Title:	**Noise Assessment Report Addendum: Low Frequency Noise and Infrasound**
Project:	Hastings Generation Project Environmental Noise Impact Assessment
Client:	Esso

Wood Doc No	AU01103-01-FN1	**Wood Job No.**	AU01103-01

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1 INTRODUCTION

Esso are seeking to obtain regulatory planning approval for the Hastings Generation Project (The Project). The Hastings Generation Project is to be located at an Esso Australia Pty Ltd (Esso) and BHP Petroleum (Bass Strait) Pty Ltd owned site adjoining the existing Long Island Point (LIP) facility. Noise from The Project has the potential to impact noise sensitive areas (hereby referred to as NSRs/noise sensitive receivers) surrounding the proposed operations.

Noise impacts at four of the closest noise sensitive receivers were previously assessed, based on noise modelling and background noise monitoring of The Project, as contained in the report document *Rpt01-AU00659-Rev1-26.Nov.2021 Hastings Generation Project Environmental Noise Impact Assessment*. The assessment results from this report indicate that noise emissions (*effective noise levels*) due to the operation of The Project would fall below the noise limits at all noise sensitive receivers identified in the assessment and are thus compliant with the relevant regulations.

A public concern was raised about the possible presence of infrasound emanating from the facility as a result of The Project. This report presents a review of low frequency noise levels detected at the closest NSR, with consideration of infrasound as part of low frequency noise emissions. For the purposes of this addendum, it is important to note that infrasound is typically considered to be noise in frequency bands between 0-20 Hz and is generally considered to be inaudible. The applicable *EPA Victoria Noise Guidelines: Assessing low frequency noise – Publication 1996 June 2021* do not specifically address emissions or impact of infrasound.

1.1 Scope

The scope for this addendum to the noise assessment report is to:

- Present noise assessment results for NSR1 from 6.3 Hz – 160 Hz, following similar methodology to that described in the original report *Rpt01-AU00659-Rev1-26.Nov.2021 Hastings Generation Project Environmental Noise Impact Assessment* (**Section 3**), but instead applying assessment guidelines for low frequency noise (*EPA Victoria Noise Guidelines: Assessing low frequency noise – Publication 1996 June 2021),* and provide a short discussion on the results.

2 ASSESSMENT METHODOLOGY

2.1 Noise Modelling Methodology for Low Frequency or Infrasound

Noise modelling of low frequency noise or infrasound was undertaken using the existing noise model and methodology used to determine compliance with the regulations in report document *Rpt01-AU00659-Rev2-25.May.2021 Hastings Generation Project Environmental Noise Impact Assessment*. The details of The Project and its operations as affecting noise emissions, as well as assessment methodology to determine compliance with the regulations is provided in report document **Sections 2 (Description of Site & Operations),** and **5 (Noise Modelling Methodology).**

In addition to the methodology outlined in the report, low frequency sound power levels (SWL) for the exhaust stack of the three packages has been remodelled in SoundPlan.

2.1.1 Uncertainty in Infrasound Noise Modelling

Noise modelling was undertaken using the CONCAWE[1][2] algorithm. Uncertainty of the CONCAWE algorithm has been determined in a CONCAWE report[2]. The 95% confidence limits for Octave Band frequencies ranging from 63 Hz to 4 kHz with various meteorological categories within the algorithm are described in Table 2-1 below. The confidence limits are a measure of the accuracy of the model to predict the sound level at a certain place for an individual measurement under each of the defined meteorological categories.

[1] CONCAWE (Conservation of Clean Air and Water in Europe) was established in 1963 by a group of oil companies to carry out research on environmental issues relevant to the oil industry.

[2] The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, CONCAWE Report 4/81, 1981

Table 2-1 95% Confidence Limits for the CONCAWE Model

95% Confidence Limits for CONCAWE Model								
Meteorological Category	dB(A)	Octave Band Centre Frequency						
		63	125	250	500	1k	2k	4k
2	6.8	5.4	5.4	9.1	9.4	7.8	9.8	12.4
3	6.9	5.0	6.2	9.4	10.1	8.5	8.5	9.4
4	5.7	4.8	6.5	8.7	9.8	6.6	5.6	6.7
5	4.7	3.9	5.4	8.4	8.1	5.2	5.6	6.7
6	4.6	5.2	6.1	6.7	9.3	4.9	5.5	8.2

Worst-case weather conditions for noise propagation (meteorological category 6) have been assumed in the noise modelling which includes the presence of a temperature inversion, wind speed of 3 m/s and NSRs downwind of the facility.

A further statistical assessment of the CONCAWE algorithm was determined in the CONCAWE report[2]. The mean differences between the predicted and observed noise levels in each meteorological category were calculated, providing a quantitative measure of model algorithm performance over a longer-term timeframe. The mean difference for overall level and individual octave bands are listed Table 2-2 below.

Table 2-2 Mean Difference for the CONCAWE Model

Mean Difference (Observed minus predicted) for CONCAWE Model								
Meteorological Category	dB(A)	Octave Band Centre Frequency, Hz						
		63	125	250	500	1k	2k	4k
2	0.5	0.1	0.1	2.0	2.2	2.2	-0.2	0.4
3	0.6	-0.0	0.5	1.6	0.4	0.8	0.8	0.4
4	0.5	0.3	0.8	-1.2	-0.2	0.1	1.4	0.2
5	0.0	-0.1	-0.0	-2.3	0.4	-0.6	0.9	-0.9
6	0.5	-0.8	-0.3	-1.7	1.2	-0.2	0.1	-0.9

The Mean Difference for the algorithm do not include infrasound frequencies however, from the table above we can see that, generally, across all meteorological conditions the confidence limits decrease with low frequency noise. Therefore, a conservative assessment of Mean Difference for infrasound noise is -0.5 to -0.8 dB.

2.2 Low Frequency or Infrasound Noise Measurement Uncertainty

Background noise measurements conducted by Wood at noise sensitive receivers were undertaken using a Brüel & Kjaer Sound Level Meter (SLM). The meter is designed to meet the requirements for Type 1 instruments as specified in AS IEC 61672.1-2004 and for 1/3 octave band filters as specified in AS/NZS 4476:1997 *Acoustics—Octave-band and fractional-octave-band filters*.

The SLM was field calibrated prior to starting measurements and on completion of measurements using a Brüel and Kjaer Type 4231 reference sound source. A list of equipment used is given in Table 2-3 below.

Table 2-3 Noise Monitoring Equipment

Equipment Type	Serial Number
Sound Level Meter, Brüel & Kjaer Type 2270	3000342
Reference Sound Source, Brüel & Kjaer Type 4231	2253111

AS IEC 61672.1-2004 Clause 5.6.5 and Clause 5.6.7 detail acceptable level of linearity for a Class 1 SLM:

- *Clause 5.6.5*: Measured values of level linearity deviations shall not exceed ±0,8 dB for class 1 and ±1,1 dB for class 2 sound level meters.*
- *Clause 5.6.7*: The specifications in 5.6.5 and 5.6.6 apply over the total level range for any frequency within the frequency range of the sound level meter and for any frequency weighting or frequency response provided.*

**NOTE: In principle, the requirements for level linearity apply at least for any frequency from 16 Hz to 16 kHz for class 1 sound level meters and from 20 Hz to 8 kHz for class 2 sound level meters.*

The standard does not provide an acceptable level linearity deviation for 1/3 octave band data measured at 12.5 Hz. However, a review of the Brüel and Kjaer SLM User Manual[3] states that the free field frequency range for the B&K 2270 SLM with standard 4189 microphone has a +- 1 dB response for frequencies ranging from 6.8 Hz to 22.4 kHz.

In summary, the measurements undertaken using the Brüel & Kjaer SLM in the infrasound range are within +- 1 dB. The SLM is designed to meet the requirements for Type 1 instruments as specified in AS IEC 61672.1-2004.

[3] USER MANUAL - Hand-held Analyzer Types 2250 and 2270, *Brüel and Kjaer*, (2016)

2.3 Sound Power Level of Exhaust Stack

The one-third octave band centre frequency SWLs, for low frequencies in the infrasound range, were provided by Solar and presented in Table 2-4.

Table 2-4 Infrasound SWLs of Unsilenced Exhaust Stack

1/3-Octave Band Center Frequency [Hz]	6.3	8	10	12.5	16	20
Engine Exhaust Unsilenced Sound Power Level [dB re 1 pW]	104	109	110	113	112	110

2.4 Noise Sensitive Receivers

Noise impacts were assessed at four noise sensitive receivers (NSRs) nearby The Facility. These receivers have all been identified as private residences The residential address of the closest receiver is outlined in Table 2-5.

Table 2-5 Residential address of Assessed Noise Sensitive Receivers

Noise Sensitive Receiver	Address
NSR 1	11 Cemetery Rd, Hastings VIC 3915
NSR 2	65 Skinner St, Hastings VIC 3915
NSR 3	2 Hodgins Rd, Hastings VIC 3915
NSR 4	15A Lyall St, Hastings VIC 3915

The noise assessment in Section 3 predicts low frequency impacts at NSR1. This can be considered worst case impact for NSRs surrounding The Project due to the proximity to the Hastings Plant. NSRs 2 – 4 are considered lower risk receivers as they are located further from The Project. The noise assessment for these receivers can be found in APPENDIX A.

2.5 Low Frequency Guidelines

Guidelines on assessing low frequency noise is presented in *EPA Victoria Noise Guidelines: Assessing low frequency noise – Publication 1996 June 2021*. The publication contains indoor and outdoor threshold levels that are derived from UK DEFRA criteria. Advice provided in the publication is that the threshold values described are to be considered guidelines rather than compliance limits.

The disturbance from low frequency noise depends on the noise level, characteristics that can increase annoyance with the noise such as tonality and frequency modulation, and baseline noise levels in the absence of the noise of concern.

For this assessment, no tonality or frequency modulation characteristics were detected.

2.5.1 Infrasound

Infrasound is typically considered to be noise in frequency bands between less than 0-20 Hz and is generally considered to be inaudible. The *EPA Victoria Noise Guidelines: Assessing low frequency noise – Publication 1996 June 2021* do not specifically address emissions or impact of infrasound. For the purposes of this assessment, the low frequency assessment guidance will be used, including those bands at the lower end of the spectrum to provide a measure of infrasound.

3 NOISE ASSESSMENT

The noise levels that would be generated at the noise sensitive receivers by operation of the Hastings Generation Project were modelled under adverse weather conditions, as set out in Section 5.3 of the report document *Rpt01-AU00659-Rev1-26.Nov.2021 Hastings Generation Project Environmental Noise Impact Assessment*.

Section 3.1 and Section 3.2 assess noise impacts at NSR1 (which is the receiver closest to the Hastings Plant and therefore considered worst case for noise impacts). Assessment of noise impacts for NSRs 2 – 4, which are further from The Project and therefore considered lower risk, is located in APPENDIX A.

3.1 Low Frequency Noise

The predicted Z-weighted (linear) noise levels are compared with the low frequency threshold levels (excluding infrasound levels) and are presented in Table 3-1, with A-weighted levels also shown in the lower rows for reference.

Table 3-1 Assessment of NSR1 Predicted Low Frequency Levels

1/3 octave Band Frequency Levels (Hz)										
		25	31.5	40	50	63	80	100	125	160
Threshold Levels	LZeq (dB)	69	61	54	50	50	48	48	46	44
	(dBA)	24.3	21.6	19.4	19.8	23.8	25.5	28.9	29.9	30.6
NSR1 - SPL from Exhaust Stack	LZeq (dB)	61.3	56	51	**59.6**	**55.1**	**51.6**	**48.3**	45.1	42.1
	(dBA)	16.6	16.6	16.4	29.4	28.9	29.1	29.2	29	28.7
Baseline Levels	LZeq (dB)	56.2	55.5	53.4	52.6	52.7	55.1	51.8	44.6	43.0
	(dBA)	11.5	16.1	18.8	22.4	26.5	32.6	32.7	28.5	29.6

The assessment results for NSR1 presented in Table 3-1 indicate that noise emissions due to the operation of The Project may result in exceedances in the 50 Hz, 63 Hz, 80 Hz and 100 Hz bands. However, the exceedances in the 80 Hz and 100 Hz bands fall below the baseline levels measured by Wood at NSR1 and therefore are unlikely to be audible.

Current baselines levels exceed in the 50Hz and 63 Hz, and predicted impacts from The Project are well below the effective overall limit for these bands. The predicted noise levels from The Project at the receiver in the 50 Hz and 63 Hz bands is approximately 30 dB(A) in each band, which is equivalent to the overall noise from *A Quiet Countryside* according to the Table of Equivalent Noise Source provided by NSW EPA in APPENDIX B. Predicted noise in the 63 Hz band is within 3 dB of current baselines levels and it is therefore unlikely that the increase in noise in this band will be audible while received noise levels in the 50 Hz band are likely to be only faintly audible.

3.2 Infrasound Noise

The predicted Z-weighted (linear) noise levels are compared with the infrasound threshold levels are presented in Table 3-2, with A-weighted levels also shown in the lower rows for reference.

Table 3-2 Assessment of NSR1 Predicted Infrasound Levels

One-third Octave Frequency Levels (Hz dB)							
		6.3	8	10	12.5	16	20
Threshold Levels	Leq (dB)	-	-	92	89	86	77
	(dBA)	-	-	21.6	25.6	29.3	26.5
NSR1 - SPL from Exhaust Stack	Leq (dB)	44.7	49.7	50.7	53.6	52.6	50.5
	(dBA)	-	-	-	-	-	0
Baseline Levels	Leq (dB)	-	-	-	60.0	65.2	62.9
	(dBA)	-	-	-	-	8.5	12.4
NSR1 – SPL from Exhaust Stack + Baseline Levels	Leq (dB)	44.7	49.7	50.7	60.9	65.4	63.1
	(dBA)	-	-	-	-	8.7	12.6

Predicted infrasound noise levels from The Project are significantly below the threshold levels and there are no exceedances under the 20 Hz range for cumulative infrasound levels (NSR1 – SPL from Exhaust Stack + Baseline Levels), therefore it is not anticipated that there will be any significant infrasound to emanate from the HGP facility.

4 CONCLUSION

The noise assessment in section 3 predicts low frequency impacts at NSR1 which can be considered worst case impact for NSRs surrounding The Project. The assessment results for NSR1 presented in Table 3-1 indicate that low frequency noise emissions due to the operation of The Project may result in exceedances in the 50 Hz, 63 Hz, 80 Hz and 100 Hz bands. However, the exceedances in the 80 Hz and 100 Hz bands fall below the baseline levels measured by Wood at NSR1 and are unlikely to be audible. Current baselines levels exceed in the 50Hz and 63 Hz, and predicted impacts from The Project are well below the effective overall limit for these bands. Predicted noise in the 63 Hz band is within 3 dB of current baselines levels and it is therefore unlikely that the increase in noise in this band will be audible, while received noise levels in the 50 Hz band are likely to be only faintly audible.

There are no exceedances under the 20 Hz range and therefore it is not anticipated that there will be any significant infrasound to emanate from the HGP facility.

Assessment of low frequency noise impacts for NSRs 2 – 4 indicate that low frequency noise emissions from The Project are not expected to exceed the guidelines in any 1/3 Octave Bands.

Assessment of the mean differences for results predicted using the CONCAWE algorithm and sound level meter measurement uncertainty indicates a range of up to +- 1 dB can be expected. Uncertainty has been considered when assessing the risk of non-compliance.

The overall effective noise level of 46 (dBA) at NSR1 is unaffected and The Project falls under the noise limit of 49 (dBA) and are thus assessed as compliant with relevant regulations.

APPENDIX A

A.1 NSR2 Assessment of Infrasound and Low Frequency Noise Impacts

One-third Octave Frequency Levels (Hz dB)																
		6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Threshold Levels	Leq (dB)	-	-	92.0	89.0	86.0	77.0	69.0	61.0	54.0	50.0	50.0	48.0	48.0	46.0	44.0
	(dBA)	-	-	21.6	25.6	29.3	26.5	24.3	21.6	19.4	19.8	23.8	25.5	28.9	29.9	30.6
NSR2	Leq (dB)	31.4	36.3	37.1	39.9	38.7	36.6	47.4	42.2	38.1	47.3	42.8	39.2	37.7	34.4	31.2
	(dBA)	-54.0	-41.5	-33.3	-23.5	-18.0	-14.0	2.7	2.8	3.5	17.1	16.6	16.7	18.6	18.3	17.8
NSR2 Baseline Levels	Leq (dB)	-	-	-	-2.2	8.2	7.9	9.0	11.9	14.0	20.1	20.1	24.4	24.3	24.0	24.0
	(dBA)	-	-	-	61.2	64.9	58.4	53.7	51.3	48.6	50.3	46.3	46.9	43.4	40.1	37.4

A.2 NSR3 Assessment of Infrasound and Low Frequency Noise Impacts

One-third Octave Frequency Levels (Hz dB)																
		6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Threshold Levels	Leq (dB)	-	-	92.0	89.0	86.0	77.0	69.0	61.0	54.0	50.0	50.0	48.0	48.0	46.0	44.0
	(dBA)	-	-	21.6	25.6	29.3	26.5	24.3	21.6	19.4	19.8	23.8	25.5	28.9	29.9	30.6
NSR3	Leq (dB)	32.3	37.3	38.3	41.2	40.2	38.1	48.9	43.6	38.7	47.5	43.0	39.5	38.4	35.1	31.9
	(dBA)	-53.1	-40.5	-32.1	-22.2	-16.5	-12.4	4.2	4.2	4.1	17.3	16.8	17.0	19.3	19.0	18.5
NSR3 Baseline Levels	Leq (dB)	-	-	-	-8.2	1.2	1.6	3.7	7.2	11.4	18.4	23.1	27.6	29.5	30.8	29.0
	(dBA)	-	-	-	55.2	57.9	52.1	48.4	46.6	46.0	48.6	49.3	50.1	48.6	46.9	42.4

A.3 NSR4 Assessment of Infrasound and Low Frequency Noise Impacts

One-third Octave Frequency Levels (Hz dB)																
		6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Threshold Levels	Leq (dB)	-	-	92.0	89.0	86.0	77.0	69.0	61.0	54.0	50.0	50.0	48.0	48.0	46.0	44.0
	(dBA)	-	-	21.6	25.6	29.3	26.5	24.3	21.6	19.4	19.8	23.8	25.5	28.9	29.9	30.6
NSR4	Leq (dB)	30.8	35.7	36.7	39.7	38.6	36.5	47.4	42.0	37.1	45.9	41.4	37.7	35.7	32.3	29.2
	(dBA)	-54.6	-42.1	-33.7	-23.8	-18.1	-14.0	2.7	2.6	2.5	15.7	15.2	15.2	16.6	16.2	15.8
NSR4 Baseline Levels (Note 1)	Leq (dB)	-	-	-	-8.2	1.2	1.6	3.7	7.2	11.4	18.4	23.1	27.6	29.5	30.8	29.0
	(dBA)	-	-	-	55.2	57.9	52.1	48.4	46.6	46.0	48.6	49.3	50.1	48.6	46.9	42.4

Note 1: Due to the presence of significant intrusive noise from an industrial premises at this location background measurements were not undertaken at this location as part of the environmental noise assessment. Background measurements were taken at a background equivalent location (NSR3), and these have been used in the table.

APPENDIX B TABLE OF EQUIVALENT NOISE LEVELS

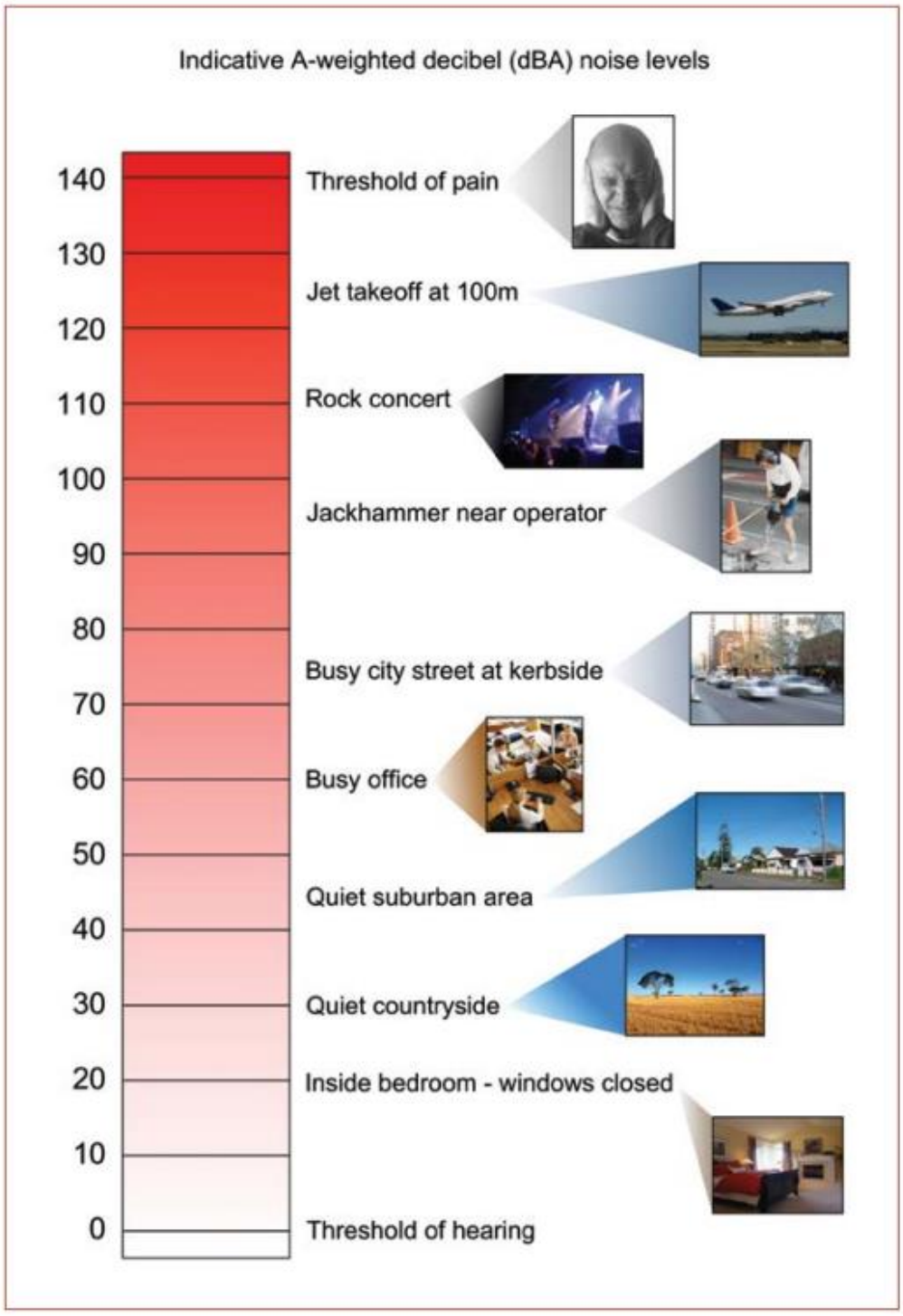

Figure 4-1 Common Noise Levels and Descriptions (Credit: NSW EPA – Noise Guide for Local Government 2021)