reasonable and feasible mitigation measures applied

DPE included all agency feedback on the EIS in the Infrastructure Approval. Reducing the maximum capacity of the power station to 660 MW is the only reasonable mitigation measure adopted to minimise plume rise.

With respect to the increase in stack height, in their response on this draft report, Defence also noted that the stacks could pose a safety risk to military rotary wind operations in the area including at night. As such Defence is of the view that consideration of obstacle lighting would be a prudent measure and should be considered as a mitigating measure. As required by Infrastructure Approval condition B20, the final design was sent to various agencies. The outcome of this is that CASA have coordinated feedback and have clarified obstacle lighting requirements – see Appendix A. Snowy Hydro will implement CASA's requirements for stack lighting.

2. Assessment Methodology

2.1 Background

The Civil Aviation Safety Authority (CASA) is the national authority which regulates Australian aviation safety. The CASA has historically established that wind gusts with vertical velocity exceeding 4.3 metres per second (m/s) may cause damage to an aircraft airframe or otherwise upset an aircraft flying at low levels. The CASA subsequently required that proponents of a facility where the vertical velocity of exhaust plumes exceeds a critical plume velocity (CPV) of 4.3 m/s or 10.6 m/s at an aerodrome Obstacle Limitation Surface (OLS), or at 110 m above ground level anywhere else, must undertake plume rise modelling to assess the potential hazard to aircraft operations. Requirements of the plume rise modelling were originally outlined in CASA's Advisory Circular (AC 139-5) titled "Guidelines for conducting plume rise assessments" (CASA, 2004).

The CASA 2019 plume rise assessment guidelines (detailed in AC-139-5) advise the critical plume velocity (CPV) threshold as 4.3 to 6.1 m/s to reflect the latest information on potential hazards to aviation (CASA, 2019). In this latest 2019 Advisory Circular, CASA does not specify a specific CPV, rather it simply states that it will assess the circumstances and decide upon an appropriate CPV as it may decide to adopt a lower CPV for certain types of aircraft. To address this requirement, this plume rise assessment has considered worst-case operation scenario of the power station, in terms of plume rise, and five years of meteorological conditions to determine risk to aircraft in the vicinity of the Project Site.

The Project will have a Capacity Factor[1] of up to 10 per cent on natural gas and up to two per cent on diesel (providing a combined Capacity Factor of 12 per cent) in any given year. However, it is expected that likely operations will result in a Capacity Factor of two per cent in any given year.

2.2 Study Requirements

Plume rise assessments to meet the requirements of the CASA are based around the use of the CSIRO's prognostic model known as TAPM (The Air Pollution Model). TAPM is a prognostic model which has the ability to generate meteorological data for any location in the world based on synoptic information determined from global weather models such as the Global Forecast System (GFS).

The requirements of CASA, when conducting plume rise modelling and assessment, can be summarised as follows:

- Modelling using TAPM version 2.0 or higher
- At least five years of continuous meteorological data modelled
- Horizontal displacement of the plume centreline evaluated as a function of height
- Plume spread about the centreline evaluated as a function of height
- Consideration of "average" and "peak" vertical plume velocities for each height
- Wind speed evaluated as a function of height
- Probability of vertical velocity exceeding the CPV threshold of 6.1 or 10.6 m/s.

[1] The Capacity Factor is the proportion of actual energy generated per year (expressed as MWh) compared with the total energy that could have been produced if operating at full load for every hour of the year (expressed as MWh).

3. Plume Rise Modelling

TAPM (version 4.0.5) modelling was undertaken in accordance with the CASA requirements outlined above. The simulation period was 2015 to 2019 inclusive. Table 3.1 provides a summary of TAPM inputs and settings for this assessment.

Table 3.1: Summary of TAPM modelling parameters

Parameter	Value (s)
TAPM version	4.0.5
Number of grids (spacing)	3 (30 km, 10 km, 3 km)
Number of grid points	25 x 25 x 25
Simulation period	Jan 2015 to Dec 2019 inclusive
Terrain information	AUSLIG 9 second DEM data
Centre of analysis	32°47'S, 151°29'E
Local data assimilation	None
Mode	Meteorology and pollution mode

The gas turbine exhaust stack emission characteristics used in the modelling are shown in Table 3.2. These stack emission characteristics include gas fired generation as this will be the primary fuel used for the power station. The assessment also used the stack emission characteristics from the F Class open cycle gas turbine (OCGT) model which would have resulted in the most adverse (that is, highest) plume rise results, in comparison to the turbine models that could potentially be selected for the Project.

Table 3.2 also shows that operation on gas would result in a higher stack exit temperature, and consequently higher plume buoyancy and potential plume height compared to operation on diesel fuel, and thus operation on gas was considered to be more conservative for use in the modelling and assessment.

Table 3.2: Stack emission characteristics used in the modelling

Parameter	2 x OCGT operating on gas		2 x OCGT operating on diesel	
Stack ID	SCGT1	SCGT2	SCGT1	SCGT2
Easting (m)	357519	357509	357519	357509
Northing (m)	6371474	6371405	6371474	6371405
Stack height (m)	60	60	60	60
Base elevation (m)	14	14	14	14
Stack tip diameter (m)	7.50	7.50	7.50	7.50
Stack exit temperature (°C)	650	650	525	525
Stack exit velocity (m/s)	40	40	39	39

For emissions from multiple stacks there is the possibility that merged, overlapping hot plumes may interact with one another, resulting in a single, higher buoyancy plume. This process is referred to as buoyancy enhancement.

The buoyancy enhancement factor (N_E) is defined (Hibberd *et al*, 2005) as follows:

Equation 1

$$N_E = \left[\frac{n+S}{1+S}\right]$$

Where *n* is the number of stacks and *S* is a dimensionless separation factor, defined as:

Equation 2

$$S = 6 \times \left[\frac{(n-1).\Delta s}{n^{\frac{1}{3}}.\Delta z}\right]^{\frac{3}{2}}$$

Where Δs is the stack separation and Δz is the rise of an individual plume. It should be noted that this approach is relevant to stack emissions of similar physical and emission characteristics, such as a group of gas turbine stacks separated by equal distances.

To determine relevant buoyancy enhancement factors, TAPM was run twice in pollution mode. The first run was used to predict the final rise of an individual plume. The second run included two adjacent plumes with the same emissions characteristics, with the calculated buoyancy enhancement, and was used for the final analysis. The "like" stack emissions in this instance were the two OCGT exhaust stack sources.

Statistics on the final rise of individual plumes, after modelling all stack emissions with no buoyancy enhancement, are shown below in Table 3.3. Buoyancy enhancement for the two sources has been determined.

The data from Table 3.3 show that the maximum final plume rise of individual plumes will be approximately 1,551 m above ground-level. The final rise is the height above ground at which the vertical velocity falls to zero. The buoyancy enhancement factor (BEF) of 1.96 was determined from the maximum final rise of individual plumes, which is a conservative approach.

Table 3.3: Final rise of individual plumes and buoyancy enhancement factors

Configuration	**Statistics for final rise of individual plumes (metres above ground)**		**Buoyancy enhancement of stack configuration**
	Maximum	**Average**	
2 x OCGT operating on gas	1,551	562	1.96
2 x OCGT operating on diesel	1,530	546	1.96

TAPM has a limitation in that only one value of the BEF can be used for the entire model simulation. In reality, the BEF will vary from hour to hour, due to variations in meteorology.

4. Model Results

TAPM generates output gradual plume rise data for every hour in the five year simulation period for each stack. Gradual plume rise data include vertical velocity, plume height and plume dimensions from the time of release to the time of final plume height. Statistics were generated from this data by interpolating to selected heights above ground.

An analysis of plume rise data was undertaken to determine the heights at which the plume vertical velocity exceeded the velocities of 4.3, 6.1 and 10.6 m/s. Results for 4.3, 6.1 and 10.6 m/s are provided for completeness and to allow an assessment to occur if the CPV is to vary depending on the aircraft type(s) likely to be encountered at the nearby airports. Results for gas and diesel operation are also provided for comparison and completeness purposes.

Results of this analysis for various percentile bands are shown in Table 4.1 and can be seen in Figure 4.1 to Figure 4.6. Over the five year modelling period the height at which the plume vertical velocity falls below the critical plume velocity threshold of 6.1 m/s would not exceed 1,113 m AGL, when operating on gas. The conditions which led to this maximum result coincided with very light winds (0.1 m/s) on a winter day, a condition which only occurred for one hour in the five year simulation period. At the other meteorological conditions experienced during the five year simulation period, the corresponding maximum heights were all below 1,113 m AGL.

Table 4.1: Height at which plume vertical velocity falls below 4.3, 6.1 and 10.6 m/s

Percent exceedance	Equivalent number of hours of exceedance per year	Height at which plume vertical velocity falls below 4.3 m/s (m AGL)		Height at which plume vertical velocity falls below 6.1 m/s (m AGL)		Height at which plume vertical velocity falls below 10.6 m/s (m AGL)	
		Gas	Diesel	Gas	Diesel	Gas	Diesel
0%	0	1480	1418	**1113**	1057	302	276
0.05%	4	1307	1260	917	873	264	240
0.10%	9	1241	1181	841	778	251	228
0.20%	18	1147	1098	755	702	229	214
0.30%	26	1086	1040	706	656	226	203
0.50%	44	1013	954	647	601	210	191
1%	88	872	822	555	514	189	176
2%	175	736	691	456	425	167	153
3%	263	647	604	405	376	152	140
4%	350	585	544	364	339	141	137
5%	438	539	502	338	313	138	127
6%	526	502	469	316	294	127	125
7%	613	474	441	300	279	126	115
8%	701	450	419	286	267	117	114
9%	788	430	401	273	254	114	114
10%	876	412	383	262	245	114	113
20%	1,752	302	282	198	186	101	90
30%	2,628	251	235	168	159	89	89

Percent exceedance	Equivalent number of hours of exceedance per year	Height at which plume vertical velocity falls below 4.3 m/s (m AGL)		Height at which plume vertical velocity falls below 6.1 m/s (m AGL)		Height at which plume vertical velocity falls below 10.6 m/s (m AGL)	
		Gas	Diesel	Gas	Diesel	Gas	Diesel
40%	3,504	219	206	149	141	88	88
50%	4,380	198	187	137	130	78	78
60%	5,256	183	173	128	121	77	77
70%	6,132	169	160	120	113	77	77
80%	7,008	158	149	112	106	77	76
90%	7,884	144	138	104	98	76	76
100%	8,760	99	98	80	80	74	74

Table 4.2 shows the frequency of time that the plume vertical velocity was predicted to fall below 4.3, 6.1 and 10.6 m/s for a range of heights above local ground-level. This form of presenting the results has been prescribed by the CASA and shows how often the plume vertical velocities exceed thresholds at specific heights during the five year simulation period. As an example, from Table 4.2, the modelling shows that the frequency of the plume vertical velocity, generated by 2 x OCGT units on gas, exceeding 6.1 m/s at 1,000 m AGL is 0.01%, or approximately 1 hour in a year.

Table 4.2: Frequency of plume vertical velocity exceeding 4.3, 6.1 and 10.6 m/s in height bands

Height above ground level (m AGL)	Frequency of plume vertical velocity exceeding 4.3 m/s at each height (%)		Frequency of plume vertical velocity exceeding 6.1 m/s at each height (%)		Frequency of plume vertical velocity exceeding 10.6 m/s at each height (%)	
	Gas	Diesel	Gas	Diesel	Gas	Diesel
50	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
100	100.00%	99.92%	93.41%	89.79%	20.46%	18.36%
150	85.43%	79.36%	39.24%	34.14%	3.43%	2.53%
200	48.69%	42.55%	19.59%	16.83%	0.77%	0.40%
300	20.28%	17.37%	7.00%	5.69%	0.00%	0.00%
400	10.71%	9.03%	3.10%	2.46%	0.00%	0.00%
500	6.06%	5.04%	1.47%	1.13%	0.00%	0.00%
600	3.64%	3.03%	0.70%	0.50%	0.00%	0.00%
800	1.48%	1.14%	0.13%	0.10%	0.00%	0.00%
1000	0.52%	0.38%	0.02%	0.01%	0.00%	0.00%
1200	0.13%	0.09%	0.00%	0.00%	0.00%	0.00%
1400	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
1600	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1800	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Figure 4.1 to Figure 4.6 provide graphical representations of the modelling results including the hourly plume radius, displacement from source and height at which the plume vertical velocity has fallen below thresholds. The plume radius, displacement and height values decrease when considering the increasing thresholds from 4.3 to 6.1 to 10.6 m/s. In addition, the graphs provide an indication of the frequency that the vertical velocity thresholds will reach particular heights, to accompany the statistics from Table 4.1 above.

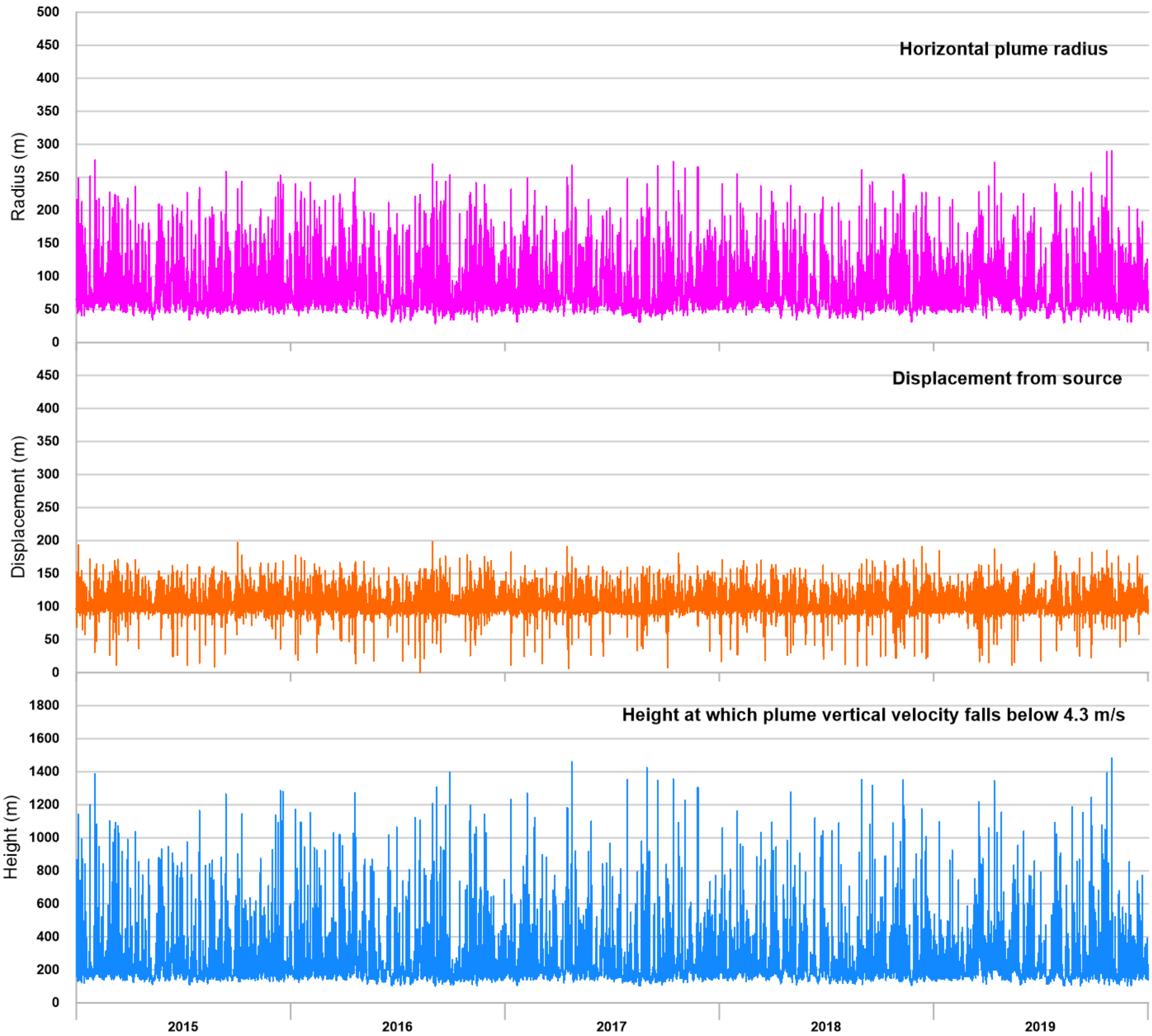

Figure 4.1: Height at which plume vertical velocity falls below 4.3 m/s for gas operation

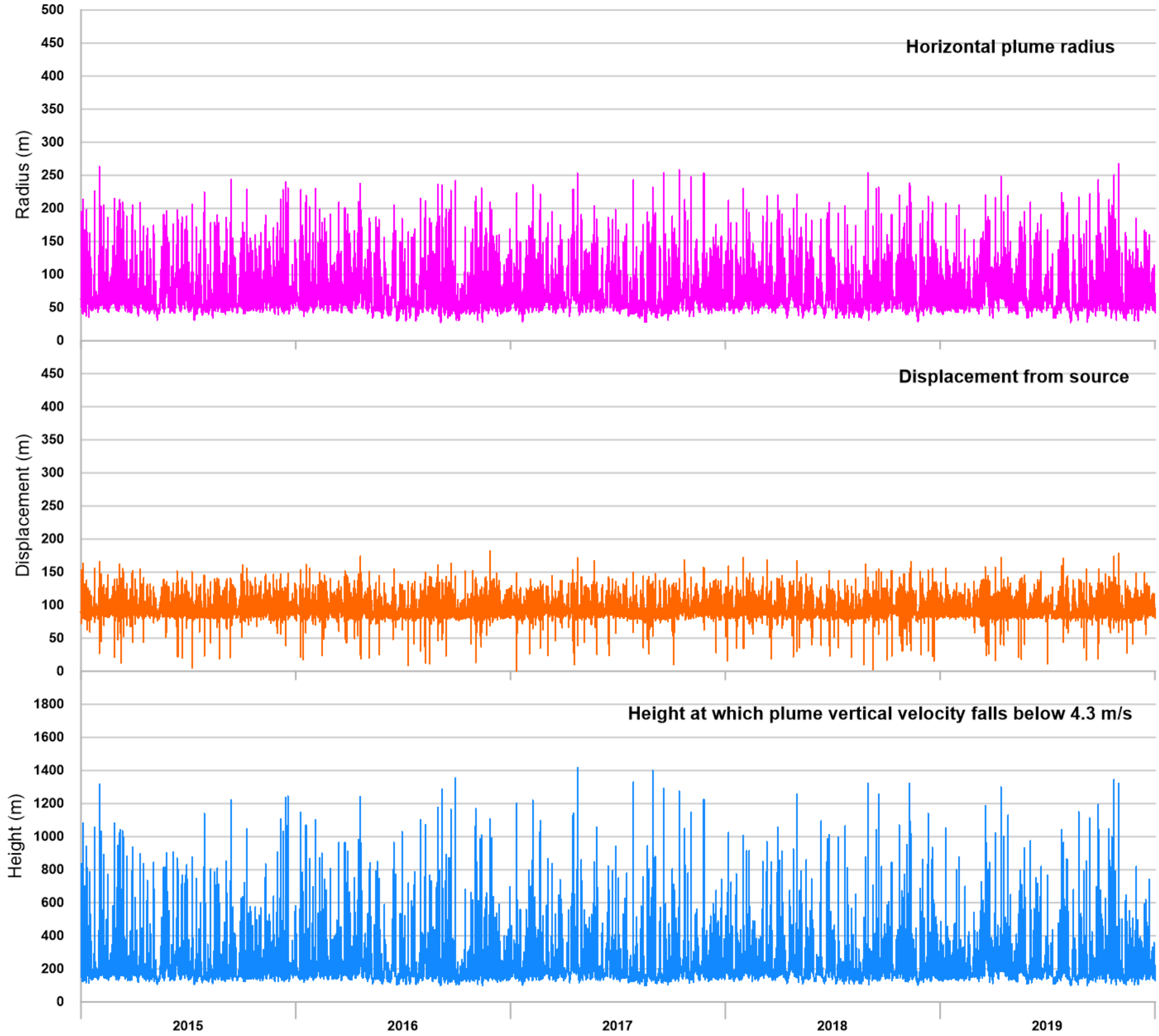

Figure 4.2: Height at which plume vertical velocity falls below 4.3 m/s for diesel operation

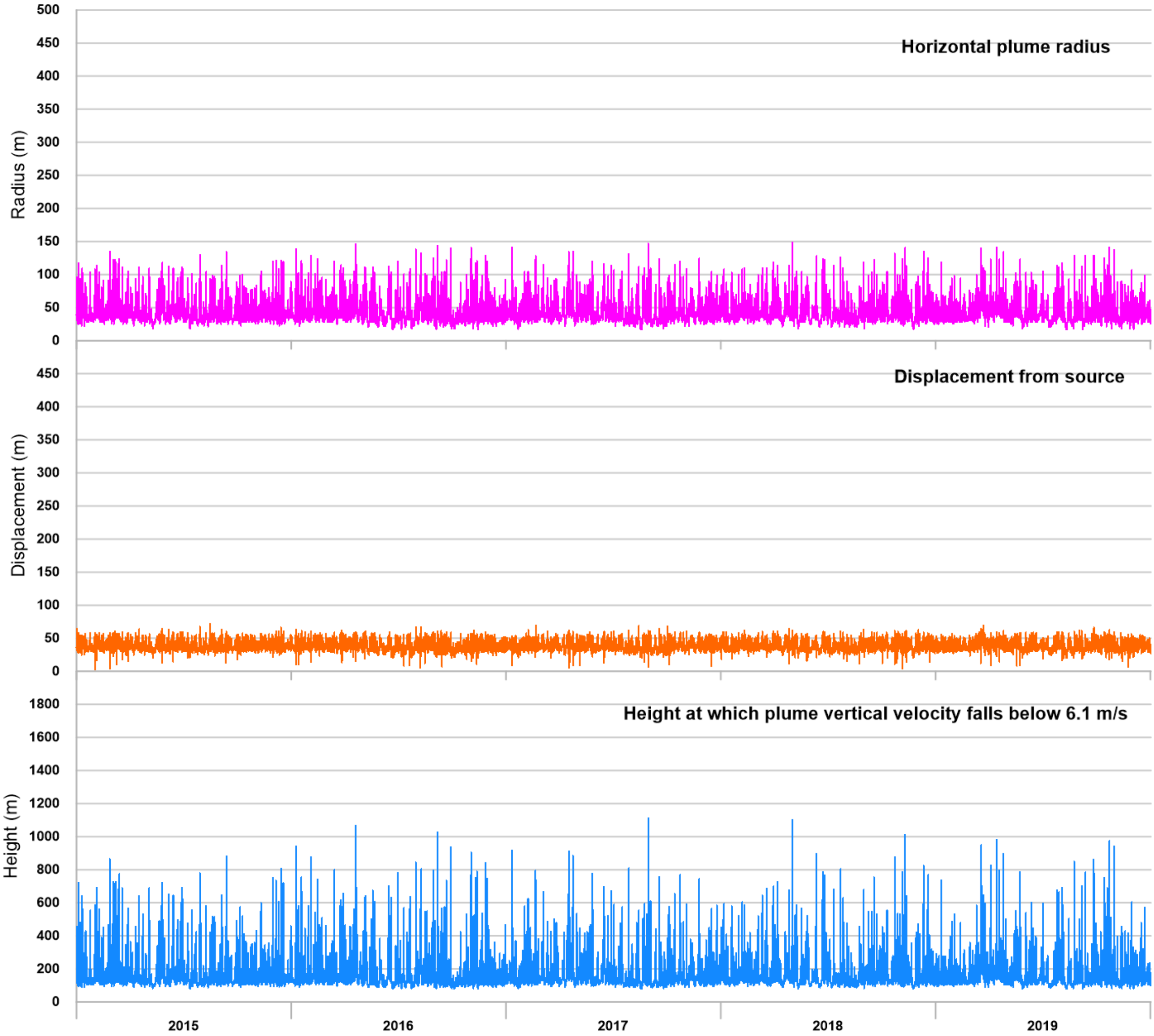

Figure 4.3: Height at which plume vertical velocity falls below 6.1 m/s for gas operation

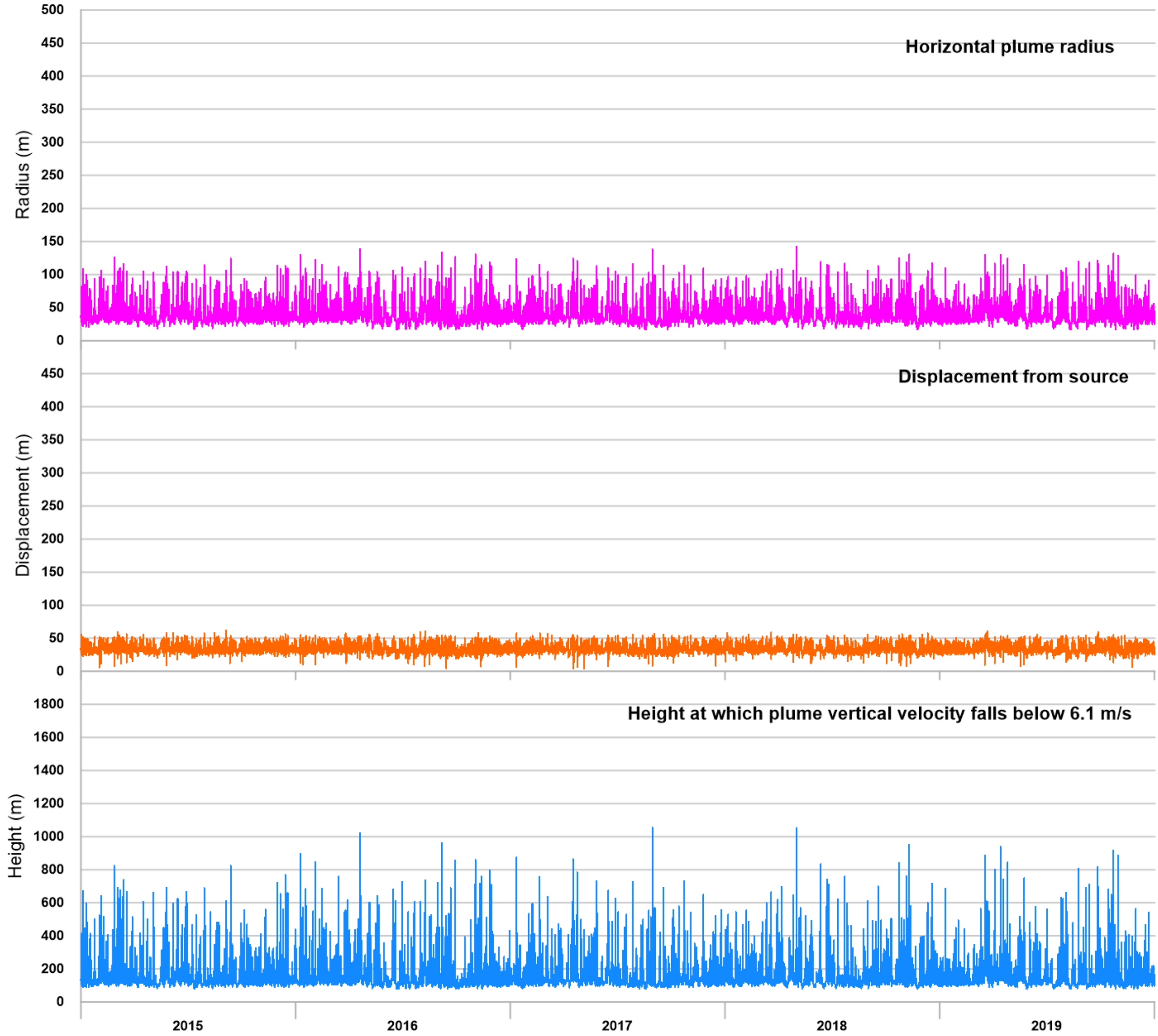

Figure 4.4: Height at which plume vertical velocity falls below 6.1 m/s for diesel operation

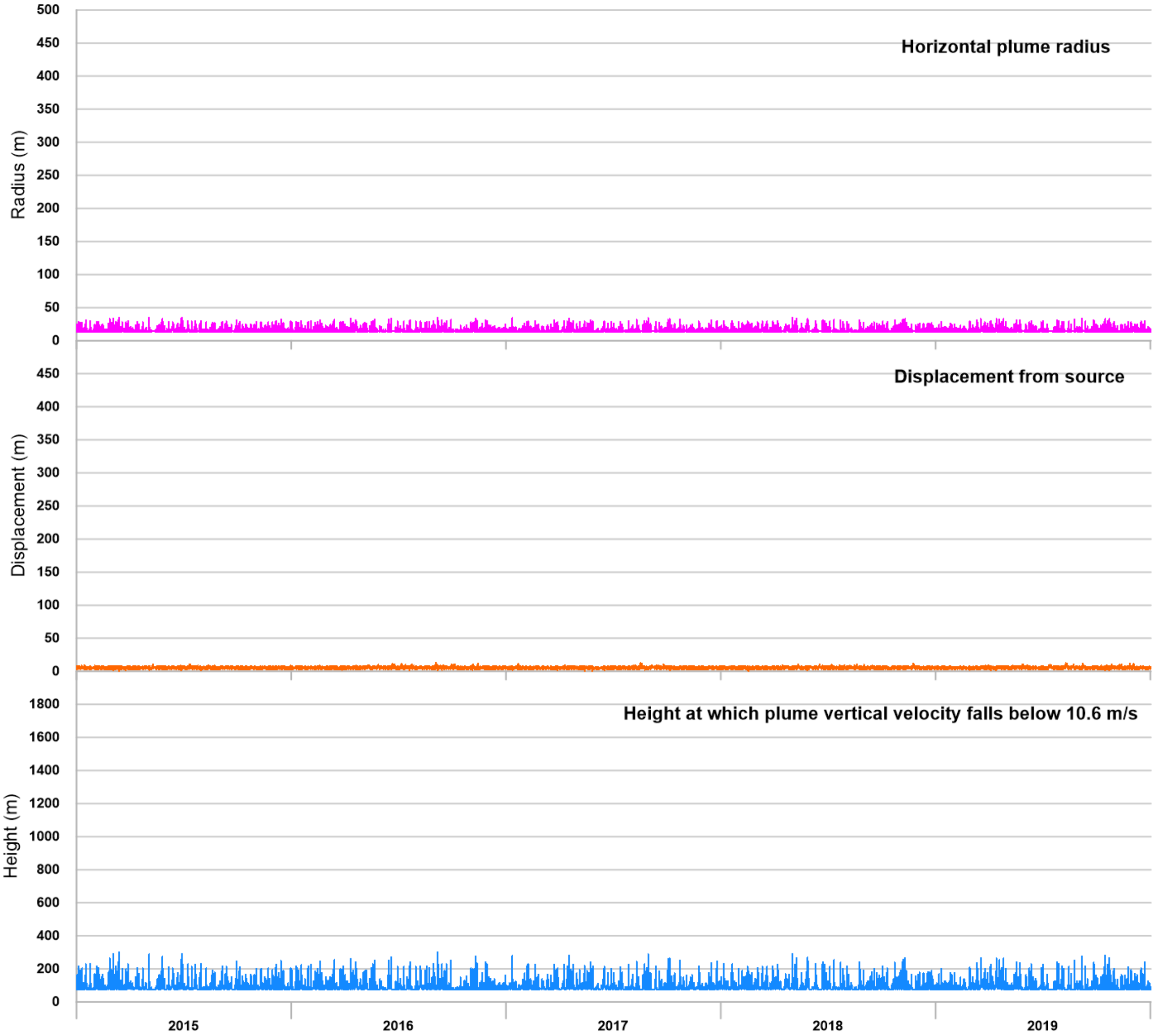

Figure 4.5: Height at which plume vertical velocity falls below 10.6 m/s for gas operation

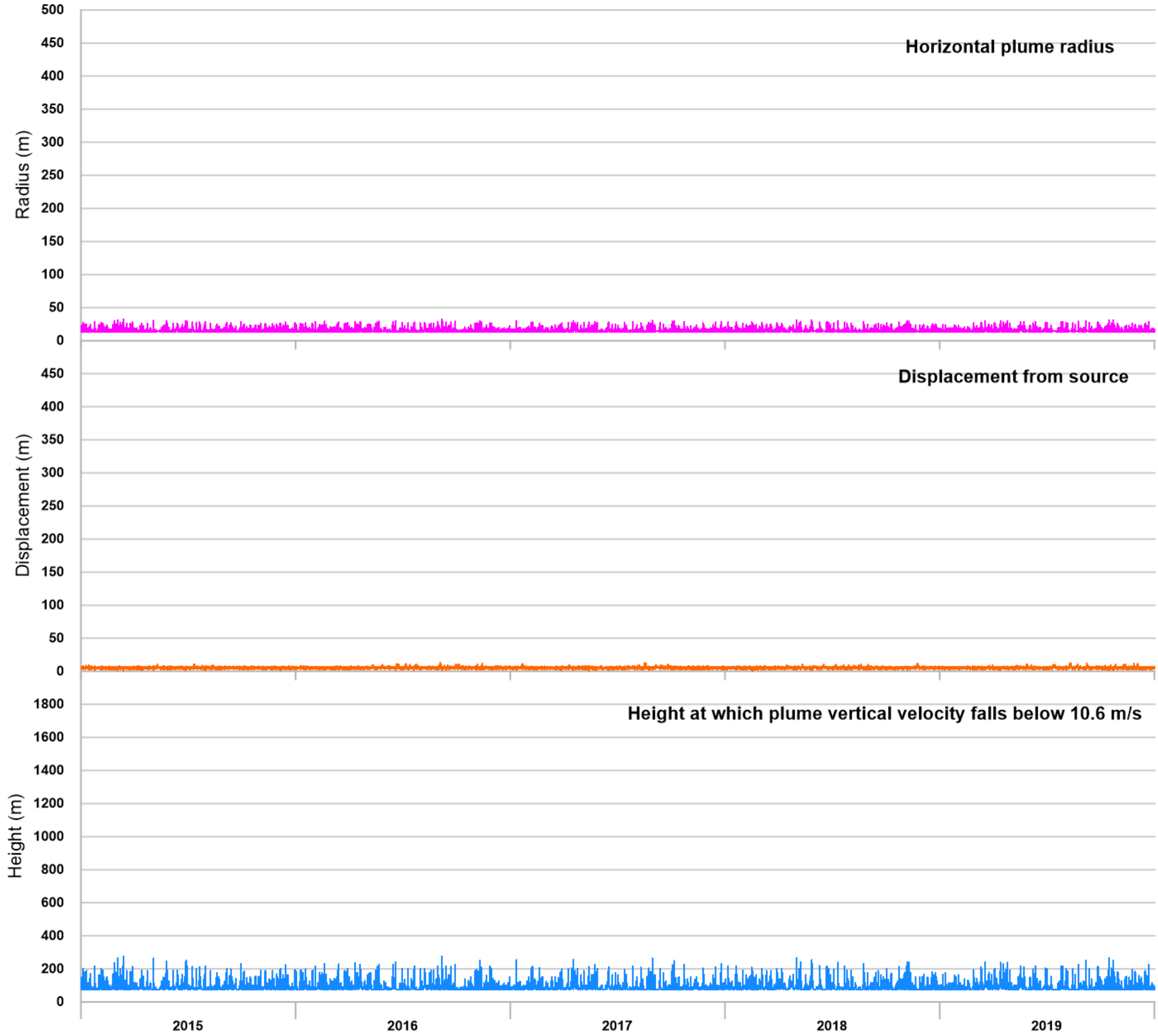

Figure 4.6: Height at which plume vertical velocity falls below 10.6 m/s for diesel operation

Table 4.3 includes additional statistics from the modelling and specifically, the maximum and median plume horizontal radius for the heights at which the plume vertical velocity falls below each threshold. These statistics have been included to address the requirements of all potential stakeholders. The data show a decrease in the maximum radius from 290 to 35 m for the 4.3 to 10.6 m/s thresholds. The radii for all scenarios include consideration of plume merging.

Table 4.3: Radius statistics

Statistic	Plume horizontal radius for the height at which plume vertical velocity falls below 4.3 m/s (m)		Plume horizontal radius for the height at which plume vertical velocity falls below 6.1 m/s (m)		Plume horizontal radius for the height at which plume vertical velocity falls below 10.6 m/s (m)	
	Gas	Diesel	Gas	Diesel	Gas	Diesel
Maximum	290	267	149	142	35	32
Median	69	64	39	36	15	14

5. Conclusions

Plume rise modelling was conducted using TAPM in accordance with the requirements of CASA and results were presented such that the regions of space where the vertical plume velocity exceeded 4.3, 6.1 and 10.6 m/s could be determined.

Modelling for a five year simulation period showed that the heights at which the plume vertical velocity falls below 6.1 m/s were 1,113 m AGL for gas operation and 1,057 m AGL for diesel operation. The meteorological conditions which led to the maximum results was based on the assumption that two gas turbines were operating at a time of very light winds (0.1 m/s) on a winter day, a meteorological condition which occurred for one hour in the five year simulation period. For all other meteorological conditions experienced during the five year simulation period, the corresponding maximum heights were below 1,113 m AGL. The modelling also showed that the frequency of the plume vertical velocity exceeding 6.1 m/s at 1,000 m AGL is 0.01% (or approximately 1 hour in a year) for 2 x OCGT units operating on gas.

These plume rise heights are consistent (in fact having a slightly lower impact) compared to the predictions in the Environmental Impact Statement. The Environmental Representative's endorsement of this report is contained in Appendix B.

6. References

Civil Aviation Safety Authority (2004). “Guidelines for Conducting plume Rise Assessment”. Advisory Circular, AC 139-05(0), Civil Aviation Safety Authority, Australian Government, June 2004.

Civil Aviation Safety Authority (2012). “Plume Rise Assessment”. Advisory Circular, AC 139-5(1), Civil Aviation Safety Authority, Australian Government, 2012.

Civil Aviation Safety Authority (2019). “Plume Rise Assessments”. Advisory Circular, AC 139-05v3.0, Civil Aviation Safety Authority, Australian Government, January 2019.

Hibberd M, Hurley P, Edwards M, Luhar A, Galbally I and Bentley S (2005). “Meteorological and Dispersion Modelling using TAPM for Wagerup, Phase 3A: HRA Concentration Modelling – Current Emission Scenario”, CSIRO Atmospheric Research Final Report.

Hurley (2008). “TAPM v.4. User Manual”. CSIRO Marine and Atmospheric Research Internal Report No. 5. October 2008.

Jacobs (2021): “Hunter Power Project: Environmental Impact Statement”, April 2021.

Strategic Airspace (2021). “Kurri Kurri Power Station Development – Aeronautical Impact & Risk Assessment of the Plume Rise”.

Appendix A. Correspondence

DocuSign Envelope ID: B7935209-BFE5-4FE3-BBA4-C034E1A83B93

8 June 2022

Civil Aviation Safety Authority
GPO Box 2005
Canberra ACT 2601

Attention: Brad Parker

Subject: Hunter Power Station – updated plume rise assessment report: consultation request

Dear Brad,

The Hunter Power Project (Kurri Kurri Gas-Fired Power Station) (the Project) was approved as SSI-12590060 by the then Minister for Planning and Public Spaces on 17 December 2021. Condition B19 of the Infrastructure Approval for the Project requires that an updated plume rise assessment report based on the final design is prepared in consultation with Civil Aviation Safety Authority (CASA), Department of Defence, and RAAF Williamtown. The plume rise being that generated from the power station gas turbine exhausts when in operation.

This purpose of this letter is to request your feedback on the attached draft and updated plume rise assessment report to demonstrate this consultation to the Department of Planning and Environment (DPE). The attached report is an update of the plume rise assessment that was submitted with the Project Environmental Impact Statement (EIS) in April 2021, and is based on the gas turbine final design as opposed to the preliminary information from gas turbine manufacturers available at the time of the EIS. The follow sections of this letter therefore serve to highlight the changes between the EIS version (which was based on the preliminary design) and the updated plume rise report (which is based on the final design).

Identical plume modelling parameters were used in both the EIS and final design. The model used is The Air Pollution Model (TAPM) version 4.0.5. The stack emission characteristics used in the EIS and for the proposed final design are shown in **Table 1**.

Table 1. Stack emission characteristics

Parameter	EIS (operating on gas)		Proposed final design (operating on gas)		Proposed final design (operating on diesel)	
Stack ID	OCGT1	OCGT2	OCGT1	OCGT2	OCGT1	OCGT2
Easting (m)	357520	357510	357519	357509	357519	357509
Northing (m)	6371470	6371401	6371474	6371405	6371474	6371405
Height (m)	36	36	60	60	60	60
Base elevation (m)	14	14	14	14	14	14
Stack tip diameter (m)	9.8	9.8	7.5	7.5	7.5	7.5
Temperature (C)	635	635	650	650	525	525
Velocity (m/s)	25	25	40	40	39	39

Note – OCGT refers to Open Cycle Gas Turbine

An analysis of plume rise data was undertaken to determine the heights at which the plume vertical velocity exceeded the velocities of 4.3, 6.1 and 10.6 m/s. Results of this analysis for various percentile bands are shown in **Table 2.** Note that the plume rise for both the EIS and final design is based on both gas turbines operating together, which is the operating configuration that creates the highest exhaust plume.

Table 2. Height at which plume vertical velocity falls below 4.3, 6.1 and 10.6 m/s

Percent exceedance	Height at which plume vertical velocity falls below 4.3 m/s (m AGL)			Height at which plume vertical velocity falls below 6.1 m/s (m AGL)			Height at which plume vertical velocity falls below 10.6 m/s (m AGL)		
Scenario	EIS	Proposed final design (gas)	Proposed final design (diesel)	EIS	Proposed final design (gas)	Proposed final design (diesel)	EIS	Proposed final design (gas)	Proposed final design (diesel)
0%	1509	1480	1418	1144	1113	1057	291	302	276
0.05%	1316	1307	1260	938	917	873	255	264	240
0.1%	1258	1241	1181	853	841	778	239	251	228
0.2%	1162	1147	1098	766	755	702	225	229	214
0.3%	1096	1086	1040	718	706	656	214	226	203
0.5%	1024	1013	954	656	647	601	201	210	191
1%	888	872	822	557	555	514	177	189	176
2%	743	736	691	456	456	425	155	167	153
3%	650	647	604	402	405	376	140	152	140
4%	587	585	544	361	364	339	132	141	137
5%	540	539	502	332	338	313	124	138	127
6%	502	502	469	312	316	294	115	127	125
7%	474	474	441	294	300	279	112	126	115
8%	449	450	419	280	286	267	110	117	114
9%	428	430	401	267	273	254	101	114	114
10%	410	412	383	256	262	245	99	114	113
20%	298	302	282	190	198	186	85	101	90
30%	245	251	235	159	168	159	74	89	89
40%	212	219	206	141	149	141	62	88	88
50%	191	198	187	126	137	130	61	78	78
60%	175	183	173	115	128	121	61	77	77
70%	161	169	160	106	120	113	60	77	77
80%	147	158	149	99	112	106	50	77	76
90%	133	144	138	87	104	98	49	76	76
100%	82	99	98	53	80	80	47	74	74

Table 3 shows the frequency of time that the plume vertical velocity was predicted to fall below 4.3, 6.1 and 10.6 m/s for a range of heights above local ground-level.

Table 3. Frequency of plume vertical velocity exceeding 4.3, 6.1 and 10.6 m/s in height bands

Height above ground level (m AGL)	Frequency of plume vertical velocity exceeding 4.3 m/s at each height (%)			Frequency of plume vertical velocity exceeding 6.1 m/s at each height (%)			Frequency of plume vertical velocity exceeding 10.6 m/s at each height (%)		
Scenario	EIS	Proposed final design (gas)	Proposed final design (diesel)	EIS	Proposed final design (gas)	Proposed final design (diesel)	EIS	Proposed final design (gas)	Proposed final design (diesel)
50	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	71.67%	100.00%	100.00%
100	99.26%	100.00%	99.92%	79.07%	93.41%	89.79%	9.16%	20.46%	18.36%
150	77.25%	85.43%	79.36%	34.10%	39.24%	34.14%	2.28%	3.43%	2.53%
200	45.06%	48.69%	42.55%	17.94%	19.59%	16.83%	0.51%	0.77%	0.40%
300	19.56%	20.28%	17.37%	6.62%	7.00%	5.69%	0.00%	0.00%	0.00%
400	10.51%	10.71%	9.03%	3.02%	3.10%	2.46%	0.00%	0.00%	0.00%
500	6.05%	6.06%	5.04%	1.48%	1.47%	1.13%	0.00%	0.00%	0.00%
600	3.74%	3.64%	3.03%	0.73%	0.70%	0.50%	0.00%	0.00%	0.00%
800	1.55%	1.48%	1.14%	0.14%	0.13%	0.10%	0.00%	0.00%	0.00%
1000	0.55%	0.52%	0.38%	0.03%	0.02%	0.01%	0.00%	0.00%	0.00%
1200	0.14%	0.13%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1400	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1600	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1800	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The key outcome of the modelling was that the predicted maximum heights at which the plume vertical velocity falls below 6.1 m/s were 1,113 m AGL for gas operation and 1,057 m AGL for diesel operation under the proposed final design compared to 1,144 m for the EIS. This reduction in plume rise height is primarily due to a reduction in output of the power station from an envisaged 750MW to 660MW, and consequent reduction in volumetric flow of the exhaust.

Due to the negligible change in plume height, there is no change to the aviation assessment that was submitted with the EIS, and which was the basis of consultation with aviation stakeholders including local airports, CASA, and Defence during the EIS process.

I would appreciate your response with respect to this updated plume rise assessment report, which will enable any amendments to be made, and allow Snowy Hydro to demonstrate consultation to the Department of Planning and Environment. A response by **21 June 2022** would be appreciated. Should you have no additional feedback to that provided during the EIS consultation process, an email or letter indicating this would similarly be appreciated.

Please get in touch with Mike Luger on 0468 987 874 or Mike.Luger@jacobs.com for any queries or further information.

Your Sincerely,

DocuSigned by:

48B7380B5CC9467...

Ian Smith
Approvals Manager – Hunter Power Project

DocuSign Envelope ID: 69DAC015-2C31-4116-9975-5328F8180B28

8 June 2022

Department of Defence
Estate and Infrastructure Group
PO Box 7925
Canberra ACT 2610

Attention: Timothy Hogan

Subject: Hunter Power Station – updated plume rise assessment report: consultation request

Dear Timothy,

The Hunter Power Project (Kurri Kurri Gas-Fired Power Station) (the Project) was approved as SSI-12590060 by the then Minister for Planning and Public Spaces on 17 December 2021. Condition B19 of the Infrastructure Approval for the Project requires that an updated plume rise assessment report based on the final design is prepared in consultation with Civil Aviation Safety Authority (CASA), Department of Defence, and RAAF Williamtown. The plume rise being that generated from the power station gas turbine exhausts when in operation.

This purpose of this letter is to request your feedback on the attached draft and updated plume rise assessment report to demonstrate this consultation to the Department of Planning and Environment (DPE). The attached report is an update of the plume rise assessment that was submitted with the Project Environmental Impact Statement (EIS) in April 2021, and is based on the gas turbine final design as opposed to the preliminary information from gas turbine manufacturers available at the time of the EIS. The follow sections of this letter therefore serve to highlight the changes between the EIS version (which was based on the preliminary design) and the updated plume rise report (which is based on the final design).

Identical plume modelling parameters were used in both the EIS and final design. The model used is The Air Pollution Model (TAPM) version 4.0.5. The stack emission characteristics used in the EIS and for the proposed final design are shown in **Table 1**.

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Easting (m)	357520	357510	357519	357509	357519	357509
Northing (m)	6371470	6371401	6371474	6371405	6371474	6371405
Height (m)	36	36	60	60	60	60
Base elevation (m)	14	14	14	14	14	14
Stack tip diameter (m)	9.8	9.8	7.5	7.5	7.5	7.5
Temperature (C)	635	635	650	650	525	525
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Note – OCGT refers to Open Cycle Gas Turbine

An analysis of plume rise data was undertaken to determine the heights at which the plume vertical velocity exceeded the velocities of 4.3, 6.1 and 10.6 m/s. Results of this analysis for various percentile bands are shown in **Table 2.** Note that the plume rise for both the EIS and final design is based on both gas turbines operating together, which is the operating configuration that creates the highest exhaust plume.

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1000	0.55%	0.52%	0.38%	0.03%	0.02%	0.01%	0.00%	0.00%	0.00%
1200	0.14%	0.13%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1400	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1600	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1800	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The key outcome of the modelling was that the predicted maximum heights at which the plume vertical velocity falls below 6.1 m/s were 1,113 m AGL for gas operation and 1,057 m AGL for diesel operation under the proposed final design compared to 1,144 m for the EIS. This reduction in plume rise height is primarily due to a reduction in output of the power station from an envisaged 750MW to 660MW, and consequent reduction in volumetric flow of the exhaust.

Due to the negligible change in plume height, there is no change to the aviation assessment that was submitted with the EIS, and which was the basis of consultation with aviation stakeholders including local airports, CASA, and Defence during the EIS process.

I would appreciate your response with respect to this updated plume rise assessment report, which will enable any amendments to be made, and allow Snowy Hydro to demonstrate consultation to the Department of Planning and Environment. A response by **21 June 2022** would be appreciated. Should you have no additional feedback to that provided during the EIS consultation process, an email or letter indicating this would similarly be appreciated.

Please get in touch with Mike Luger on 0468 987 874 or Mike.Luger@jacobs.com for any queries or further information.

Your Sincerely,

DocuSigned by:

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Ian Smith
Approvals Manager – Hunter Power Project

Australian Government

Department of Defence

Charles Mangion
Director Land Planning and Regulation
Brindabella Business Park (BP26-1-A052)
PO Box 7925
Department of Defence
CANBERRA BC ACT 2610
☎: (02) 5109 5177
💻: charles.mangion@defence.gov.au

ID-EP-DLP&R/OUT/2022/BS31641781

Mr Ian Smith
Approvals Manager – Hunter Power Project
Snowy Hydro Ltd
PO Box 332
COOMA NSW 2630

Dear Mr Smith

HUNTER POWER PROJECT (KURRI KURRI POWER STATION), HART ROAD, LOXFORD NSW – UPDATED PLUME RISE ASSESSMENT

Thank you for referring the above updated plume rise assessment to the Department of Defence (Defence) for comment. Defence understands that the Hunter Power Project (Kurri Kurri Gas-Fired Power Station) was approved by the NSW Minister for Planning and Public Spaces on 17 December 2021. A Condition (B19) of the Approval requires that an updated plume rise assessment report based on the final design is prepared in consultation with Civil Aviation Safety Authority (CASA), Department of Defence, and RAAF Williamtown.

Defence has reviewed the recently submitted updated plume rise assessment associated with the proposal for any possible impact on the safety of flying operations at RAAF Base Williamtown and its advice is provided below.

The information provided in the revised plume assessment indicates that the height at which the velocity of the merged plume from the two proposed exhaust stacks falls below 6.1m/s (0.1 percent exceedance or 99.9th percentile) is 855m AHD (841m AGL) for gas and 792m AHD (778m AGL) for diesel. This compares to an initial plume height of 867m AHD (853m AGL) that was assessed as part of the EIS in 2021.

On the current assessment, Defence considers that the construction of the power station will not adversely impact upon civil or military flying operations at RAAF Base Williamtown / Newcastle Airport. This advice is on the basis that all the mitigating measures identified in Defence correspondence to the Department of Planning, Industry and Environment dated 8 June 2021 (see enclosed) are fully adhered to.

In addition, Defence notes that the exhaust stacks for the final design have increased in height to 60m AGL which is 24m higher than the 36m AGL high stacks that were assessed during the EIS phase of the proposal. Defence is concerned that at this height the exhaust stacks could pose a safety risk to military rotary wing operations in the area, particularly as helicopters regularly use the Singleton Military Area including at night. As such Defence is of the view that consideration of obstacle lighting would be a prudent measure and should be considered as a mitigating measure.

Should you wish to discuss the content of this advice further, my point of contact is Tim Hogan at land.planning@defence.gov.au

Yours sincerely,

Charles.Mangion Digitally signed by Charles.Mangion Date: 2022.06.27 14:17:11 +10'00'

Charles Mangion
Director Land Planning & Regulation

27 June 2022

Enclosure 1.
Defence correspondence dated 8 June 2021- SSI-12590060 EIS Report – Hunter Power Project (Kurri Kurri Power Station), Hart Road, Loxford

Cc: Branch Manager, Air Navigation, Airspace and Aerodromes, Civil Aviation Safety Authority.
Resource Assessments, Planning and Assessment, Department of Planning, Industry and Environment

Australian Government
Department of Defence
Estate and Infrastructure Group

Charles Mangion
Director Land Planning and Regulation
Estate Planning Branch
Brindabella Business Park (BP26-1-A053)
PO Box 7925
Department of Defence
CANBERRA BC ACT 2610
☎: (02) 5109 5177
💻: charles.mangion@defence.gov.au

ID-EP-DLP&R/OUT/2021/BS20074212

Director
Resource Assessments
Planning and Assessment
Department of Planning, Industry and Environment
Locked Bag 5122
PARRAMATTA NSW 2124

Dear Sir/Madam

RE: SSI-12590060 EIS REPORT – HUNTER POWER PROJECT (KURRI KURRI POWER STATION), HART ROAD, LOXFORD NSW 2326

Thank you for referring the above Environmental Impact Statement to the Department of Defence (Defence) for comment. Defence understands that this application is for the development of a gas fired power station at Kurri Kurri, NSW. Defence has reviewed the proposal and in particular the plume associated with the proposal for any possible impact on the safety of flying operations at RAAF Base Williamtown and its advice is provided below.

Based on the information provided and earlier consultation with consultants engaged by the proponent, Defence agrees that it is appropriate that the Critical Plume Extent (CPE_ (mAHD) be based on the 99.9% percentile statistic of hourly results and a Critical Plume Velocity (CPV) of 6.1 m/s. This approach is also consistent with subject matter advice from government bodies including the Civil Aviation Safety Authority (CASA) and Defence stakeholder input.

The height at which the velocity of the merged plume from the two proposed 36m high exhaust stacks falls below 6.1m/s (0.1 percent exceedance or 99.9th percentile) is 867m AHD (2845ft AHD). On this assessment, Defence considers that the construction of the power station will not adversely impact upon civil or military flying operations at RAAF Base Williamtown / Newcastle Airport, provided that the following mitigating measures are adhered to.

Defence requests that a permanent charted Danger Area is to be promulgated using Global Airspace Solutions dimensions to account for the vertical plume velocities generated from the plant. The parameters of the Danger Area will include a vertical elevation of 884 metres (2,900 feet) and a horizontal radius of 155 metres, it should include a note to avoid the Danger Area.

In addition, I note that CASA have also assessed the plume and in correspondence dated 27 April 2021 they have requested that the proponent conduct another plume study once a vendor is selected and the final design is approved. Defence concurs with this request.

It is therefore requested by Defence that if the NSW Department of Planning, Industry and Environment issue an approval for the relevant State Significant Infrastructure application that the proponent be advised on such approval to liaise with and provide information on the final design and emission parameters to the following organisations so that required mitigation measures can be put in place:

- Department of Defence – Estate Planning Branch ;
- Civil Aviation Safety Authority;
- Aeronautical Information Service - Air Force
- Air Services Australia;
- Newcastle Airport Pty LTD; and
- Global Airspace Solutions.

Defence will undertake to work with CASA and Airservices Australia with regard to the mitigation measures proposed by the above mentioned organisations.

Should you wish to discuss the content of this advice further, my point of contact is Mr Tim Hogan contactable at land.planning@defence.gov.au or by telephone on (02) 6266 8686. Please also note our new Defence group email address for all land planning matters.

Yours sincerely

Charles.Mangion Digitally signed by Charles.Mangion Date: 2021.06.08 12:24:33 +10'00'

Charles Mangion
Director Land Planning & Regulation

8 June 2021

Cc: Branch Manager, Air Navigation, Airspace and Aerodromes, Civil Aviation Safety Authority.
CEO, Strategic Airspace, Ms Cathy Pak-Poy

Australian Government

Civil Aviation Safety Authority

AIR NAVIGATION, AIRSPACE AND AERODROMES

File Ref: F20/19365-5

27/6/2022

Clay Preshaw
Executive Director
Energy, Resources and Industry Assessments
NSW Dept of Planning, Industry and Environment
Locked Bag 5022
Parramatta NSW 2124

Dear Mr Preshaw

Hunter Power Project - Kurri Kurri Gas-Power Plant

I refer to the comments CASA provided to NSW Planning regarding the above project.

The proponent, Snowy Hydro Ltd, recently submitted a revised plume rise assessment report.

CASA is pleased to advise that at a critical plume height of 841m AHD, the proposal presented will not create any unacceptable impacts to the safety of aircraft operations in the vicinity of the site.

CASA's understanding is that the proponent has now finalised its design process and the plume study provided is the updated version required by the NSW Infrastructure Approval for the project.

CASA advises we will work with the Department of Defence and Airservices Australia to determine what, if any, appropriate mitigation measures are required.

Yours sincerely

Digitally signed by
Brad.Parker
Date: 2022.06.27
12:43:02 +10'00'

Brad Parker
Acting Branch Manager

cc Mr Magnion, Director – Land Planning and Regulation, Department of Defence
Mr Tomlinson, Airport Development and Engagement Adviser, Airservices Australia
Mr Smith, Approvals Manager- Hunter Power Project, Snowy Hydro Ltd

Australian Government
Civil Aviation Safety Authority

AIR NAVIGATION, AIRSPACE AND AERODROMES

File Ref: F20/19365-5

5/9/2022

Clay Preshaw
Executive Director
Energy, Resources and Industry Assessments
NSW Dept of Planning, Industry and Environment
Locked Bag 5022
Parramatta NSW 2124

Dear Mr Preshaw

Hunter Power Project - Kurri Kurri Gas-Power Plant

I refer to the comments CASA provided to NSW Planning regarding the above project.

The proponent, Snowy Hydro Ltd, recently sought advice from CASA regarding obstacle lighting requirements.

Based on input from the Department of Defence, it is recommended that each stack be lit with a low intensity steady red obstacle light at night and during periods of low visibility. As this recommendation is to mitigate the risk to low level aircraft operations, the lighting recommendation applies at all times once the stack is constructed, including periods when the power plant is not operating.

If LED obstacle lighting is used, the Department of Defence has requested that the wavelength range is within 665-930 nanometres to allow for the use of Night Vision Devices (NVD).

Yours sincerely

Brad Parker
Manager, CNS/ATM

cc Mr Magnion, Director – Land Planning and Regulation, Department of Defence
Mr Tomlinson, Airport Development and Engagement Adviser, Airservices Australia
Mr Bokil, Engineering Director - Hunter Power Project, Snowy Hydro Ltd

Appendix B. Environmental Representative Endorsement

HBI Healthy Buildings International Pty Ltd
A.C.N. 003 270 693 A.B.N. 39 003 270 693

Suite 2.06, Level 2
29-31 Solent Circuit
Norwest, NSW 2153

Tel: 61 (02) 9659 5433
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Isaac Strachan
Health, Safety and Environment Lead
Snowy Hydro Limited
Lot 3, Pier 8/9, 23 Hickson Rd
Walsh Bay NSW 2000

9 September 2022

REF: REVISED PLUME RISE ASSESSMENT

Dear Isaac,

RE: Hunter Power Project -Revised Plume Rise Assessment for Final Design Rev 2 (8 September 2022)

I refer to Snowy Hydro Limited's (SHL) submission of the following document required by Condition B19 of the Hunter Power Project (Kurri Kurri Gas-Fired Power Station) Infrastructure Approval (SSI 12590060) for review and endorsement by the Environmental Representative:

- Hunter Power Project -Revised Plume Rise Assessment for Final Design Rev 2 (8 September 2022)

It is noted that:

- The Revised Plume Rise Assessment has been developed by Jacobs Group Australia (Jacobs) on behalf of SHL to provide an updated plume rise assessment report based on the final generator design including satisfying Condition B19.
- The ER review did not include a technical review of the Updated Plume Rise Assessment outputs, nor assess the accuracy of the modelling.
- Following the review, the document is considered to contain information required by the Conditions of Approval (SSI 12590060) in relation to Aviation Safety (Condition B19).

Notwithstanding the above, as the approved Environmental Representative for the Hunter Power Project (Kurri Kurri Gas-Fired Power Station) and as required by Conditions A23(a), the Revised Plume Rise Assessment for Final Design Rev 2 (8 September 2022) is endorsed for submission to the Secretary for consideration and approval.

Snowy Hydro Limited and their contractors must continue to obtain and comply with any relevant approval, licence or permit required for the works; complying with relevant Conditions of Approval as they relate to the works; and appropriate notifications being issued prior to the works.

Yours sincerely

Greg Byrnes
Environmental Representative – Hunter Power Project (Kurri Kurri Gas-Fired Power Station)