Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Overview

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW.

Port Kembla Gas Terminal consists of four key components:

- LNG carrier vessels — there are hundreds of these in operation worldwide transporting LNG from production facilities all around the world to demand centres.
- Floating Storage and Regasification Unit (FSRU) — a cape-class ocean-going vessel, which would be moored at Berth 101 in Port Kembla.
- Berth and wharf facilities — including landside offloading facilities to transfer natural gas from the FSRU into a natural gas pipeline located on shore.
- Gas pipeline — a Class 900 carbon steel high-pressure pipeline connection from the berth to the existing gas transmission network.

LNG will be sourced from worldwide suppliers and transported by LNG carriers to the Port Kembla Gas Terminal. The LNG will then be re-gasified for input into the NSW gas transmission network. The project will be the first of its kind in NSW and provide a simple, flexible solution to the state's gas supply challenges.

The Project was declared Critical State Significant Infrastructure (CSSI) in accordance with section 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and received Infrastructure Approval from the Minister for Planning and Public Spaces on the 24th of April 2019.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

The EIS stated the project would have the capacity to deliver in excess of 100 petajoules (PJ) per annum and also indicated that the capacity of the project could be increased further to 140–150 PJ per annum in the future. The EIS assumed a relatively flat demand profile throughout the year based upon the predicted demands from a predominantly industrial customer base. The assessment presented in the EIS for operation of the gas terminal was therefore based upon a flat rate of production with two LNG trains operating within the FSRU.

Further analysis of market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. The rate of production will need to respond to this demand and will also be influenced by operational parameters such as the calorific content of LNG delivered to the project. Accordingly, the supply will likely vary from the assumed flat rate of around 300 Terajoules (TJ) per day for any given season or shipment of LNG.

AIE is therefore seeking a modification of the Minister's approval for the Port Kembla Gas Terminal under section 5.25 of the *Environmental Planning and Assessment Act 1979*. The modification will seek authorisation to increase capacity of the project and allow for seasonality.

The variation in demand between high season and low season is not as described in the EIS and the operations in high season are in excess of the intensity of operations considered as part of the environmental assessment process. Likewise, the low season impacts are considerably lower than those described in the EIS.

The modification will also require an increase to the overall number of LNG carrier deliveries per year to accommodate both the seasonality and the increase in capacity. The EIS anticipated the arrival of 24 consistently sized (170,000 cubic metre) vessels. However, with seasonality, incoming vessels may vary considerably in size from approximately 140,000 cubic metres to 180,000 cubic metres.

1.2 Previous assessment

A previous NVIA was undertaken for the project in Appendix L Noise and vibration of the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018). This assessment considered the construction and operation of the project.

The proposed modification will not significantly change the construction noise and vibration impacts or operational road traffic noise impacts identified in the EIS. Therefore Appendix L Noise and vibration of the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018).should be referred to with regards to the potential construction noise and vibration impacts and operational traffic impacts.

The previous assessment assessed operations based on constant demand throughout the year. This assessment expands on the previous assessment and considers the operational noise emissions associated with increased demand to determine potential worst-case impacts during the high season.

1.3 Scope and structure

The purpose of this Noise Impact Assessment (NIA) is to assess and document the potential noise impacts associated with the proposed modifications to the project to assess the variation in demand between high season and low season.

This report has been prepared to support the Environmental Assessment being prepared for the proposed modification . The scope of the NIA is:

- Review the modification and operational equipment requirements
- Assessment of the potential operational noise impacts at nearby sensitive receivers
- Provision of mitigation measures where applicable

The structure and content of this report is as follows:

- **Section 1 – Introduction:** provides the background and an overview of the project and modification
- **Section 2 – Existing environment**: summarises the existing noise conditions and details the noise monitoring methodology
- **Section 3 – Compliance criteria:** provides an overview of the operational noise criteria
- **Section 4 –Impact assessment:** presents a summary of the noise modelling and identifies potential noise impacts during operation
- **Section 5 – Mitigation**: provides an overview of the proposed noise and vibration mitigation measures during operation
- **Section 6 – Conclusion**: presents a summary of the NIA findings and sets out the principal conclusions for the assessment.

1.4 Limitations

This report: has been prepared by GHD for Australian Industrial Energy and *may only be used and relied on by Australian Industrial Energy for the purpose agreed between GHD and the Australian Industrial Energy as set out in Section 1.5 of this report.*

GHD otherwise disclaims responsibility to any person other than Australian Industrial Energy arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Australian Industrial Energy and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.5 Assumptions

This NIA relied upon the following assumptions:

- Operational characteristics and likely operational scenarios of the FSRU and LNG carrier were supplied by AIE
- Modelling assumptions in section 4.1.2 of this report

2. Existing environment

Port Kembla is a deep water harbour located in the Illawarra region, approximately 3 kilometres south of the Wollongong Central Business District and 80 kilometres south of Sydney. The port operates across two harbours, consisting of an Inner and Outer Harbour. NSW Ports is responsible for infrastructure at the port, while the NSW Port Authority manage functions including harbour control, vessel tracking, pilotage and navigation.

There are a total of 18 berths at Port Kembla with services ranging from motor vehicle imports, grain and coal exports, general cargo facilities, dry bulk and break bulk facilities and bulk liquid facilities as shown on Figure 2.1.

Berth 101 is proposed for use as part of the project and is located between Berth 102 and “the Cut” shipping channel providing access to the Inner Harbour. Berth 101 is currently operated by the PKCT and was most recently utilised as an off-loading wharf for materials handling equipment, but does not currently have any regular use with the majority of coal exports operating out of Berth 102.

Land use surrounding Berth 101 is predominantly heavy industrial or special uses associated with port operations. Wollongong Sewage Treatment Plant is located to the north of the coal export facility.

The closest residential properties to Berth 101 are located approximately two kilometres to the north in Coniston, to the west in Cringila and to the south at Port Kembla and Warrawong.

The pipeline to connect the FSRU with the existing gas transportation network at Cringila passes through a predominantly industrial setting around the outskirts of Port Kembla.

2.1.1 Transport and access

Springhill Road and Masters Roads are the two main vehicular traffic routes connecting Port Kembla to the regional road network including the M1 Princes Motorway. Tom Thumb, Springhill and Masters Roads all carry a high level of heavy vehicle traffic due to their direct link to and from Port Kembla. Tom Thumb Road services the existing port facilities including the PKCT.

The rail network within the port precinct consists of rail lines, sidings and loops. The Port Kembla rail network links to the Illawarra and Moss Vale-Unanderra rail line, managed by the NSW Government and ARTC respectively. The Illawarra Line is a shared passenger and freight rail line.

2.2 Noise monitoring

2.2.1 Noise monitoring methodology

Unattended background noise monitoring was undertaken at two locations for a period of 13 days between 11 September to 24 September 2018 as part of the original approval and considered valid for the proposed modification. The two locations were:

- Location 1: Background noise monitoring location about 340 metres north of the proposed pipeline alignment and 2.5 kilometres north-west of Berth 101. This residential receiver is set-back at a similar distance to the closest sensitive receivers and is considered representative of the reasonably most-affected residences. Noise at this location is influenced by industrial noise from Port Kembla to the north-west, road traffic noise from Gladstone Avenue and rail operations located 20 metres to the south.
- Location 2: Background noise monitoring location about 170 metres south of the proposed pipeline alignment and 2.2 kilometres west of Berth 101. This residential receiver is set-

back at a similar distance to the closest sensitive receivers and is considered representative of the reasonably most-affected residences. Noise at this location is influenced by industrial noise from Port Kembla to the north-west and road traffic noise from Five Islands Road located 60 metres to the north.

The methodology of the unattended noise monitoring data included:

- The noise loggers were set to record L_{A90}, L_{A10}, L_{Aeq} and L_{Amax} noise descriptors. The instruments were programmed to accumulate environmental noise data continuously over a sampling period of 15 minutes over the entire monitoring period;
- A calibration check was performed on the noise monitoring equipment using a sound level calibrator with a sound pressure level of 94 dBA at 1 kHz. At completion of the measurements, the meter's calibration was re-checked to ensure the sensitivity of the noise monitoring equipment had not varied. The noise loggers were found to be within the acceptable tolerance of ± 0.5 dB(A);
- Meteorological data for the monitoring period was sourced from the Bureau of Meteorology Port Kembla NTC Automatic Weather Station (AWS) (station number: 067113). The AWS is located about 1.3 kilometres north-west of the project site;
- Noise levels were excluded during periods where average wind speeds were greater than 5 m/s or when rainfall occurred.

A summary of the noise monitoring locations and details of the noise loggers are provided in Table 2-1.

Table 2-1 Unattended noise logger details

Parameter	Location 1	Location 2
Monitoring location	117 Gladstone Avenue, Coniston	16 Merrett Avenue, Cringilla
Logger Type / Serial No.	Rion NL-52 / 131632	SVAN 977 / 36871
Measurement started	11 September 2018	11 September 2018
Measurement ceased	24 September 2018	24 September 2018
Pre/Post calibration	94.1 / 93.9 @ 1 kHz	93.7 / 93.8 @ 1 kHz
Freq. weighting	A	A
Time response	Fast	Fast
Photo		

2.2.2 Noise monitoring results

The measured noise monitoring data was used to determine the Rating Background Levels for the assessment during the day, evening and night-time periods in accordance with the *Noise Policy for Industry* (EPA, 2017). A summary of the measured Rating Background Levels and ambient noise levels is provided in Table 2-2. Daily noise levels are provided in Appendix B and daily noise level charts are provided in Appendix C.

The evening background noise levels are greater than the day-time background noise levels at location 1. The night-time levels are higher than the day and evening background noise levels at location 2. This is likely to be attributed to existing industrial noise in the area, noting that the evening period has fewer sample points, which inherently makes it more susceptible to variance using the *Noise Policy for Industry* (EPA, 2017) 90th percentile method.

Table 2-2 Summary of measured noise levels, dBA

Location	Rating background level, L_{A90}			Ambient level, L_{Aeq}		
	Day	Evening	Night	Day	Evening	Night
Location 1	39	40	39	52	50	50
Location 2	43	42	45	51	49	50

2.3 Sensitive receivers and land uses

Noise and vibration sensitive receivers are defined upon the type of occupancy and the activities performed within the land parcel. The receivers can be classified within the following categories:

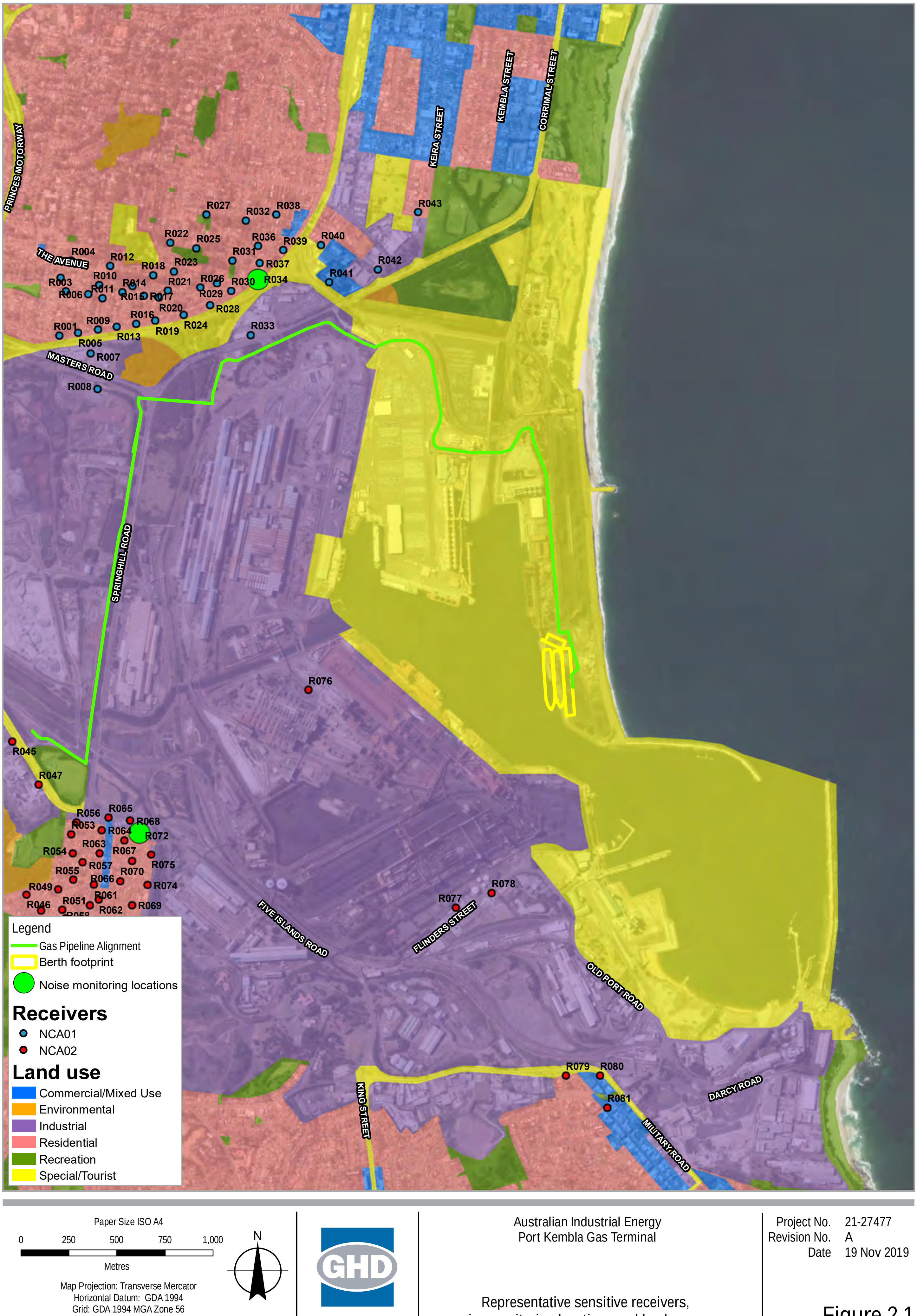
- residential premises;
- educational institutes;
- hospitals and medical facilities;
- places of worship;
- passive and active recreation areas; and
- commercial or industrial premises.

Noise catchment areas (NCA) are used to represent areas with similar noise environments. Two NCAs have been identified for this assessment and are detailed in Table 2-3.

Table 2-3 Noise catchment areas

NCA	Distances to pipeline	Distances to operational areas	Description
NCA01	250 metres – 900 metres	2.5 kilometres – 3.5 kilometres	Mix of residential, commercial and industrial receivers located to the north of the project.
NCA02	100 metres – 900 metres	2.0 kilometres – 3.0 kilometres	Mix of residential, commercial and industrial receivers located to the south of the project.

The representative sensitive receivers used for modelling and assessment purposes are listed in Appendix D and shown in Figure 2.1. Representative sensitive receivers were modelled at the most affected point located within 30 metres of the building in accordance with the *Noise Policy for Industry* (EPA, 2017).



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

Australian Industrial Energy
Port Kembla Gas Terminal

Representative sensitive receivers, noise monitoring locations and land use map

Project No. 21-27477
Revision No. A
Date 19 Nov 2019

Figure 2.1

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: eibbertson

3. Compliance criteria

3.1 Operational noise

3.1.1 Secretary Environmental Assessment Requirements

The SEARs for the original approval under SSI 9471 required an assessment of operational noise impacts under the *NSW Industrial Noise Policy* (EPA, 2000). The *NSW Industrial Noise Policy* (EPA, 2000) has been superseded by the *Noise Policy for Industry* (EPA, 2017) which is adopted for the proposed modification.

3.1.2 Noise Policy for Industry

The *Noise Policy for Industry* (EPA, 2017) provides guidance on the assessment of operational noise impacts.

The project noise trigger level is the lower value of the intrusiveness noise level and the amenity noise level. The intrusiveness noise aims to protect against significant changes in noise levels and the amenity noise level aims to protect against cumulative noise impacts from existing industry.

Project intrusiveness noise level

The intrusiveness noise level aims to protect against significant changes in noise levels. Typically, this will be the project noise trigger level in areas with low existing background noise levels. The intrusiveness noise level is determined by a 5 dBA addition to the measured background noise level. The *Noise Policy for Industry* (EPA, 2017) recommends that the intrusive noise criteria for the evening period should not exceed the day-time period and the night-time period should not exceed the evening period. The intrusiveness noise criteria are only applicable to residential receivers.

Project amenity noise level

The recommended amenity noise level is the noise level objective for total industrial noise at a receiver and is determined based on the overall acoustic characteristics of the receiver area, the receiver type and the existing level of industrial noise.

The project amenity noise level represents the noise level objective for noise from a single development. It aims to limit the cumulative noise impacts from other industries and developments on all receiver types. The project amenity noise level is determined by a 5 dBA subtraction from the recommended amenity noise level for receivers that are not impacted by more than four individual industrial noise sources.

The project amenity noise level may be modified in the following cases:

- developments within high traffic noise levels;
- developments located near or inside an existing industrial cluster such as Port Kembla;
- where the project amenity noise level is at least 10 dBA lower than the existing industrial noise level; and
- where there are no other existing or proposed industries within the development area.

The *Noise Policy for Industry* (EPA, 2017) recommended amenity criteria for the identified receiver types surrounding the Project site are provided in Table 3-1.

Table 3-1 Noise policy for industry amenity noise levels

Type of receiver	Noise amenity area	Time of day	Recommended amenity noise level $L_{Aeq(period)}$ noise level, dBA
Residence	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dBA above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom	All	When in use (noisiest 1 hour period)	35 (internal)
Hospital ward	All	When in use (noisiest 1 hour period)	35 (internal) 50 (external)
Place of worship	All	When in use	40 (internal)
Passive recreation	All	When in use	50
Active recreation	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	5 dBA above recommended noise amenity area

Maximum noise level events

The *Noise Policy for Industry* (EPA, 2017) recommends a maximum noise level assessment to assess the potential for sleep disturbance impacts which include awakenings and disturbance to sleep stages. An initial screening test for the maximum noise levels events should be assessed to the following levels.

- $L_{Aeq(15\ min)}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is greater, and/or
- L_{AFmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is greater.

If the screening test indicates there is a potential for sleep disturbance then a detailed maximum noise level assessment should be undertaken. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period.

3.1.3 Project noise trigger levels

The project noise trigger levels that would be used to assess operational noise impacts are provided in Table 3-2.

The *Noise Policy for Industry* (EPA, 2017) states that *"To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows: Project amenity noise level for industrial developments = Recommended amenity noise level (Table 2.2) minus 5 dB(A)"*

As the project is in an existing industrial cluster and the development constitutes a single premises addition to the existing cluster, the project amenity noise level has been calculated by reducing the *Noise Policy for Industry* (EPA, 2017) amenity noise levels by 5 dBA.

Table 3-2 Project noise trigger levels, dBA

Receiver	Time period	Intrusiveness noise level $L_{Aeq(15\ min)}$	Project amenity noise level, $L_{Aeq(15\ min)}$[1,2,3]	Maximum noise level events	Project noise trigger level, dBA
Residential NCA01 suburban	Day	44	58	-	**44** $L_{Aeq(15\ min)}$
	Evening	44[4]	48	-	**44** $L_{Aeq(15\ min)}$
	Night	44	43	54 L_{Amax}	**43** $L_{Aeq(15\ min)}$ **54** L_{Amax}
Residential NCA02 suburban	Day	48	58	-	**48** $L_{Aeq(15\ min)}$
	Evening	47	48	-	**47** $L_{Aeq(15\ min)}$
	Night	47[5]	43		**43** $L_{Aeq(15\ min)}$
Place of worship	When in use		50[6]		**53** $L_{Aeq(15\ min)}$
Active recreation	When in use		55		**58** $L_{Aeq(15\ min)}$
Commercial	All		63	-	**63** $L_{Aeq(15\ min)}$
Industrial	All		68	-	**68** $L_{Aeq(15\ min)}$

Note 1: The project amenity noise levels have been calculated by subtracting 5 dBA from the recommended amenity noise levels as the project constitutes a single premises addition to an existing industrial area.

Note 2: The NPI recommends applies a 3 dBA addition to the $L_{Aeq(period)}$ noise level to convert the amenity noise level to a $L_{Aeq(15\ min)}$.

Note 3: Receivers are located in an industrial interface. A 5 dBA addition has been applied to the residential recommended amenity levels as existing industrial noise levels are above the suburban recommended amenity level.

Note 4: The NPI recommends that evening intrusiveness levels should be no greater than the day-time intrusiveness level. Therefore the day-time background noise level has been used to calculate the project intrusiveness noise level for the evening period.

Note 5: The NPI recommends that night-time intrusiveness levels should be no greater than the evening intrusiveness level. Therefore the evening background noise level has been used to calculate the project intrusiveness noise level for the night-time period.

Note 6: Assuming open windows provide a 10 dB external to internal noise reduction.

3.1.4 Low frequency, tonal and impulsive noise

The *Noise Policy for Industry* (EPA, 2017) requires that modifying factor adjustments are added to the measured or predicted noise levels if the noise sources contain tonal, low frequency or noise characteristics. These noise characteristics can cause greater annoyance to the community than other noise at the same noise level. The modifying factor adjustments are summarised in Table 3-3 and are assessed at the receiver.

Table 3-3 Modifying factor adjustments

Factor	Assessment/ measurement	When to apply	Correction[1,2]
Tonal noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500 – 10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160 – 400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25 – 125 Hz	5 dBA[2]
Low frequency noise	Measurement of C-weighted and A-weighted level	Measure/assess C and A weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more and: • where any of the one-third octave noise threshold level are exceeded by up to and including 5 dB and cannot be mitigated, a 2-dBA positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise threshold levels are exceeded by more than 5 dB and cannot be mitigated, a 5-dBA positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2-dBA positive adjustment applies for the daytime period.	5 dBA[2]
Impulsive noise	A-weighted fast response and impulse response	If the difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB.	Apply the difference in measured noise levels as the correction up to a maximum of 5 dBA
Intermittent noise	Subjectively assessed	The source noise heard at the receiver varies by more than 5 dBA and the intermittent nature of the noise is clearly audible. This adjustment is applied to the night-time period only.	5 dBA

Note 1: Where two or more modifying factors are present the maximum correction is limited to 10 dBA.

Note 2: Where a source emits a tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low frequency range.

Note 3: Duration correction is a negative correction which increases the noise criteria

4. Impact assessment

4.1 Assessment methodology

4.1.1 Modelling parameters

Operational noise impacts have been assessed for the worst-case 15 minute assessment period during the day, evening and night-time periods.

Noise modelling was undertaken using SoundPlan Version 7.4. SoundPlan is a computer program for the calculation, assessment and prognosis of noise exposure. SoundPlan calculates environmental noise propagation according to *ISO 9613-2 'Acoustics – Attenuation of sound during propagation outdoors'.*

The following noise modelling assumptions were made:

- surrounding land outside the industrial area was modelled as a mix of soft and hard ground with a ground absorption coefficient of 0.5. Water and the industrial land surrounding the port was modelled as reflective with an absorption coefficient of 0;
- atmospheric absorption was based on an average temperature of 10°C and an average humidity of 70%;
- atmospheric propagation conditions were modelled with noise enhancing wind conditions for noise propagation (downwind conditions) or an equivalently well-developed moderate ground based temperature inversions;
- modelled scenarios take into account the shielding effect from surrounding buildings and structures on and adjacent to the site.

Seasonal demand scenarios have been developed to predicted variations in output throughout the year. The operational requirements of the predicted high and low seasonal variations are shown in Table 4-1. During the low season, one engine on board the FSRU would be required and during the high season, two engines would be required. The LNG carrier, while docked infrequently for short periods of time, would require two engines to be operational regardless of seasonal variation.

The operational requirements during the high season has been modelled to predict the worst-case noise emissions expected from operation of the FSRU and LNG carrier. Noise emissions during low season operation would be lower and therefore have not been considered in the modified assessment.

Table 4-1 Proposed seasonal operational emissions sources

Operational emissions source	Low season (approx. 6 months)	High season (approx. 6 months)
FSRU emissions		
LNG Trains	1	2
LNG booster pumps	1	4
FSRU engines required	1	2
LNG carrier emissions		
LNG carrier	2	2

4.1.2 Assumptions

The following assumptions have been applied to determine inputs for the model:

- the project would be operational for 24 hours per day, 7 days per week;
- all equipment would run at 100% capacity during the assessment periods;
- the loading arms would operate at 50% capacity during a worst-case 15 minute period, these would include loading and unloading movements
- four tugboats are used to guide the LNG carrier to its berthing location alongside the FSRU;
- the FSRU and LNG carrier engines would be located under the main deck. Two engines have been assumed to be operating for the carriers as a worst-case scenario. Noise propagation from the engines would be reduced by 40 dBA assuming airborne sound transmission through steel
- each engine for the FSRU and LNG carrier have a separate exhaust. Each exhaust has been modelled assuming a 35 dBA silencer is fitted. The silencer is based off the specifications in the Wärtsilä datasheet
- two boilers would be located in the FSRU engine room.

4.1.3 Operational noise equipment

Noise generating equipment from the FSRU and the LNG carrier are listed in Table 4-2. The sound power levels of the operational equipment expected on site is provided in Table 4-3. The locations of the operational noise equipment are based off information provided by Australian Industrial Energy.

Table 4-2 Operational equipment

	Equipment	Location	Number modelled
FSRU	Wärtsilä Engine W 8L50DF	3rd and 4th deck (FSRU engine room)	2
	Wärtsilä Exhaust	FSRU funnel (above engine room)	2
	Regasification boiler	3rd and 4th deck (FSRU engine room)	2
	LNG train including BCG compressors, condensers, heat exchangers, seawater pumps, booster pumps	On main deck toward the bow of the FSRU	2 LNG trains 4 booster pumps
	Loading arms / cranes	On main deck	1
LNG Carrier	Wärtsilä Engine W 8L50DF	3rd and 4th deck (FSRU engine room)	2
	Wärtsilä Exhaust	LNG funnel (above engine room)	2
Tug boat	Diesel engine	Adjacent LNG carrier for mooring and unmooring	4

The following equipment would be operational however they are expected to be housed within shielded structures on the FSRU. Noise emission from these equipment would be considered negligible as they are shielded from direct emission to the surrounding environment.

- mechanical plant in the air conditioning unit room;
- generators to support utilities, controls and electricity;
- condensers and compressors used for the LNG regasification process
- seawater pumps used to pump seawater for the vaporisers.

Table 4-3 Equipment sound power levels, dBA

Source	Source height (metre)	Octave band centre frequency, Hz										Reference
		31.5	63	125	250	500	1000	2000	4000	8000	Total	
Wärtsilä Engine W 8L50DF FSRU engine room LNG Carrier engine room 3rd and 4th deck 40 dBA reduction assumed	10	-	45	59	70	78	78	77	75	64	83	Wärtsilä datasheet
Wärtsilä Exhaust W 8L50DF FSRU funnel LNG Carrier funnel 35 dBA exhaust silencer fitted	45	83	72	77	75	85	91	89	74	-	94	Wärtsilä datasheet
Regasification boiler FSRU engine room 3rd and 4th deck	10	-	49	64	71	82	85	86	71	69	90	Noise Emission from Industrial Facilities VDI2571
LNG train **Regasification booster pump** **Sea water pump** FSRU main deck towards the bow	30	-	91	93	93	93	93	93	90	83	101	Based on 1400 kW pump
Loading arm / crane FSRU main deck	30	-	96	99	96	90	94	94	83	74	105	Based on a crane
Tugboat	1.5	-	78	87	94	100	103	104	104	102	110	Based on a diesel engine

4.1.4 Operational noise scenarios

The operational noise scenarios in Table 4-4 have been modelled for this assessment:

Table 4-4 Operational noise scenarios

Scenario	Stage	Description
OS1	LNG carrier berthing	Four tug boats would be used to moor and unmoor the LNG carrier from its berthing location beside the FSRU
OS2	FSRU operation	Transfer of LNG from the LNG carrier to the FSRU Regasification of the LNG
OS1 + OS2	Cumulative impacts	Impacts associated with operation of the FSRU in addition to mooring / unmooring the LNG carrier from its berthing location.

4.2 Operational noise impacts

Overall predicted $L_{Aeq(15\ min)}$ and $L_{Ceq(15\ min)}$ noise levels from the two modelled operational noise scenarios are provided in Appendix E and Appendix F for all receivers. Predicted one-third octave noise levels are provided in Appendix G. Noise contour maps are provided in Appendix H. Noise levels during the worst-case 15 minute assessment period are expected to be the same across the day, evening and night-time assessment periods as the FSRU and associated infrastructure would be in constant operation.

A summary of the maximum predicted noise levels in each NCA for residential receivers and for each non-residential receiver type is provided in Table 4-5. The primary contributor to the overall noise level during FSRU operation at all receivers is noise emission from the LNG trains and booster pumps.

The predicted noise levels for all modelled operational scenarios are expected to be below the project noise trigger levels during all time periods. No sleep disturbance impacts are anticipated as the operational noise sources are constant and do not have impulsive noise characteristics.

Table 4-5 Most affected receivers

Receiver type	Noise criteria		Operational scenario		
			OS1	OS2	OS1 and OS2 (cumulative)
Residential – NCA01	44 $L_{Aeq(15\ min)}$ (Day/Evening) 43 $L_{Aeq(15\ min)}$ (Night)	Highest noise level	16	32	32
		Worst affected receiver	R043	R042	R042
Residential – NCA02	48 $L_{Aeq(15\ min)}$ (Day) 47 $L_{Aeq(15\ min)}$ (Evening)	Highest noise level	26	34	34
		Worst affected receiver	R080	R076	R076

Receiver type	Noise criteria		Operational scenario		
			OS1	OS2	OS1 and OS2 (cumulative)
	43 $L_{Aeq(15\ min)}$ (Night)				
Commercial	63 $L_{Aeq(15\ min)}$ (All time periods)	Highest noise level	24	29	29
		Worst affected receiver	R081	R041	R081
Industrial	68 $L_{Aeq(15\ min)}$ (All time periods)	Highest noise level	29	34	34
		Worst affected receiver	R078	R078	R078
Place of worship	53 $L_{Aeq(15\ min)}$ (When in use)	Highest noise level	16	30	30
		Worst affected receiver	R074	R074	R074
Active recreation	58 $L_{Aeq(15\ min)}$ (When in use)	Highest noise level	12	26	26
		Worst affected receiver	R007	R007	R007

4.2.1 Low frequency and tonal noise assessment

The predicted noise levels were analysed for tonal and low-frequency noise characteristics in accordance with Fact Sheet 3 of the *Noise Policy for Industry* (EPA, 2017). Predicted one-third octave noise levels are provided in Appendix G. The one-third octave band levels were reviewed at each receiver and no tonal characteristics were identified.

Low frequency noise impacts were assessed using the difference between the modelled C- and A-weighted noise levels. The results indicate that all receivers have the potential to contain low frequency noise characteristics as the differences between the C- and A-weighted noise levels are above 15 dB. The primary contribution to propagation in the low frequency one-third octave bands (from 10 Hz to 160 Hz) are due to operation of the booster pumps which has a run speed within the low-frequency range.

The predicted one-third octave noise levels at the most affected receiver is provided in Table 4-6. The predicted noise levels in each one-third octave frequency band are below the low-frequency threshold noise levels. Therefore the predicted levels do not contain low frequency content.

Table 4-6 One-third octave low-frequency noise threshold levels

Frequency	25	31.5	40	50	63	80	100	125	160
dBZ criteria	**69**	**61**	**54**	**50**	**50**	**48**	**48**	**46**	**44**
NCA01	50	45	40	49	45	41	35	32	29
NCA02	54	49	44	50	46	42	41	38	35
Commercial	50	45	40	45	41	37	32	29	26
Industrial	55	50	45	50	46	42	40	37	35
Place of worship	50	45	40	46	42	39	33	30	27
Active recreation	48	43	38	43	39	35	29	26	23

No modifying factor corrections to the noise are required as the predicted noise levels do not contain tonal and low-frequency noise characteristics.

4.3 Operational traffic

No change to the operational traffic movements is expected as part of the modification and the operational traffic assessment undertaken as part of the EIS would remain unchanged. This assessment indicated that no road traffic noise impacts are expected as existing traffic volumes would not increase by over 58 per cent.

4.4 Construction noise and vibration

The modification is not expected to change the construction timeframe, methodology or footprint. The construction stages assessed as part of the EIS include pipeline construction and berth demolition, dredging, excavation and dredging works. The predicted construction noise impacts assessed in the EIS would remain unchanged as a result of the modification.

The EIS predicted minor exceedances of the construction noise management levels during and outside standard construction hours for fixed construction activities. The impacted receivers are located in areas that are subject to existing ambient rail traffic noise and industrial noise from the port area.

No changes to the predicted construction vibration impacts or construction traffic noise impacts are expected due to the modification.

5. Mitigation measures

Operational noise levels are expected to comply with the operational noise criteria at the worst-affected receivers based on the operational assumptions which assume the following noise mitigation measures are implemented:

- The engine and boiler are located below deck in the engine room
- An exhaust gas silencer is fitted to each exhaust providing 35 dBA of noise attenuation.

These assumptions were included in the noise modelling undertaken as part of Appendix L Noise and vibration of the Port Kembla Gas Terminal Environmental Impact Statement. No additional mitigation measures would be required as a result of the modification.

6. Conclusion

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

Further analysis of market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. This seasonal variation was not considered in the EIS

This noise impact assessment has been prepared to assess the potential operational noise impacts due to the proposed modification to the Port Kembla Gas Terminal. The methodology for construction is unchanged from the EIS and no additional construction noise and vibration impacts are expected.

This assessment considered an updated operational noise scenario based on worst-case emissions due to seasonal variations in demand. Operational noise levels are not predicted to exceed the project noise trigger levels. No modifying factor corrections to the noise are required as the predicted noise levels do not contain tonal or low-frequency noise characteristics.

Construction noise and vibration and operational traffic noise will remain unchanged from the original approval under SSI 9471.

Operational noise emission from the modification were based on the following assumptions and shall be implemented prior to operation.

- The engine and boiler are located below deck in the engine room
- An exhaust gas silencer is fitted to each exhaust providing 35 dBA of noise attenuation.

7. References

Appendix L Noise and vibration of the Port Kembla Gas Terminal Environmental Impact Statement, GHD, 2018

Noise Policy for Industry, Environmental Protection Authority, 2017

ISO 9613-2, Acoustics – Attenuation of sound during propagation outdoors, International Organization for Standardization, 1996.

Appendices

Appendix A – Glossary

Abbreviation	Definition
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the LA90 descriptor.
dB	Decibel is the logarithmic unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dBA	Frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at very low and very high frequencies.
dBC	Frequency weighting filter used to measure 'C-weighted' sound pressure levels, which is designed to be more response to low frequency noise
DECCW	Department of Environment, Climate Change and Water
EPA	Environment Protection Authority
ICNG	Interim Construction Noise Guideline (DECCW, 2009)
$L_{Aeq(period)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{A90(period)}$	The sound pressure level exceeded for 90% of the measurement period.
L_{Amax}	The maximum sound level recorded during the measurement period.
$L_{Aeq(15\ hour)}$	The LAeq noise level for the period 7 am to 10 pm.
$L_{Aeq(9\ hour)}$	The LAeq noise level for the period 10 pm to 7 am.
$L_{Aeq(1\ hour)}$	The highest hourly LAeq noise level during the day and night periods.
L_W	Sound power level
NML	Noise management level
Noise sensitive receiver	An area or place potentially affected by noise including residential dwellings, schools, child care centres, places of worship, health care institutions and active or passive recreational areas.
NPI	Noise Policy for Industry (EPA, 2017)
PNTL	Project noise trigger level
Rating background level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
RNP	Road Noise Policy (DECWW, 2011)

Appendix B – Measured noise levels

Location 1 117 Gladstone Avenue, Coniston

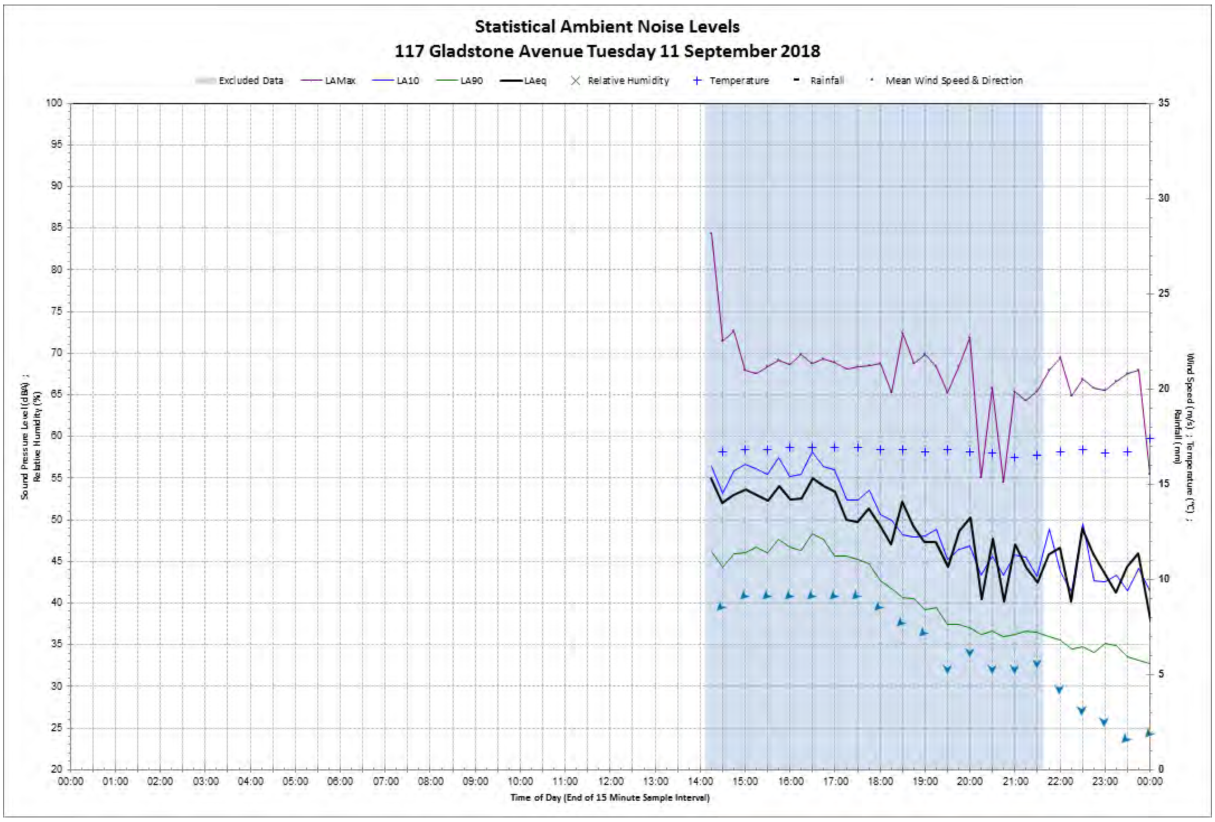
Date	Rating background level, L_{A90}			Ambient level, L_{Aeq}		
	Day	Evening	Night	Day	Evening	Night
Tuesday-11-Sep-18	-	36	32	-	46	51
Wednesday-12-Sep-18	42	41	41	51	54	52
Thursday-13-Sep-18	42	39	39	52	49	49
Friday-14-Sep-18	39	38	37	51	49	48
Saturday-15-Sep-18	38	-	40	50	-	45
Sunday-16-Sep-18	43	41	43	53	49	49
Monday-17-Sep-18	39	35	31	50	46	49
Tuesday-18-Sep-18	39	38	33	49	47	50
Wednesday-19-Sep-18	39	42	38	51	52	51
Thursday-20-Sep-18	43	40	40	55	50	52
Friday-21-Sep-18	39	36	38	51	51	48
Saturday-22-Sep-18	36	40	42	51	49	49
Sunday-23-Sep-18	42	46	43	51	51	49
Monday-24-Sep-18	-	-	-	-	-	-
RBL and Leq Overall	**39**	**40**	**39**	**52**	**50**	**50**

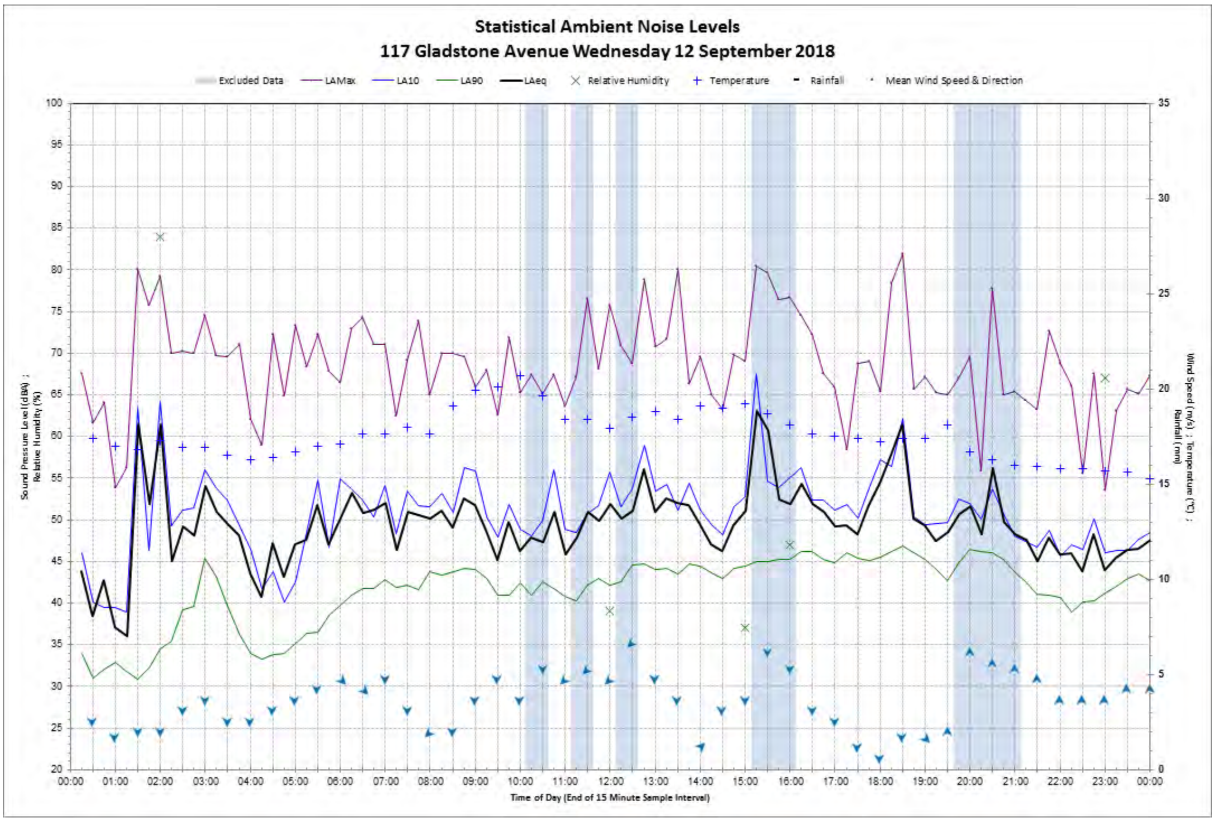
Location 2 16 Merrett Avenue, Cringilla

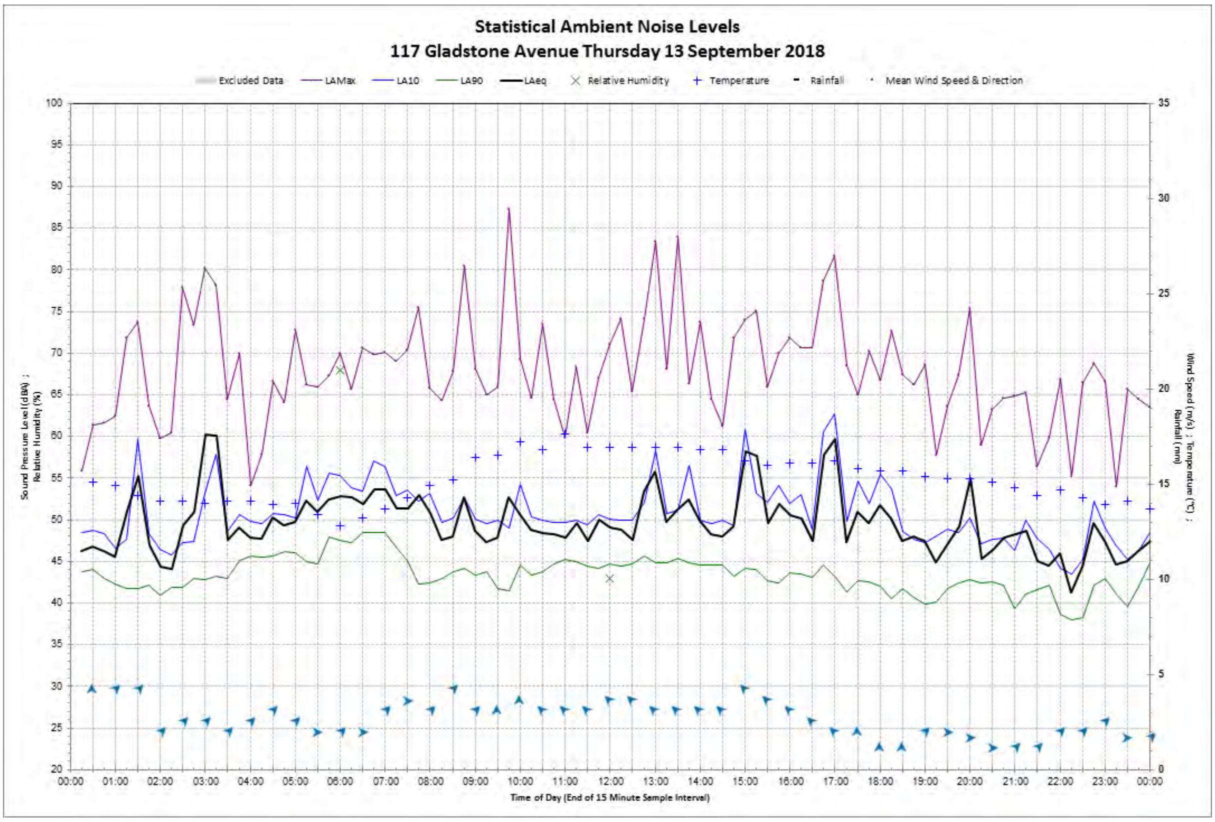
Date	Rating background level, L_{A90}			Ambient level, L_{Aeq}		
	Day	Evening	Night	Day	Evening	Night
Tuesday-11-Sep-18	-	47	47	-	49	51
Wednesday-12-Sep-18	47	37	33	53	48	47
Thursday-13-Sep-18	42	42	42	48	48	50
Friday-14-Sep-18	48	43	49	53	49	53
Saturday-15-Sep-18	43	-	40	50	-	46
Sunday-16-Sep-18	41	40	46	51	46	51
Monday-17-Sep-18	43	48	45	51	50	50
Tuesday-18-Sep-18	45	46	47	51	50	52
Wednesday-19-Sep-18	49	38	31	54	46	44
Thursday-20-Sep-18	42	43	46	51	48	52
Friday-21-Sep-18	43	46	48	51	51	52
Saturday-22-Sep-18	43	40	36	50	48	46
Sunday-23-Sep-18	40	39	36	49	45	42
Monday-24-Sep-18	-	-	-	-	-	-
RBL and Leq Overall	**43**	**42**	**45**	**51**	**49**	**50**

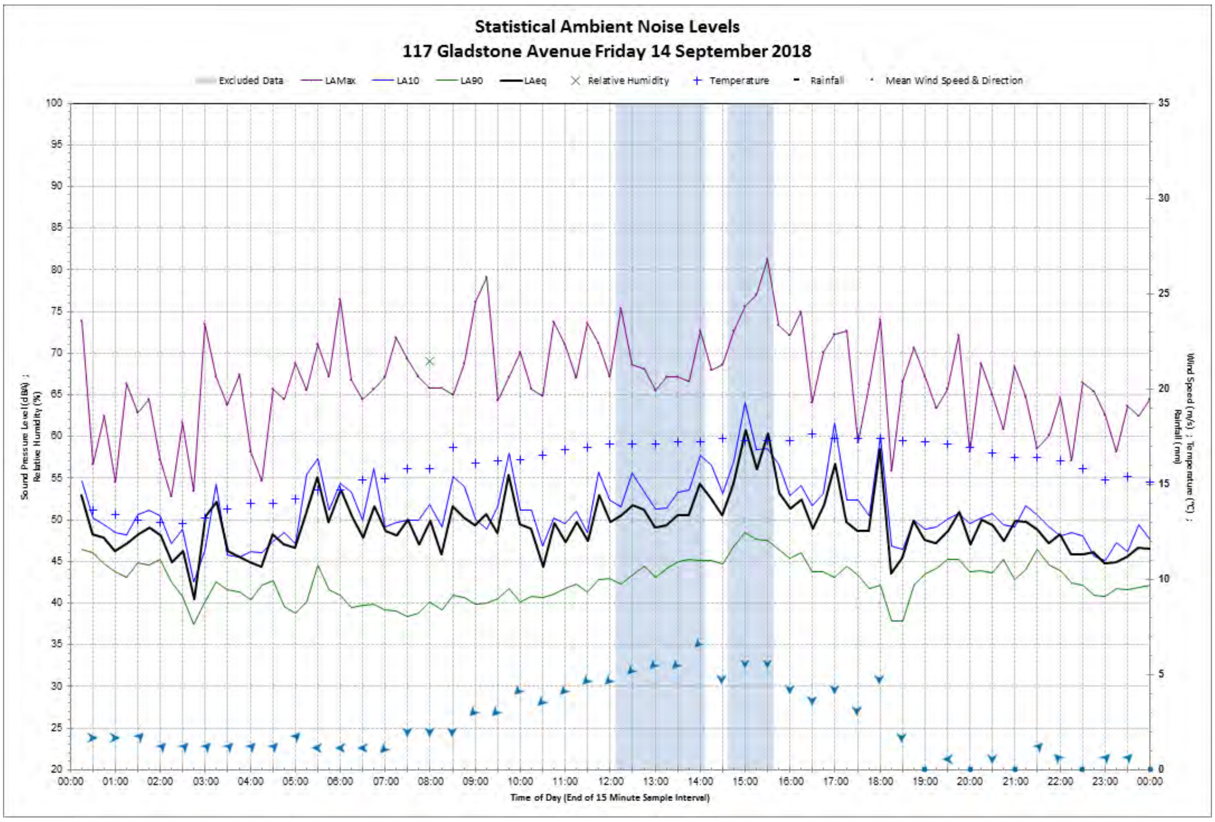
Appendix C – Daily noise level charts

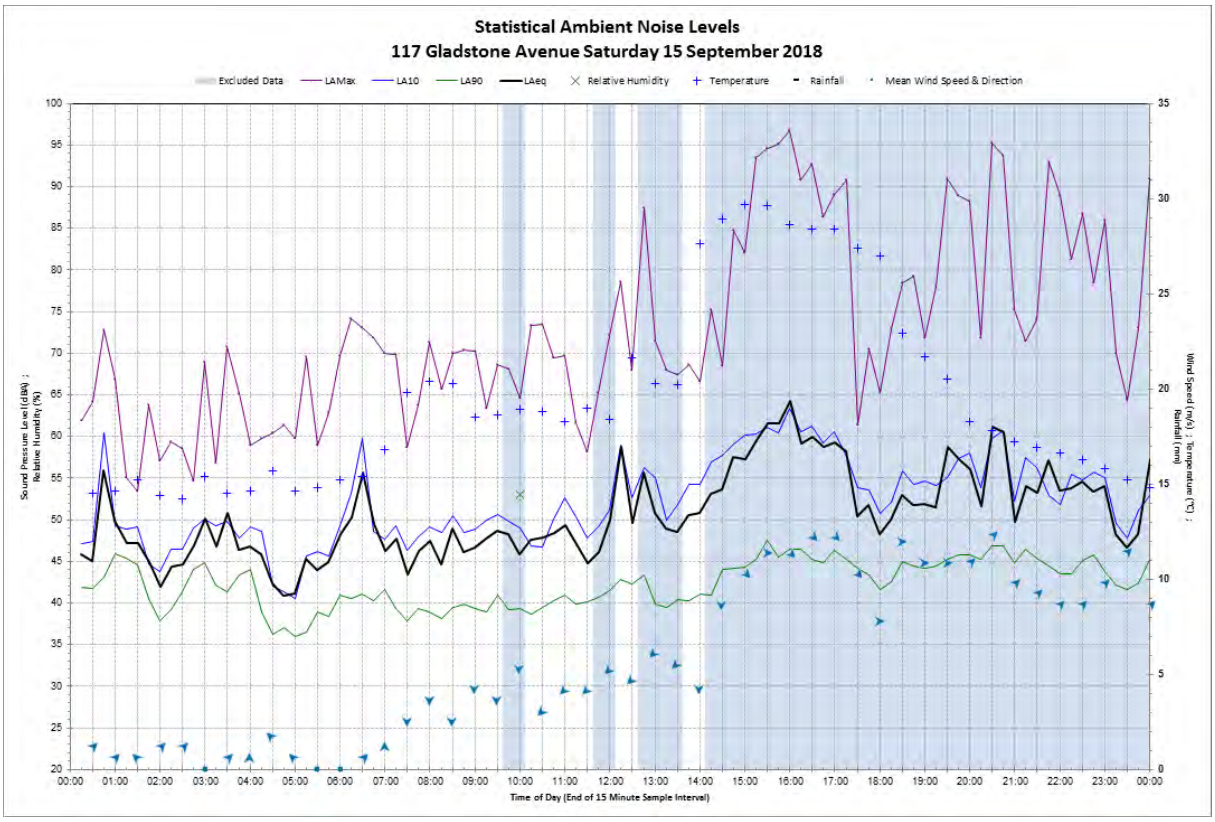
Location 1 117 Gladstone Avenue, Coniston

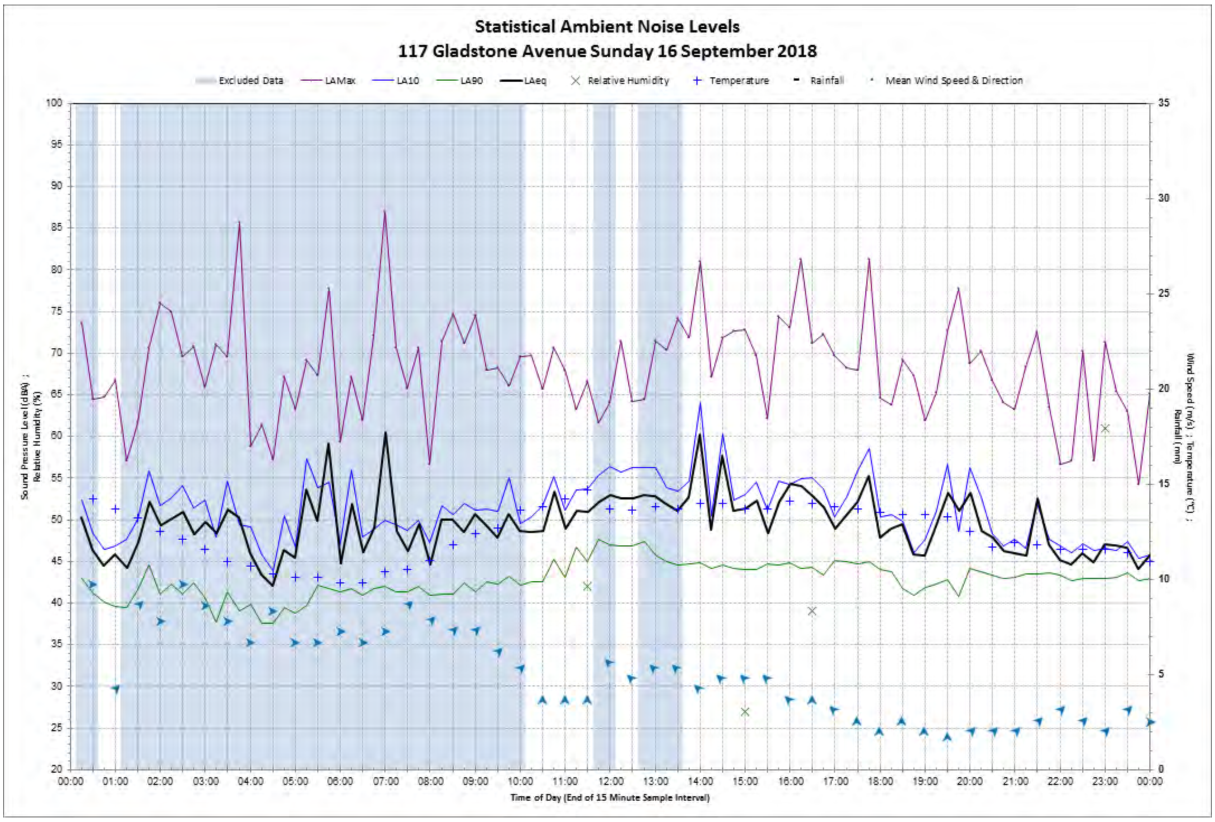


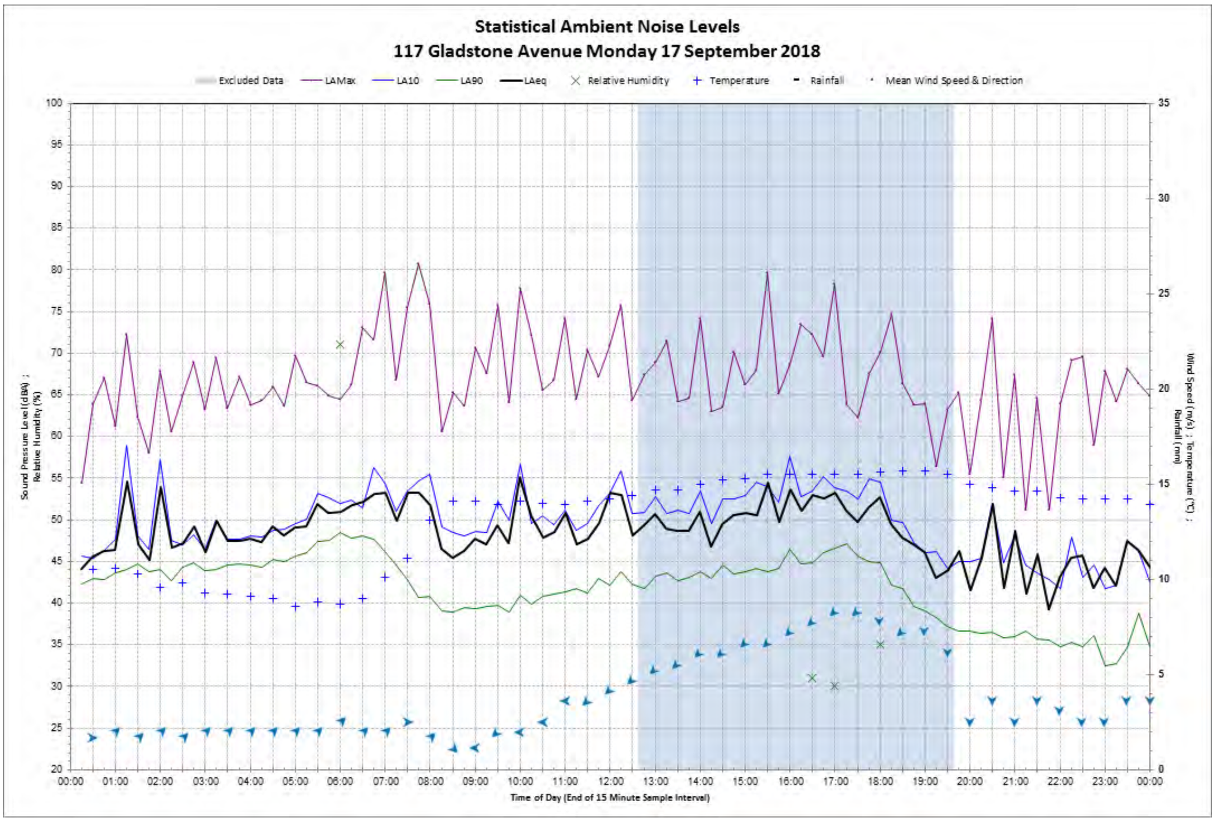


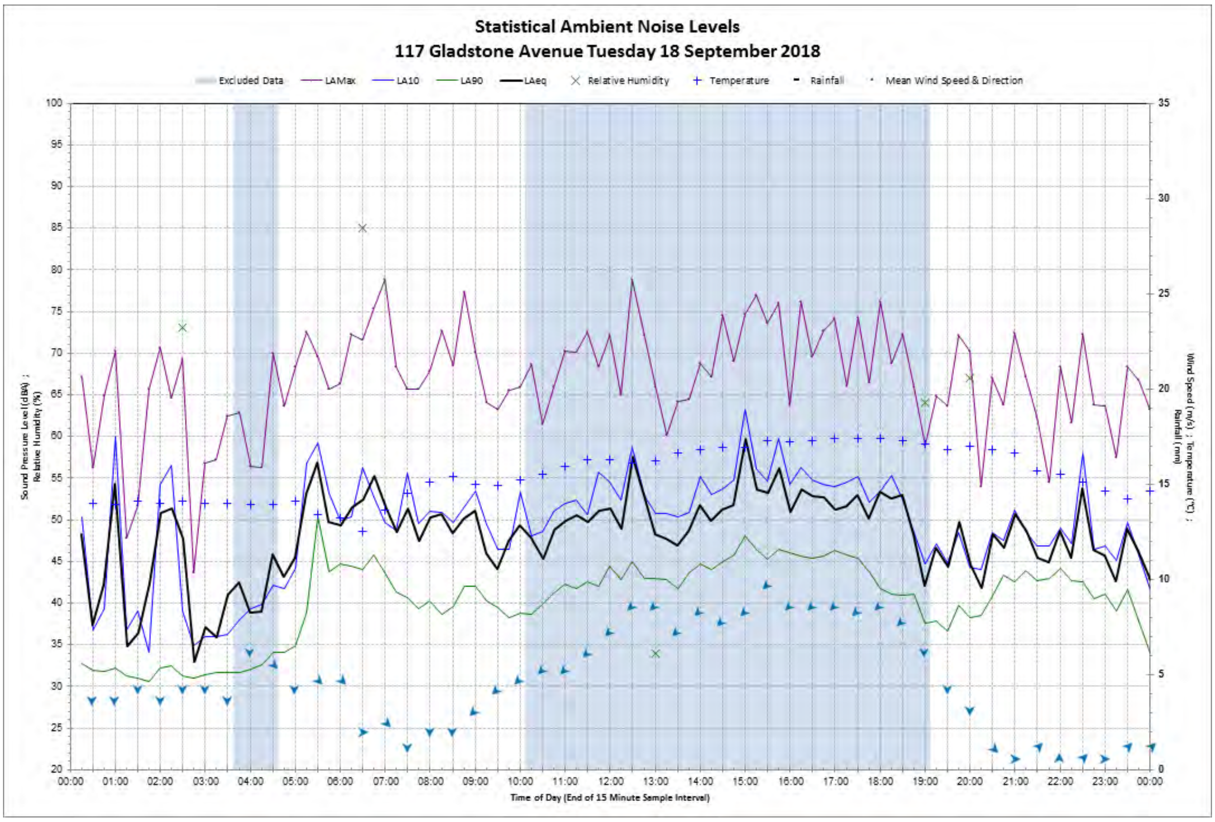

Statistical Ambient Noise Levels
117 Gladstone Avenue Thursday 13 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

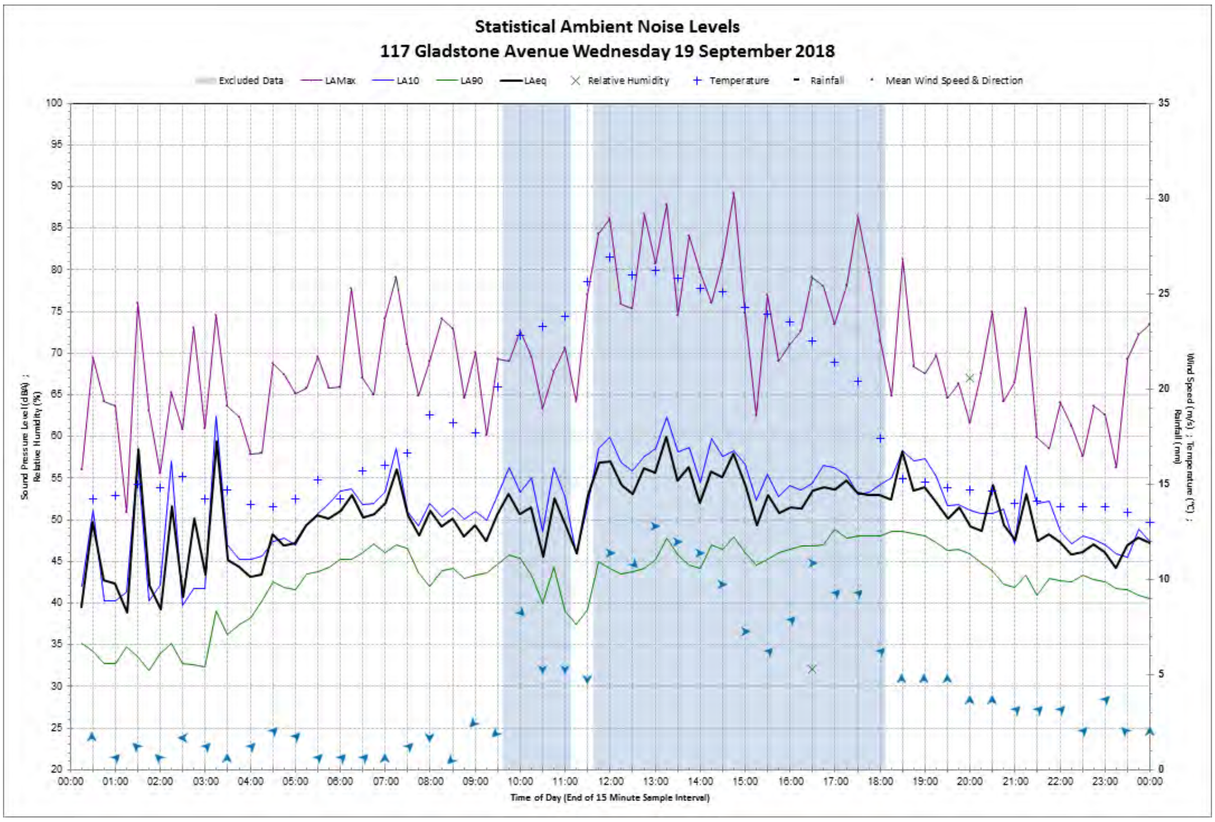

Statistical Ambient Noise Levels
117 Gladstone Avenue Friday 14 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

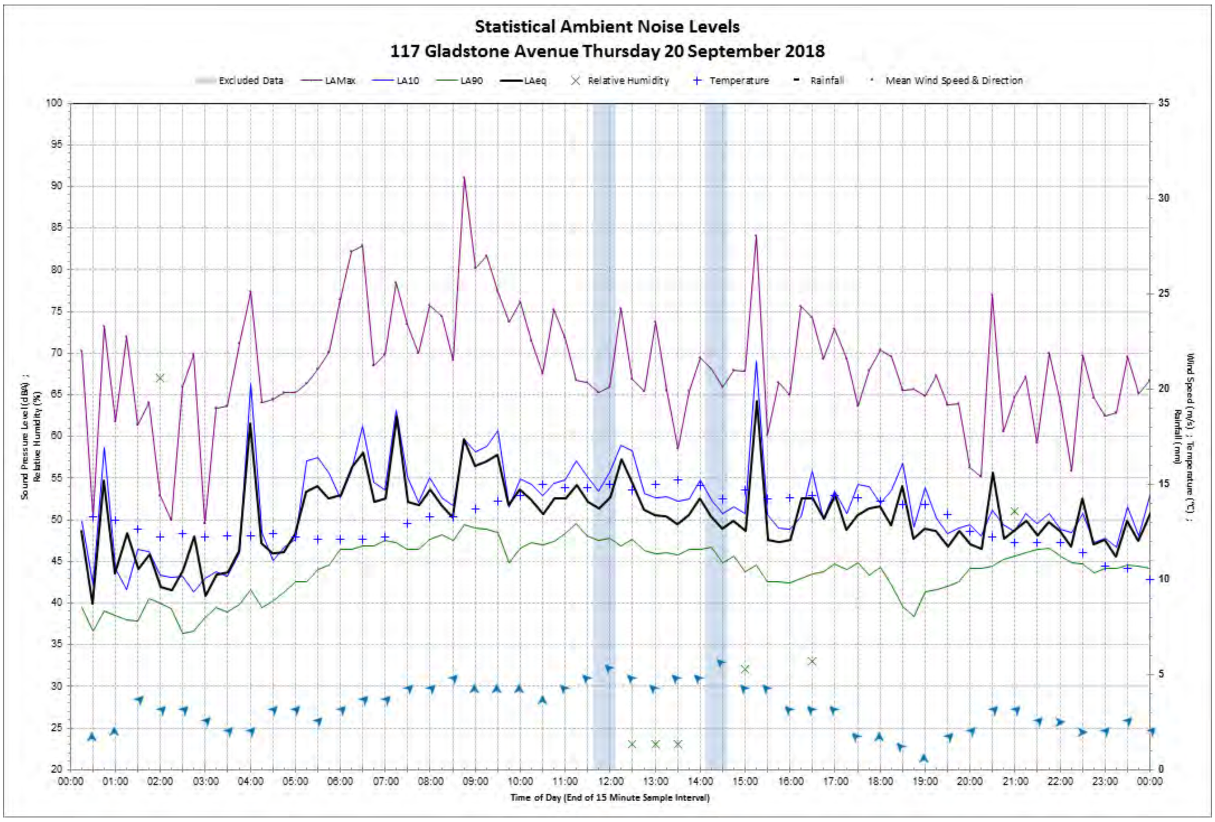

Statistical Ambient Noise Levels
117 Gladstone Avenue Saturday 15 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

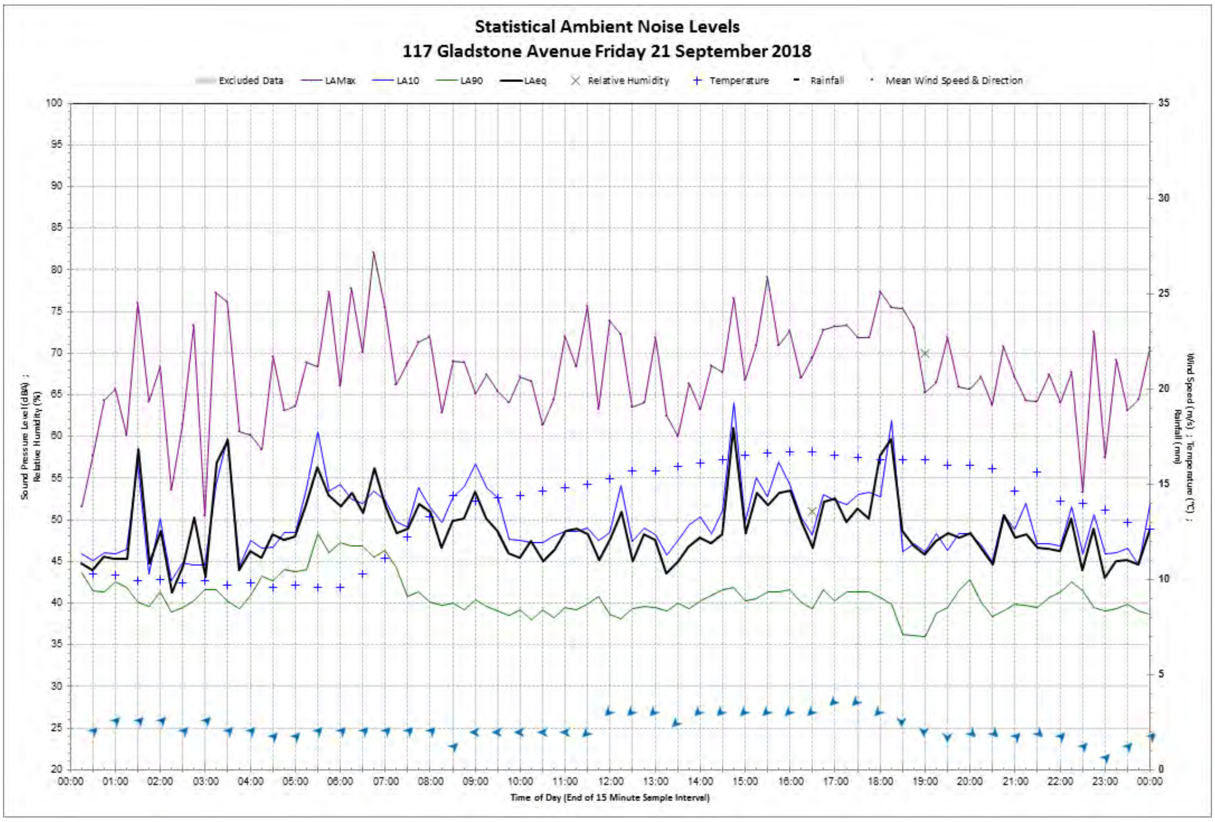

Statistical Ambient Noise Levels
117 Gladstone Avenue Sunday 16 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

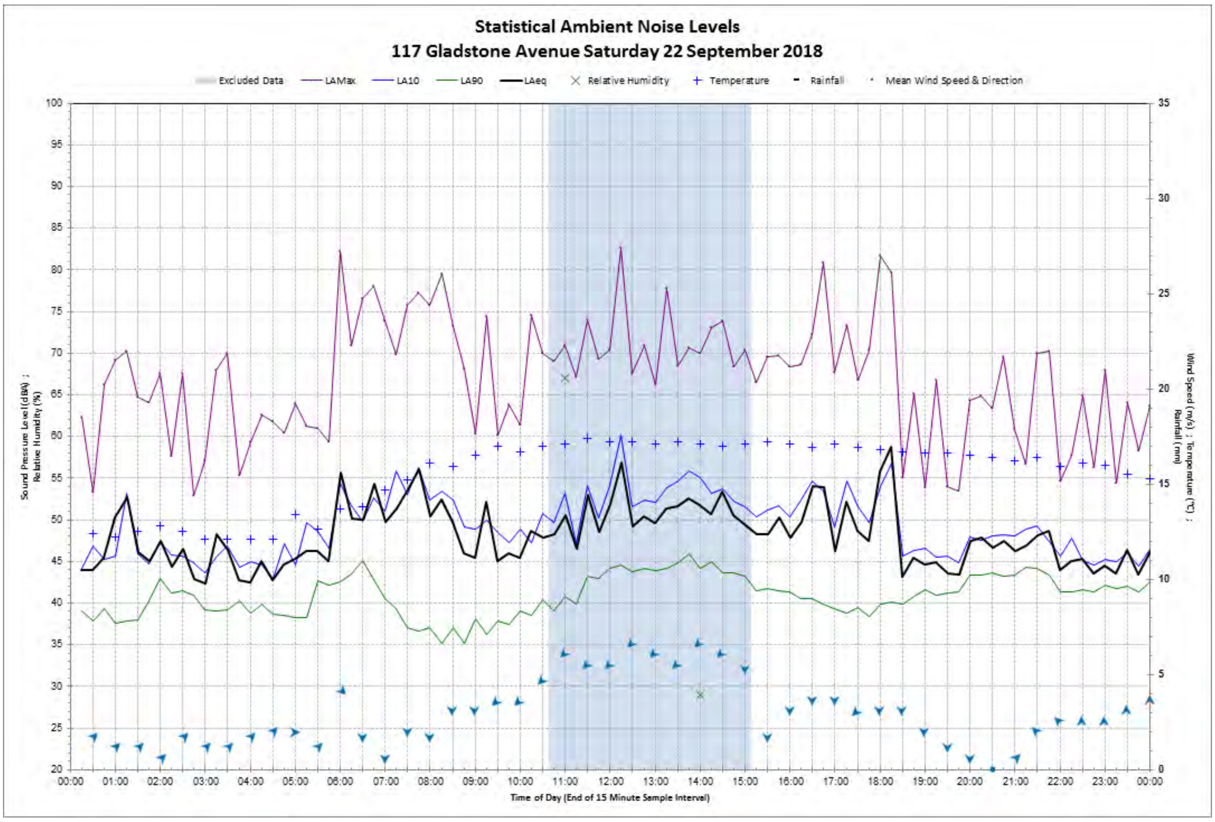

Statistical Ambient Noise Levels
117 Gladstone Avenue Monday 17 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

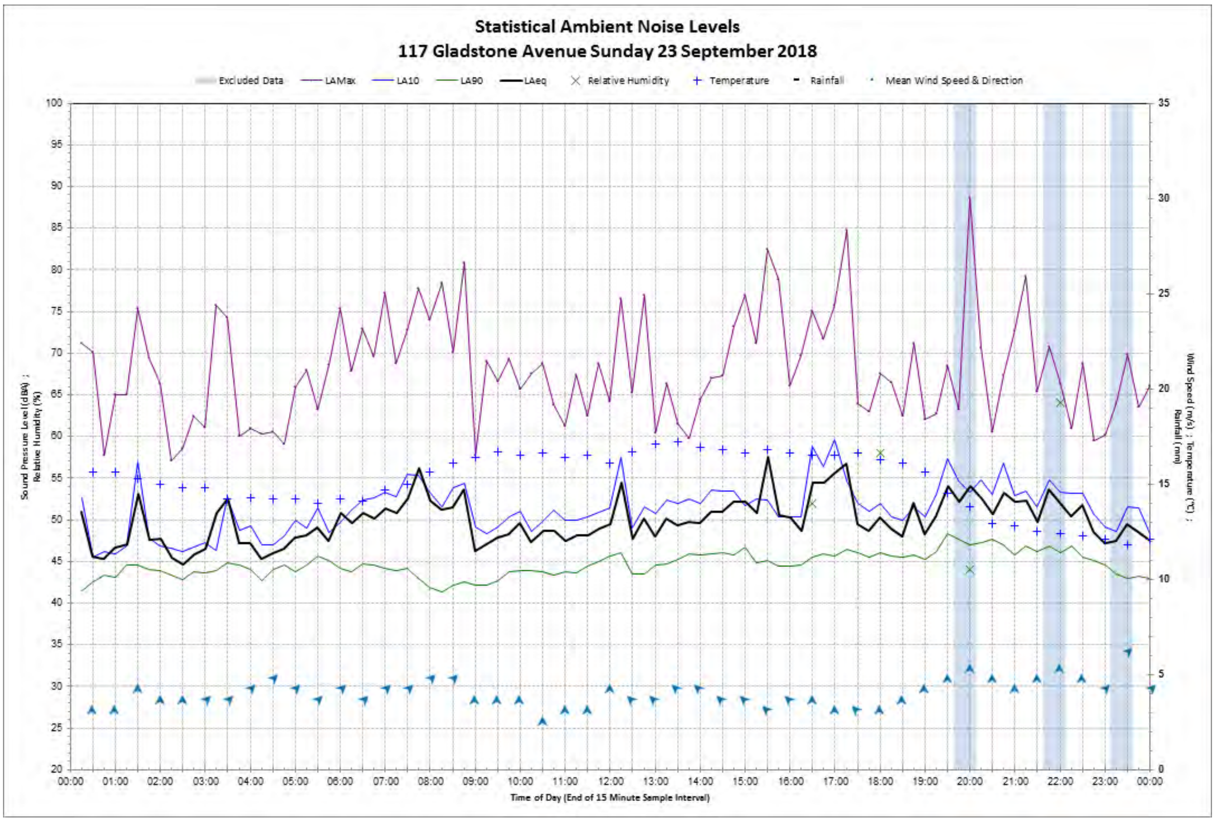

Statistical Ambient Noise Levels
117 Gladstone Avenue Tuesday 18 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

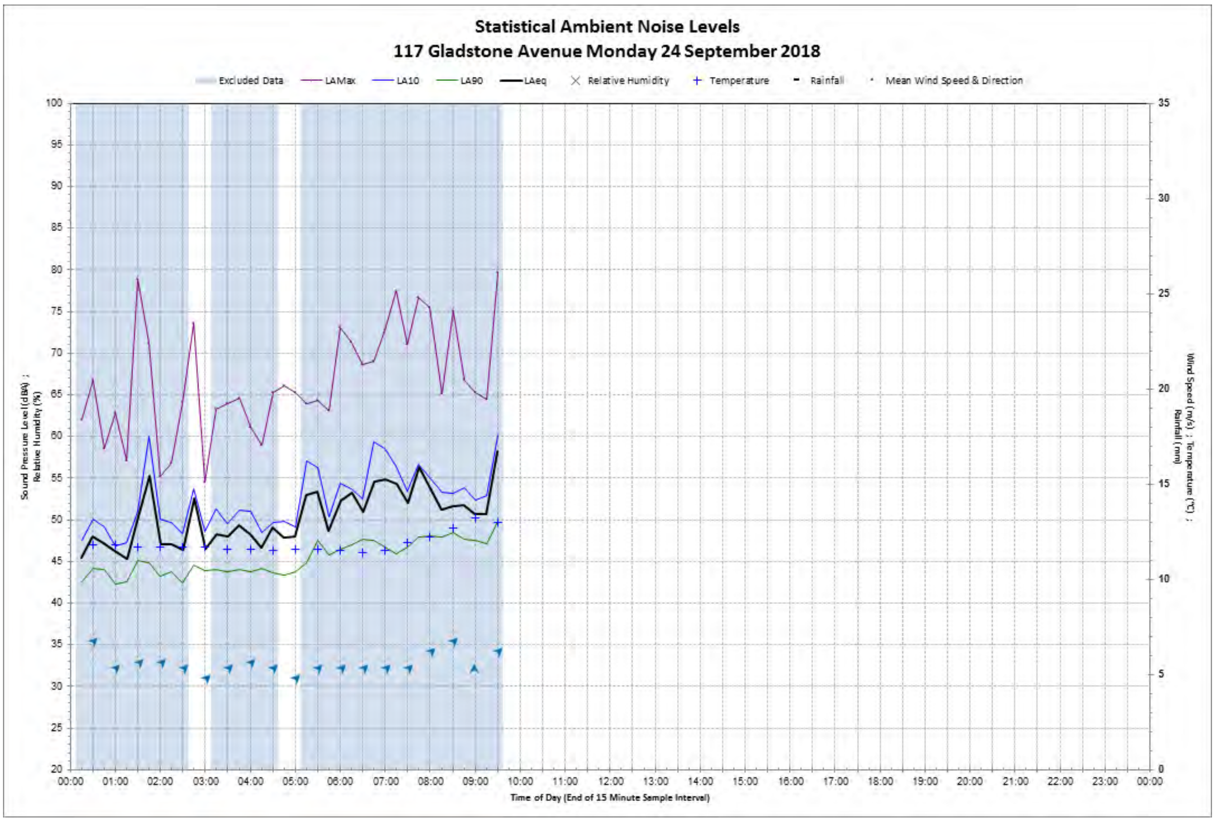

Statistical Ambient Noise Levels
117 Gladstone Avenue Wednesday 19 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
117 Gladstone Avenue Thursday 20 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

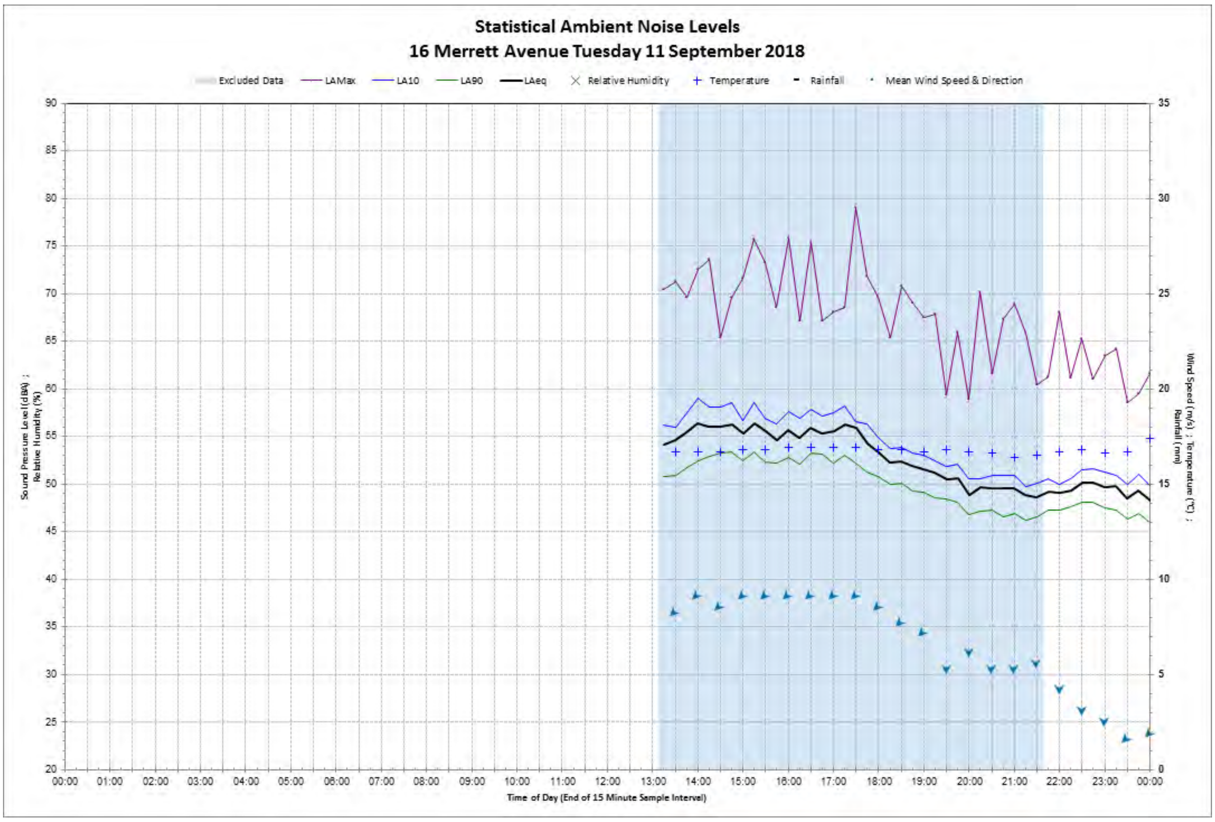

Statistical Ambient Noise Levels
117 Gladstone Avenue Friday 21 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

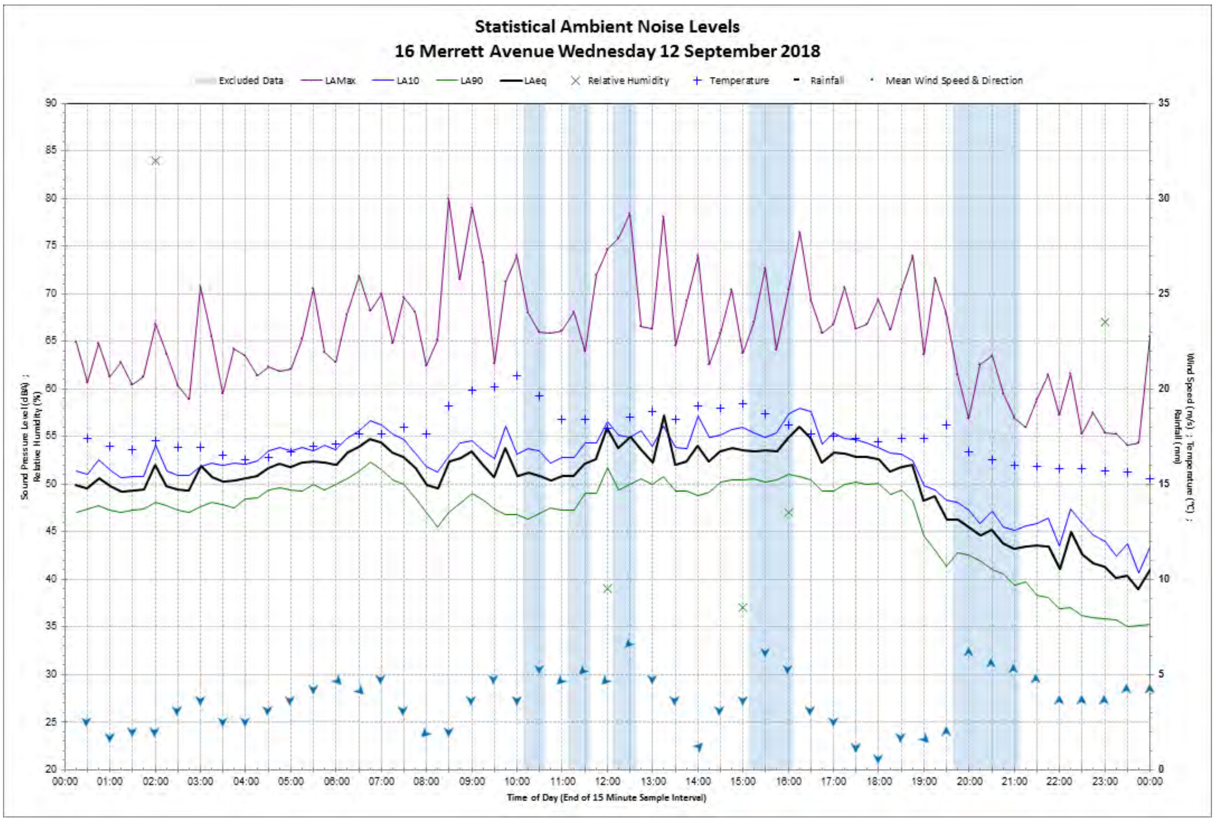

Statistical Ambient Noise Levels
117 Gladstone Avenue Saturday 22 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

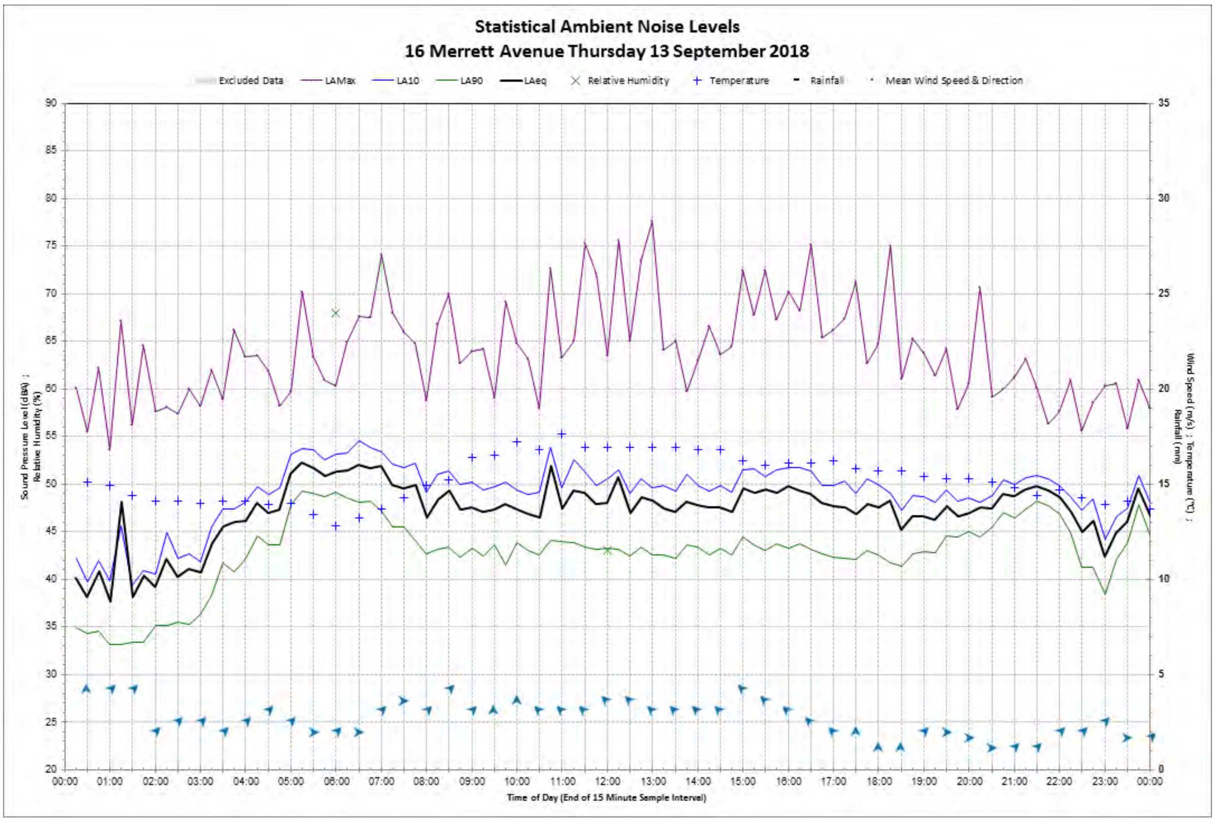

Statistical Ambient Noise Levels
117 Gladstone Avenue Sunday 23 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

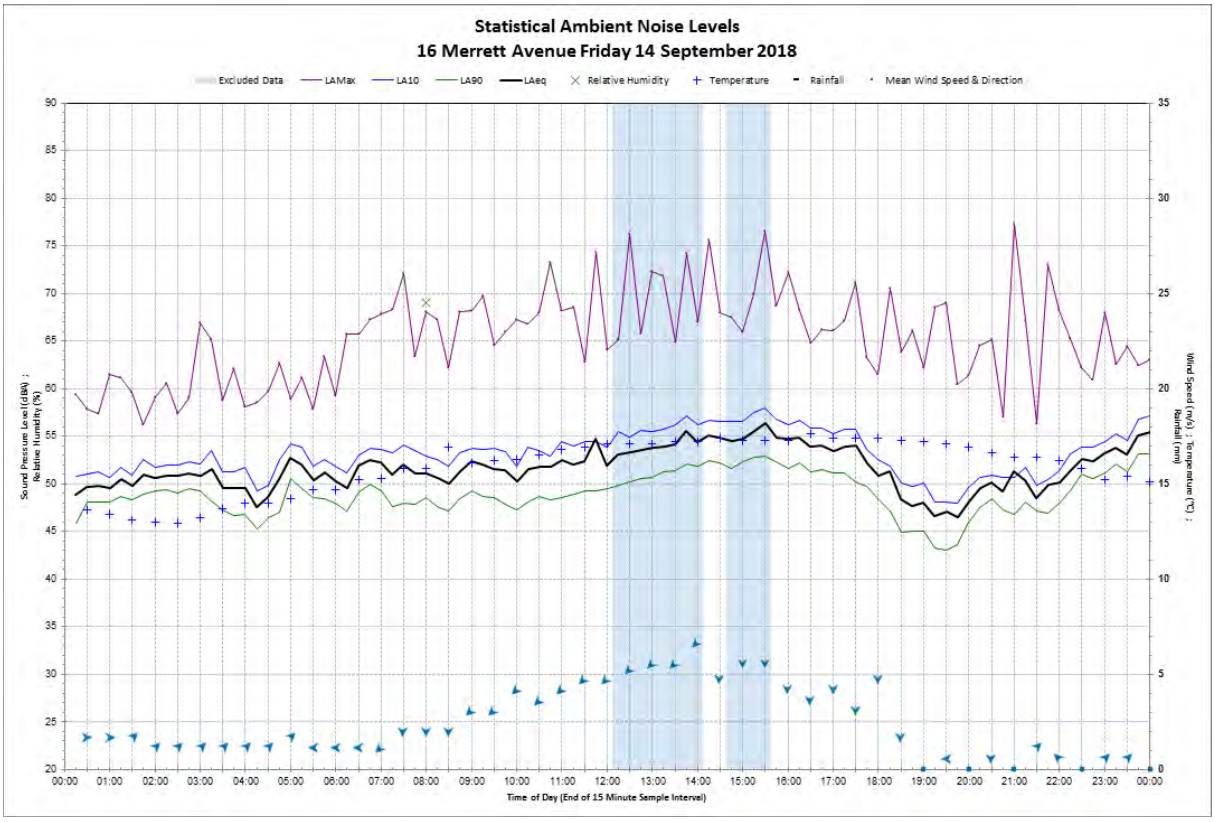

Statistical Ambient Noise Levels
117 Gladstone Avenue Monday 24 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

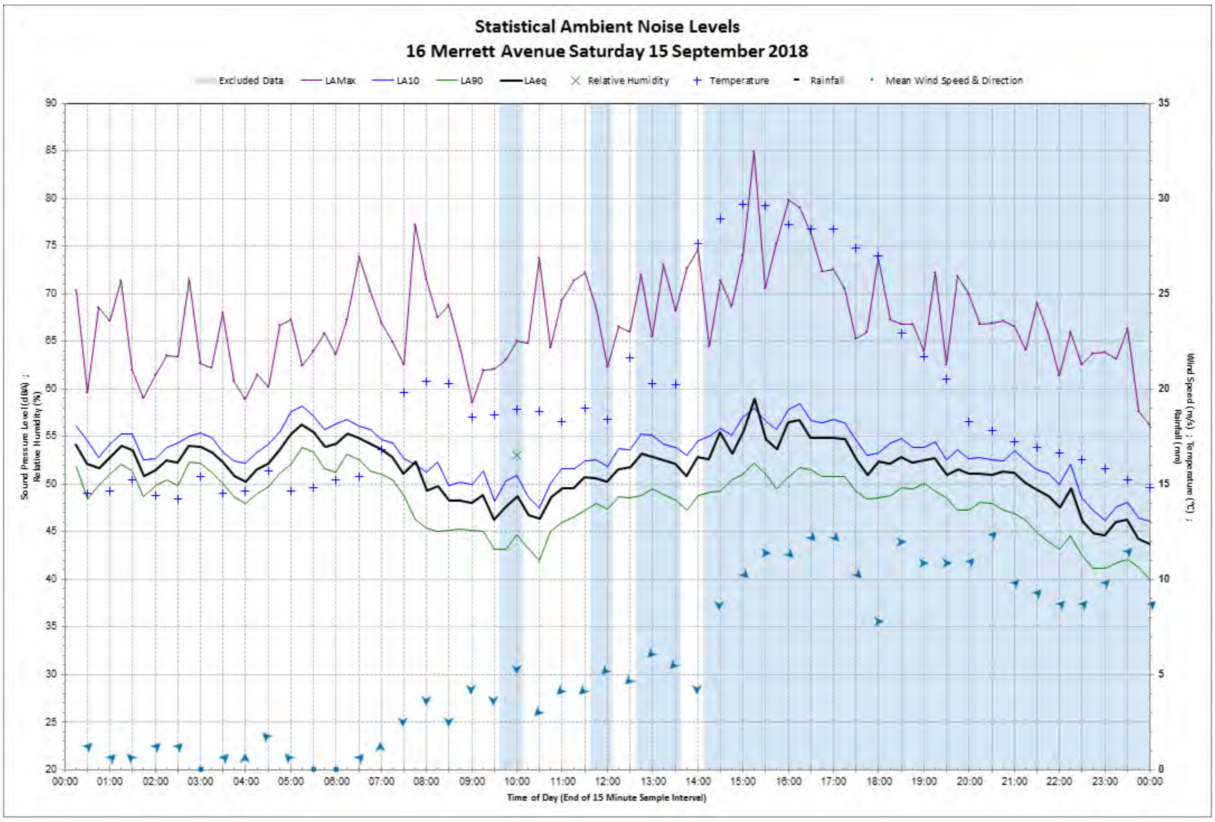
Location 2 16 Merrett Avenue, Cringilla

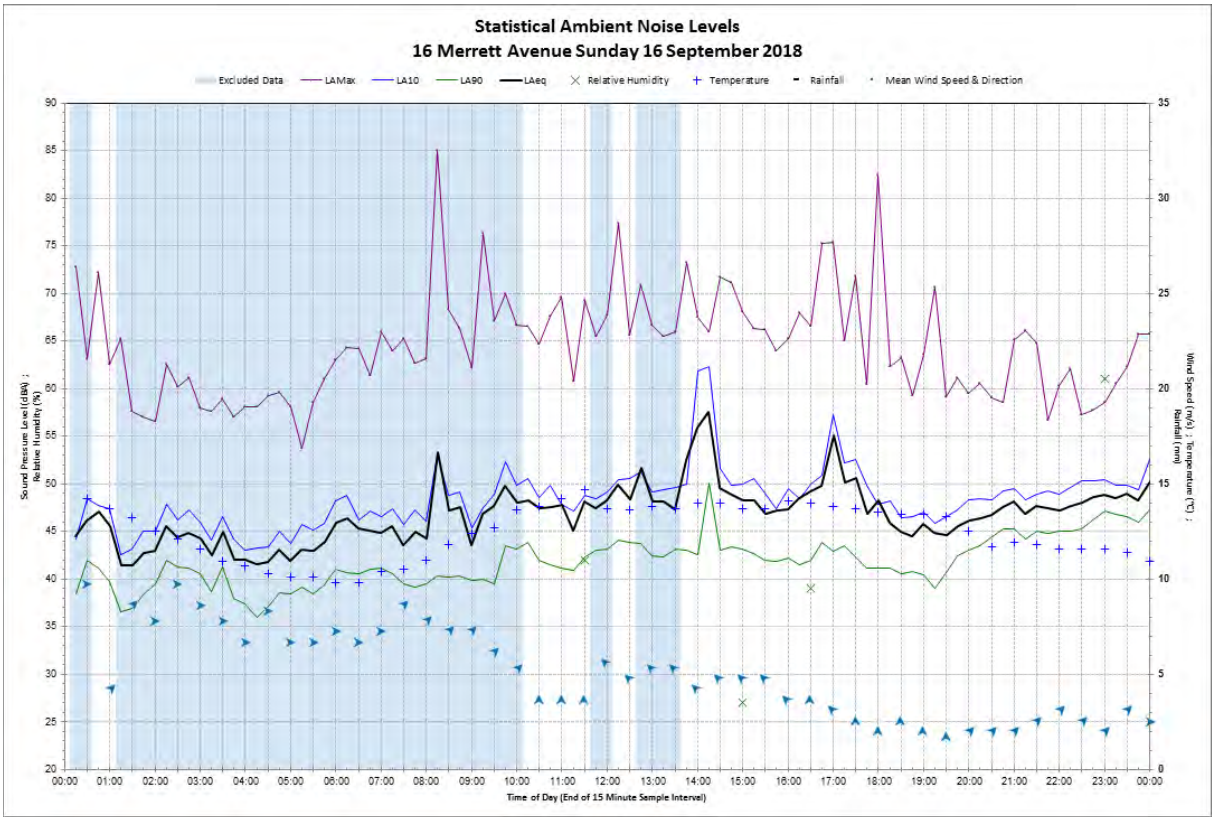


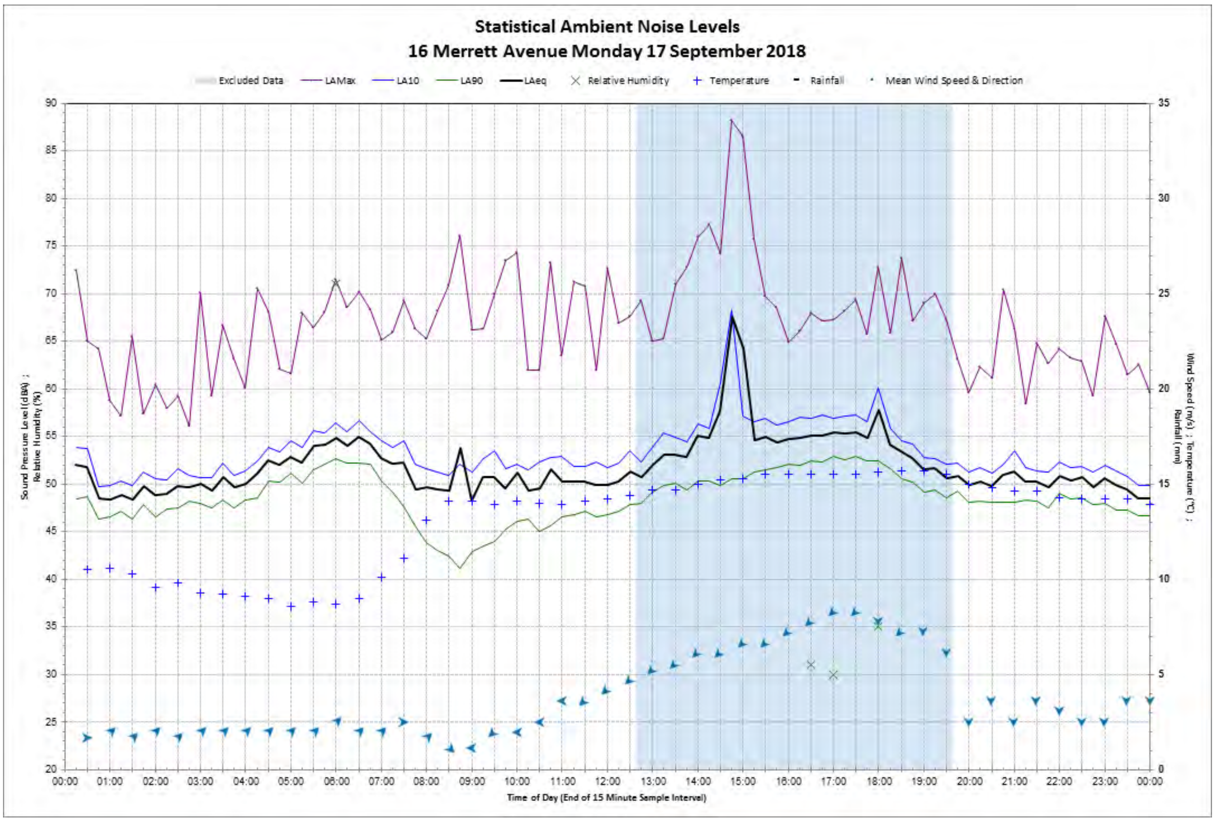


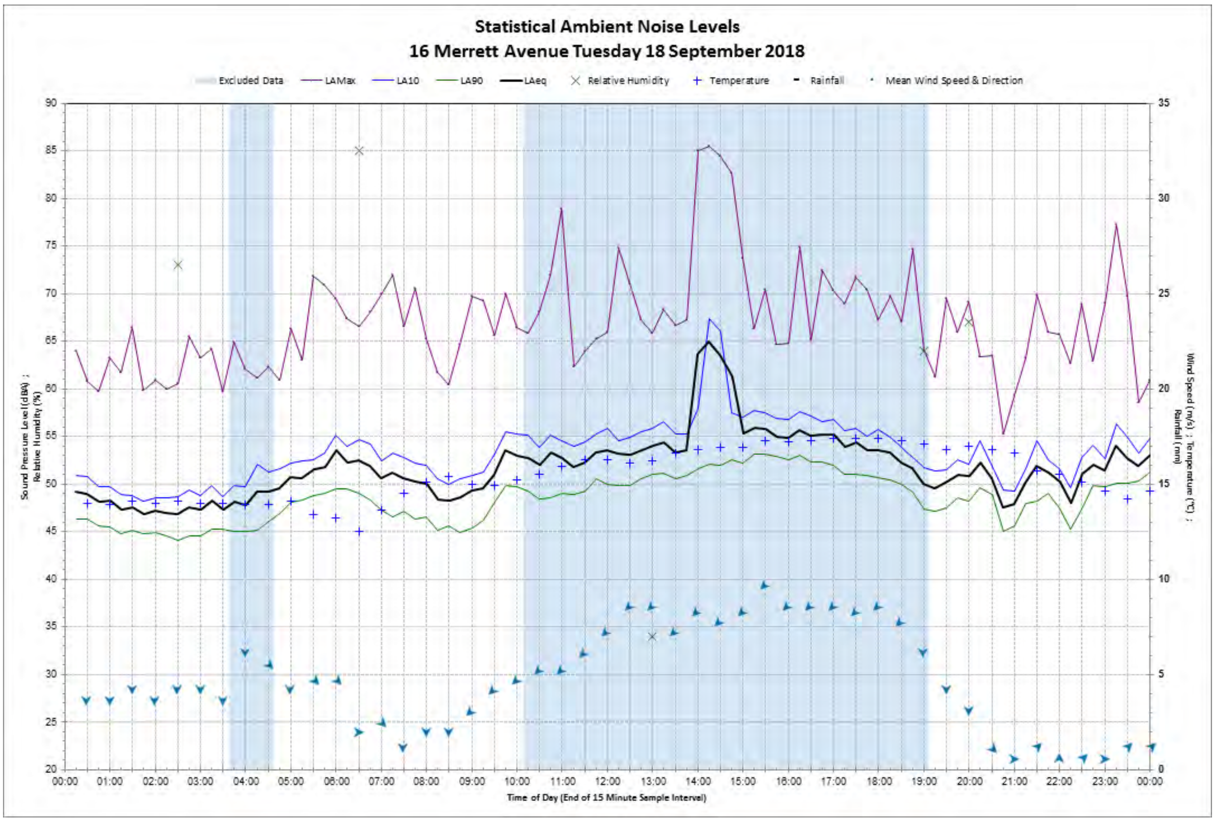

Statistical Ambient Noise Levels
16 Merrett Avenue Thursday 13 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

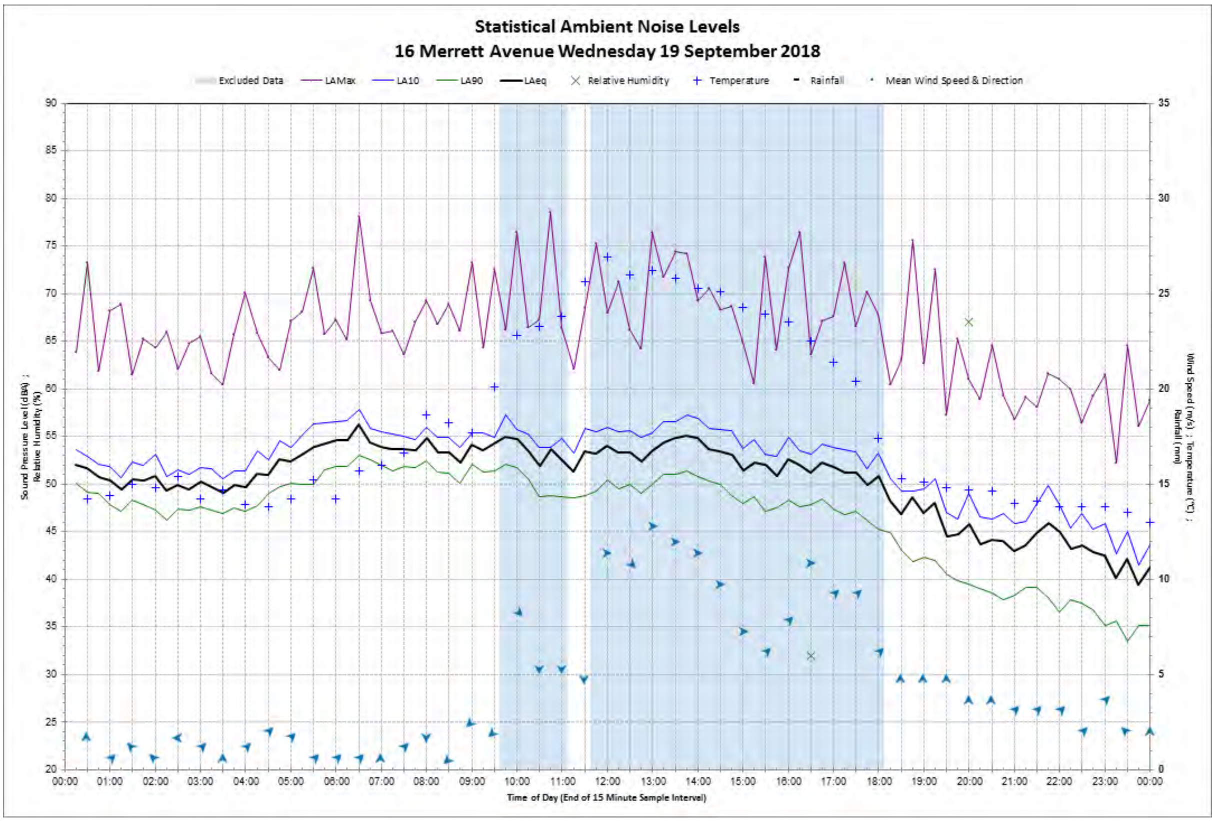

Statistical Ambient Noise Levels
16 Merrett Avenue Friday 14 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

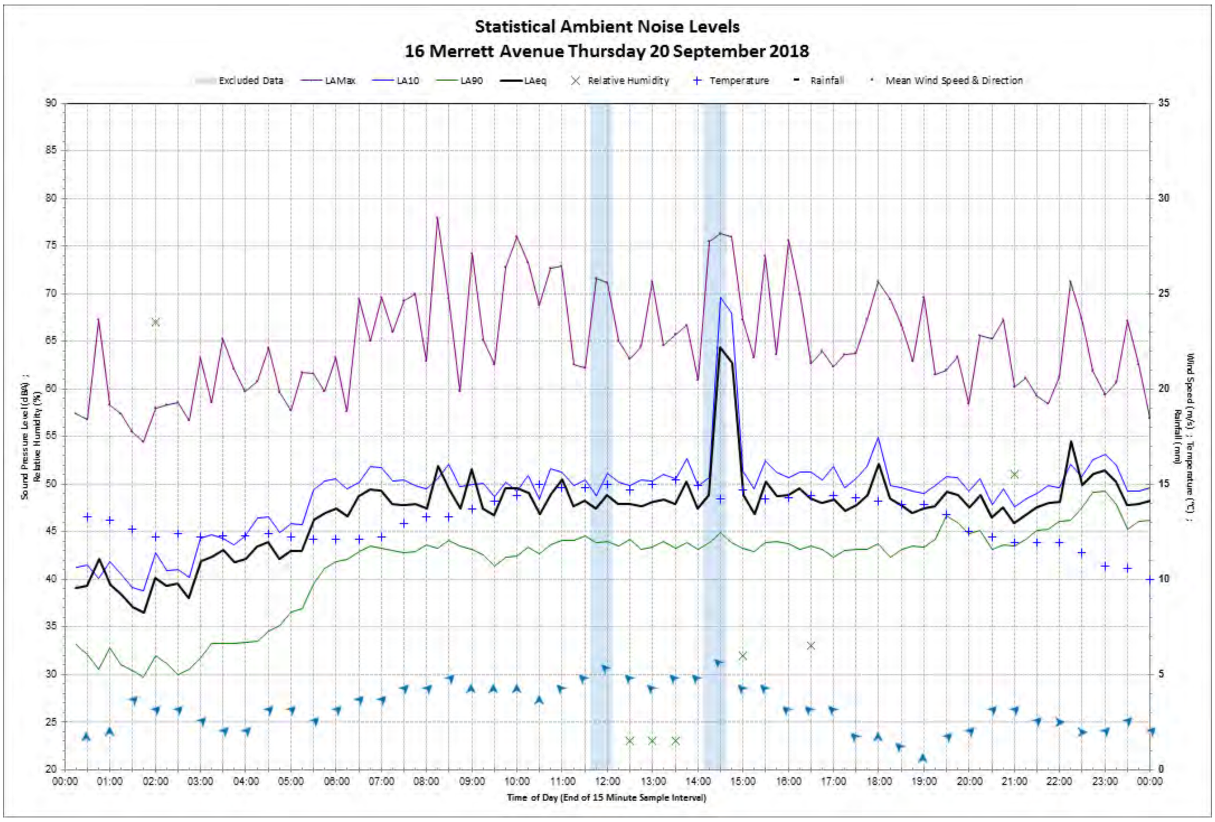

Statistical Ambient Noise Levels
16 Merrett Avenue Saturday 15 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

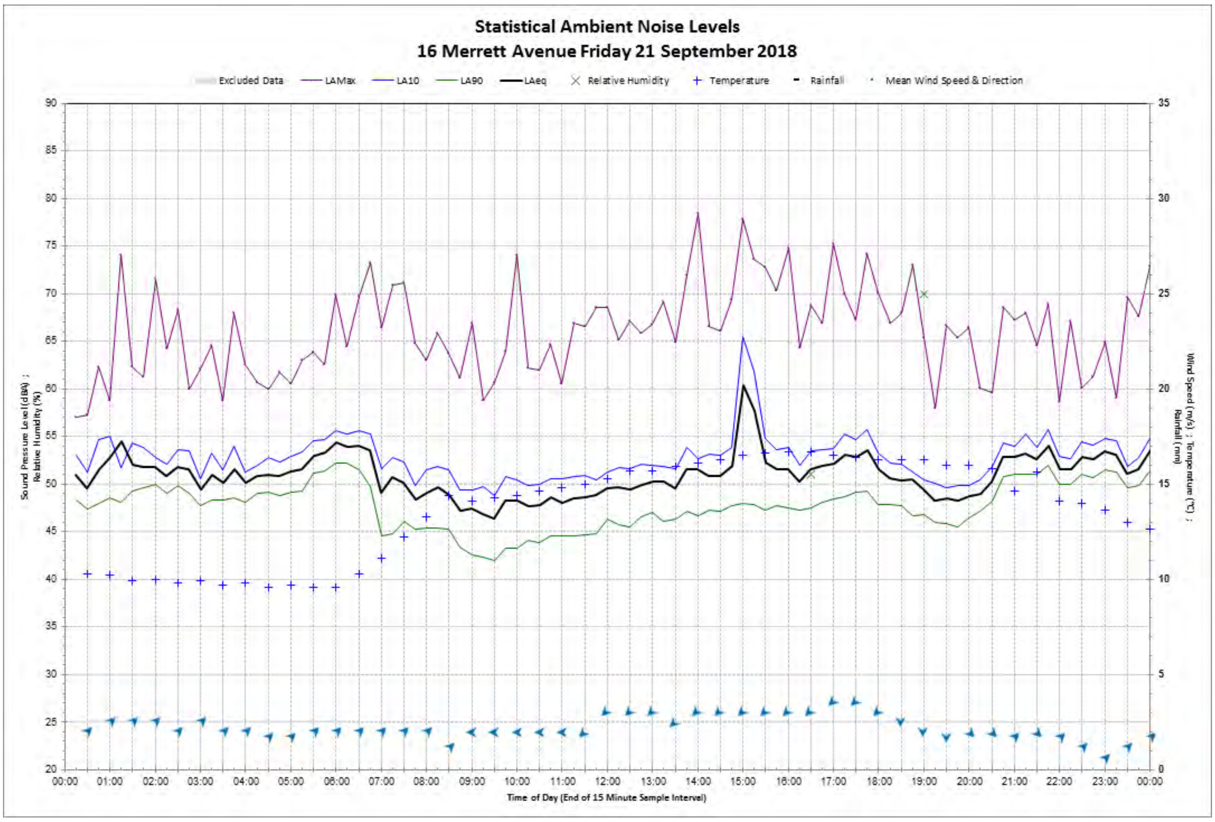

Statistical Ambient Noise Levels
16 Merrett Avenue Sunday 16 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
16 Merrett Avenue Monday 17 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

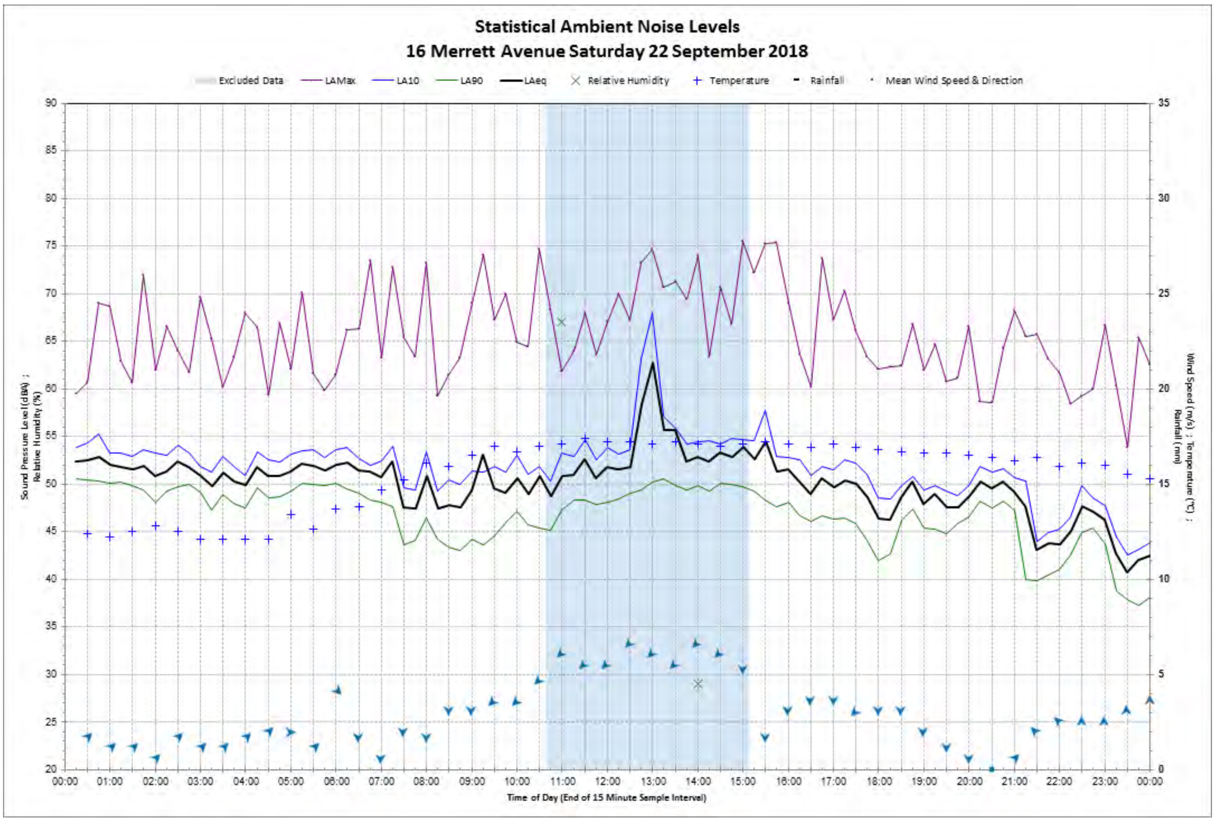

Statistical Ambient Noise Levels
16 Merrett Avenue Tuesday 18 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
16 Merrett Avenue Wednesday 19 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

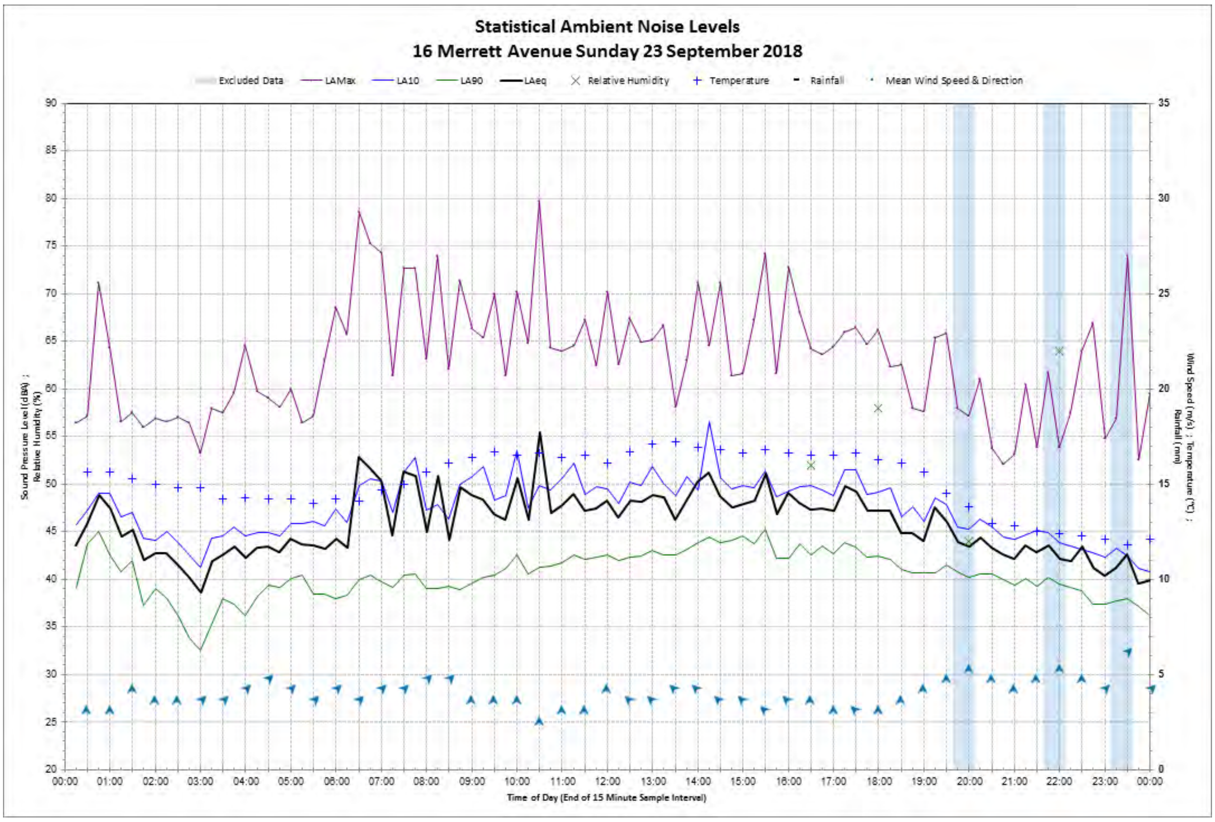

Statistical Ambient Noise Levels
16 Merrett Avenue Thursday 20 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)



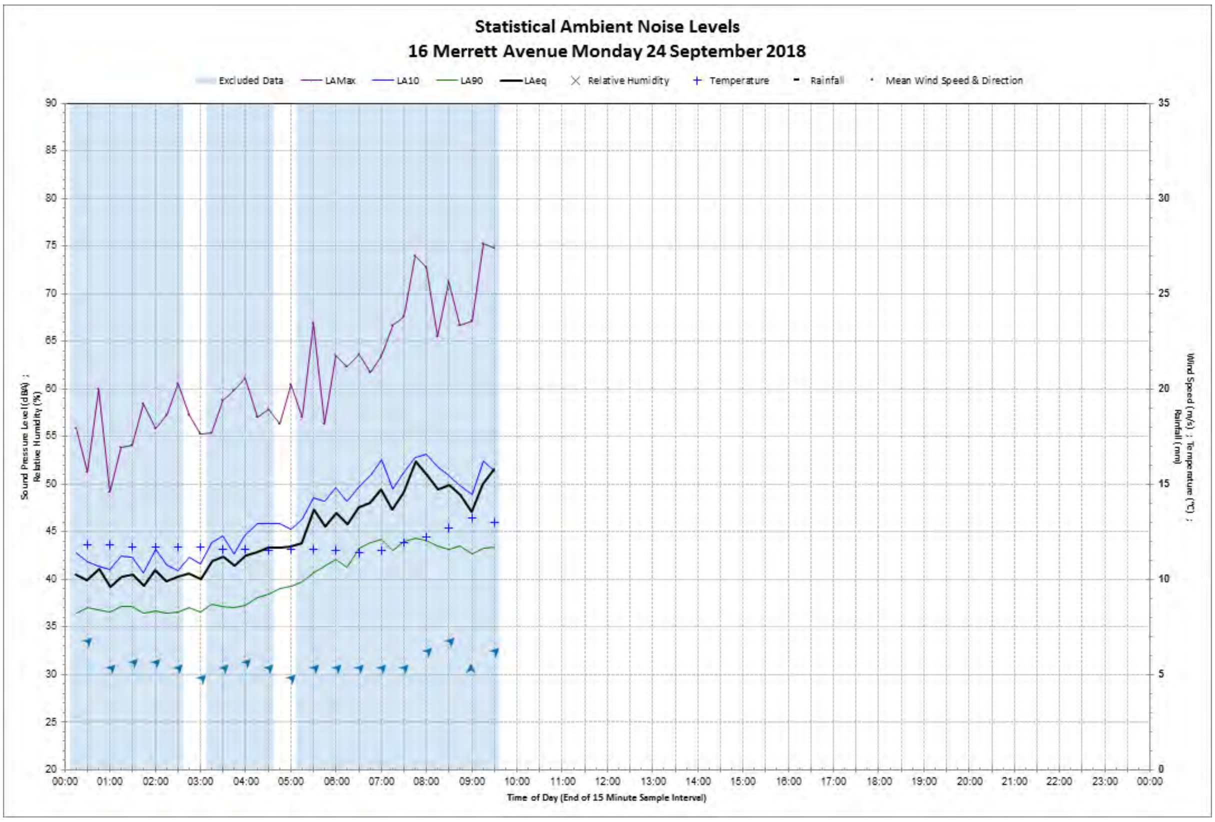
Statistical Ambient Noise Levels
16 Merrett Avenue Friday 21 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
16 Merrett Avenue Saturday 22 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
16 Merrett Avenue Sunday 23 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
16 Merrett Avenue Monday 24 September 2018
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

Appendix D – Representative sensitive receivers

Receiver ID	Address	Receiver Type	NCA
R001	330 Gladstone Avenue	Residential	NCA01
R002	136 Ocean Street	Residential	NCA01
R003	2 Mount Street	Residential	NCA01
R004	84 The Avenue	Residential	NCA01
R005	314 Gladstone Avenue	Residential	NCA01
R006	5 Hill Street	Residential	NCA01
R007	Drummond Street	Active recreation	NCA01
R008	Masters Road	Industrial	NCA01
R009	294-296 Gladstone Avenue	Residential	NCA01
R010	104 Ocean Street	Residential	NCA01
R011	8 Prospect Street	Residential	NCA01
R012	54 The Avenue	Residential	NCA01
R013	274 Gladstone Avenue	Residential	NCA01
R014	4 Grasmere Street	Residential	NCA01
R015	76 Ocean Street	Residential	NCA01
R016	262 Gladstone Avenue	Residential	NCA01
R017	3 Vale Street	Residential	NCA01
R018	23 The Avenue	Residential	NCA01
R019	250 Gladstone Avenue	Residential	NCA01
R020	4 John Street	Residential	NCA01
R021	46 Ocean Street	Residential	NCA01
R022	63 Robertson Street	Residential	NCA01
R023	12 The Avenue	Residential	NCA01
R024	230 Gladstone Avenue	Residential	NCA01
R025	47 Robertson Street	Residential	NCA01
R026	26 Ocean Street	Residential	NCA01
R027	85 Bridge Street	Residential	NCA01
R028	210 Gladstone Avenue	Residential	NCA01
R029	12 Ocean Street	Residential	NCA01
R030	192 Gladstone Avenue	Residential	NCA01
R031	21 Robertson Street	Residential	NCA01
R032	57 Bridge Street	Residential	NCA01
R033	Springhill Road	Residential	NCA01
R034	117 Gladstone Avenue	Residential	NCA01
R036	20 Robertson Street	Residential	NCA01
R037	160 Gladstone Avenue	Residential	NCA01
R038	46 Bridge Street	Residential	NCA01
R039	146A Gladstone Avenue	Residential	NCA01
R040	15 Bridge Street	Residential	NCA01
R041	5 Old Springhill Road	Commercial	NCA01
R042	Tate Street	Residential	NCA01
R043	392 Keira Street	Residential	NCA01
R044	175 Five Islands Road	Industrial	NCA02

Receiver ID	Address	Receiver Type	NCA
R045	159-163 Five Islands Road	Industrial	NCA02
R046	33 Dorman Street	Residential	NCA02
R047	147 Five Islands Road	Industrial	NCA02
R048	20 Lackawanna Street	Residential	NCA02
R049	25 Jarvie Road	Residential	NCA02
R050	1 Lackawanna Street	Residential	NCA02
R051	1 Dorman Street	Residential	NCA02
R052	17 Sheffield Street	Residential	NCA02
R053	4 Barry Street	Residential	NCA02
R054	19 Barry Street	Residential	NCA02
R055	14 Jarvie Road	Residential	NCA02
R056	52 Merrett Avenue	Residential	NCA02
R057	7 Barry Street	Residential	NCA02
R058	50 Lake Avenue	Residential	NCA02
R059	43 Cringila Street	Residential	NCA02
R060	43 Steel Street	Residential	NCA02
R061	1 Jarvie Road	Residential	NCA02
R062	41 Newcastle Street	Residential	NCA02
R063	22 Lake Avenue	Residential	NCA02
R064	6 Lake Avenue	Residential	NCA02
R065	87-93 Five Islands Road	Residential	NCA02
R066	25 Bethlehem Street	Residential	NCA02
R067	27 Merrett Avenue	Residential	NCA02
R068	59 Five Islands Road	Industrial	NCA02
R069	13 Newcastle Street	Residential	NCA02
R070	15 Birmingham Avenue	Residential	NCA02
R071	9 Steel Street	Residential	NCA02
R072	16 Merrett Avenue	Residential	NCA02
R073	1 Cringila Street	Residential	NCA02
R074	1-3 Bethlehem Street	Place of worship	NCA02
R075	4 Birmingham Street	Residential	NCA02
R076	Port Kembla Steelworks	Residential	NCA02
R077	1 Flinder Street	Industrial	NCA02
R078	16 Flinders Street	Industrial	NCA02
R079	5 Wentworth Street	Residential	NCA02
R080	91 Five Islands Road	Residential	NCA02
R081	6-8 Wentworth Street	Commercial	BCA92

Appendix E – Predicted operational noise levels, dBA

Receiver ID	Address	Receiver Type	NCA	OS1	OS2	OS1+OS2
R001	330 Gladstone Avenue	Residential	NCA01	11	20	21
R002	136 Ocean Street	Residential	NCA01	11	20	20
R003	2 Mount Street	Residential	NCA01	11	21	21
R004	84 The Avenue	Residential	NCA01	10	19	20
R005	314 Gladstone Avenue	Residential	NCA01	11	20	21
R006	5 Hill Street	Residential	NCA01	12	21	22
R007	Drummond Street	Active recreation	NCA01	12	21	21
R008	Masters Road	Industrial	NCA01	15	23	24
R009	294-296 Gladstone Avenue	Residential	NCA01	12	21	21
R010	104 Ocean Street	Residential	NCA01	12	22	23
R011	8 Prospect Street	Residential	NCA01	14	22	23
R012	54 The Avenue	Residential	NCA01	12	21	21
R013	274 Gladstone Avenue	Residential	NCA01	12	21	22
R014	4 Grasmere Street	Residential	NCA01	13	24	24
R015	76 Ocean Street	Residential	NCA01	12	22	22
R016	262 Gladstone Avenue	Residential	NCA01	12	21	22
R017	3 Vale Street	Residential	NCA01	12	22	23
R018	23 The Avenue	Residential	NCA01	13	24	24
R019	250 Gladstone Avenue	Residential	NCA01	13	21	22
R020	4 John Street	Residential	NCA01	13	21	22
R021	46 Ocean Street	Residential	NCA01	13	24	25
R022	63 Robertson Street	Residential	NCA01	12	21	21
R023	12 The Avenue	Residential	NCA01	13	22	22
R024	230 Gladstone Avenue	Residential	NCA01	14	22	23
R025	47 Robertson Street	Residential	NCA01	12	21	21
R026	26 Ocean Street	Residential	NCA01	16	23	23
R027	85 Bridge Street	Residential	NCA01	13	21	22
R028	210 Gladstone Avenue	Residential	NCA01	14	24	24
R029	12 Ocean Street	Residential	NCA01	14	23	23
R030	192 Gladstone Avenue	Residential	NCA01	13	22	23
R031	21 Robertson Street	Residential	NCA01	13	22	22
R032	57 Bridge Street	Residential	NCA01	15	23	24
R033	Springhill Road	Industrial	NCA01	18	25	26
R034	117 Gladstone Avenue	Residential	NCA01	15	23	23
R036	20 Robertson Street	Residential	NCA01	14	21	22
R037	160 Gladstone Avenue	Residential	NCA01	14	22	23
R038	46 Bridge Street	Residential	NCA01	14	22	23
R039	146A Gladstone Avenue	Residential	NCA01	14	22	23
R040	15 Bridge Street	Residential	NCA01	15	24	25
R041	5 Old Springhill Road	Commercial	NCA01	18	25	26

Receiver ID	Address	Receiver Type	NCA	OS1	OS2	OS1+OS2
R042	Tate Street	Residential	NCA01	16	27	27
R043	392 Keira Street	Residential	NCA01	16	24	24
R044	175 Five Islands Road	Industrial	NCA02	13	22	23
R045	159-163 Five Islands Road	Industrial	NCA02	14	22	22
R046	33 Dorman Street	Residential	NCA02	12	22	22
R047	147 Five Islands Road	Industrial	NCA02	13	22	22
R048	20 Lackawanna Street	Residential	NCA02	0	16	16
R049	25 Jarvie Road	Residential	NCA02	15	22	23
R050	1 Lackawanna Street	Residential	NCA02	12	21	22
R051	1 Dorman Street	Residential	NCA02	13	21	22
R052	17 Sheffield Street	Residential	NCA02	12	23	23
R053	4 Barry Street	Residential	NCA02	14	22	23
R054	19 Barry Street	Residential	NCA02	14	25	25
R055	14 Jarvie Road	Residential	NCA02	14	23	24
R056	52 Merrett Avenue	Residential	NCA02	13	22	23
R057	7 Barry Street	Residential	NCA02	14	24	24
R058	50 Lake Avenue	Residential	NCA02	16	24	25
R059	43 Cringila Street	Residential	NCA02	15	22	23
R060	43 Steel Street	Residential	NCA02	15	23	23
R061	1 Jarvie Road	Residential	NCA02	15	23	23
R062	41 Newcastle Street	Residential	NCA02	15	23	23
R063	22 Lake Avenue	Residential	NCA02	14	23	24
R064	6 Lake Avenue	Residential	NCA02	16	23	23
R065	87-93 Five Islands Road	Residential	NCA02	17	24	25
R066	25 Bethlehem Street	Residential	NCA02	16	23	24
R067	27 Merrett Avenue	Residential	NCA02	16	25	25
R068	59 Five Islands Road	Industrial	NCA02	17	24	25
R069	13 Newcastle Street	Residential	NCA02	15	23	23
R070	15 Birmingham Avenue	Residential	NCA02	15	24	25
R071	9 Steel Street	Residential	NCA02	16	23	24
R072	16 Merrett Avenue	Residential	NCA02	13	23	24
R073	1 Cringila Street	Residential	NCA02	15	22	23
R074	1-3 Bethlehem Street	Place of worship	NCA02	16	25	25
R075	4 Birmingham Street	Residential	NCA02	13	24	24
R076	Port Kembla Steelworks	Residential	NCA02	25	34	34
R077	1 Flinder Street	Industrial	NCA02	26	29	31
R078	16 Flinders Street	Industrial	NCA02	29	32	34
R079	7 Wentworth Street	Residential	NCA02	26	27	30
R080	91 Five Islands Road	Residential	NCA02	26	25	28
R081	Wentworth Street	Commercial	NCA02	24	25	28

Appendix F – Predicted operational noise levels, dBC

Receiver ID	Address	Receiver Type	NCA	OS1	OS2	OS1+OS2
R001	330 Gladstone Avenue	Residential	NCA01	48	48	51
R002	136 Ocean Street	Residential	NCA01	46	46	49
R003	2 Mount Street	Residential	NCA01	48	48	51
R004	84 The Avenue	Residential	NCA01	46	46	49
R005	314 Gladstone Avenue	Residential	NCA01	47	47	50
R006	5 Hill Street	Residential	NCA01	48	48	51
R007	Drummond Street	Active recreation	NCA01	47	47	50
R008	Masters Road	Industrial	NCA01	48	48	51
R009	294-296 Gladstone Avenue	Residential	NCA01	47	47	50
R010	104 Ocean Street	Residential	NCA01	47	47	50
R011	8 Prospect Street	Residential	NCA01	47	47	50
R012	54 The Avenue	Residential	NCA01	47	47	50
R013	274 Gladstone Avenue	Residential	NCA01	47	47	50
R014	4 Grasmere Street	Residential	NCA01	50	50	53
R015	76 Ocean Street	Residential	NCA01	47	47	50
R016	262 Gladstone Avenue	Residential	NCA01	47	47	50
R017	3 Vale Street	Residential	NCA01	50	50	53
R018	23 The Avenue	Residential	NCA01	48	48	51
R019	250 Gladstone Avenue	Residential	NCA01	48	48	51
R020	4 John Street	Residential	NCA01	47	47	50
R021	46 Ocean Street	Residential	NCA01	51	51	54
R022	63 Robertson Street	Residential	NCA01	48	48	51
R023	12 The Avenue	Residential	NCA01	47	47	50
R024	230 Gladstone Avenue	Residential	NCA01	48	48	51
R025	47 Robertson Street	Residential	NCA01	48	48	51
R026	26 Ocean Street	Residential	NCA01	48	48	51
R027	85 Bridge Street	Residential	NCA01	47	47	50
R028	210 Gladstone Avenue	Residential	NCA01	49	49	52
R029	12 Ocean Street	Residential	NCA01	49	49	52
R030	192 Gladstone Avenue	Residential	NCA01	49	49	52
R031	21 Robertson Street	Residential	NCA01	49	49	52
R032	57 Bridge Street	Residential	NCA01	50	50	53
R033	Springhill Road	Industrial	NCA01	49	49	52
R034	117 Gladstone Avenue	Residential	NCA01	50	49	52
R036	20 Robertson Street	Residential	NCA01	48	48	51
R037	160 Gladstone Avenue	Residential	NCA01	48	48	51
R038	46 Bridge Street	Residential	NCA01	49	49	52
R039	146A Gladstone Avenue	Residential	NCA01	48	48	51
R040	15 Bridge Street	Residential	NCA01	49	49	52
R041	5 Old Springhill Road	Commercial	NCA01	51	51	54

Receiver ID	Address	Receiver Type	NCA	OS1	OS2	OS1+OS2
R042	Tate Street	Residential	NCA01	51	51	54
R043	392 Keira Street	Residential	NCA01	49	49	52
R044	175 Five Islands Road	Industrial	NCA02	48	47	50
R045	159-163 Five Islands Road	Industrial	NCA02	47	47	50
R046	33 Dorman Street	Residential	NCA02	49	49	52
R047	147 Five Islands Road	Industrial	NCA02	49	49	52
R048	20 Lackawanna Street	Residential	NCA02	45	45	48
R049	25 Jarvie Road	Residential	NCA02	48	48	51
R050	1 Lackawanna Street	Residential	NCA02	47	47	50
R051	1 Dorman Street	Residential	NCA02	47	47	50
R052	17 Sheffield Street	Residential	NCA02	49	49	52
R053	4 Barry Street	Residential	NCA02	48	48	51
R054	19 Barry Street	Residential	NCA02	50	50	53
R055	14 Jarvie Road	Residential	NCA02	51	51	54
R056	52 Merrett Avenue	Residential	NCA02	48	48	51
R057	7 Barry Street	Residential	NCA02	51	51	54
R058	50 Lake Avenue	Residential	NCA02	51	51	54
R059	43 Cringila Street	Residential	NCA02	47	47	50
R060	43 Steel Street	Residential	NCA02	48	48	51
R061	1 Jarvie Road	Residential	NCA02	48	48	51
R062	41 Newcastle Street	Residential	NCA02	48	48	51
R063	22 Lake Avenue	Residential	NCA02	49	49	52
R064	6 Lake Avenue	Residential	NCA02	48	48	51
R065	87-93 Five Islands Road	Residential	NCA02	49	49	52
R066	25 Bethlehem Street	Residential	NCA02	48	48	51
R067	27 Merrett Avenue	Residential	NCA02	50	50	53
R068	59 Five Islands Road	Industrial	NCA02	50	50	53
R069	13 Newcastle Street	Residential	NCA02	49	49	52
R070	15 Birmingham Avenue	Residential	NCA02	51	51	54
R071	9 Steel Street	Residential	NCA02	48	48	51
R072	16 Merrett Avenue	Residential	NCA02	49	49	52
R073	1 Cringila Street	Residential	NCA02	50	50	53
R074	1-3 Bethlehem Street	Place of worship	NCA02	49	49	52
R075	4 Birmingham Street	Residential	NCA02	50	50	53
R076	Port Kembla Steelworks	Residential	NCA02	54	54	57
R077	1 Flinder Street	Industrial	NCA02	53	53	56
R078	16 Flinders Street	Industrial	NCA02	54	54	57
R079	7 Wentworth Street	Residential	NCA02	50	50	53
R080	91 Five Islands Road	Residential	NCA02	50	49	52
R081	Wentworth Street	Commercial	NCA02	49	49	52

Appendix G – Predicted 1/3 octave operational noise levels, dBZ

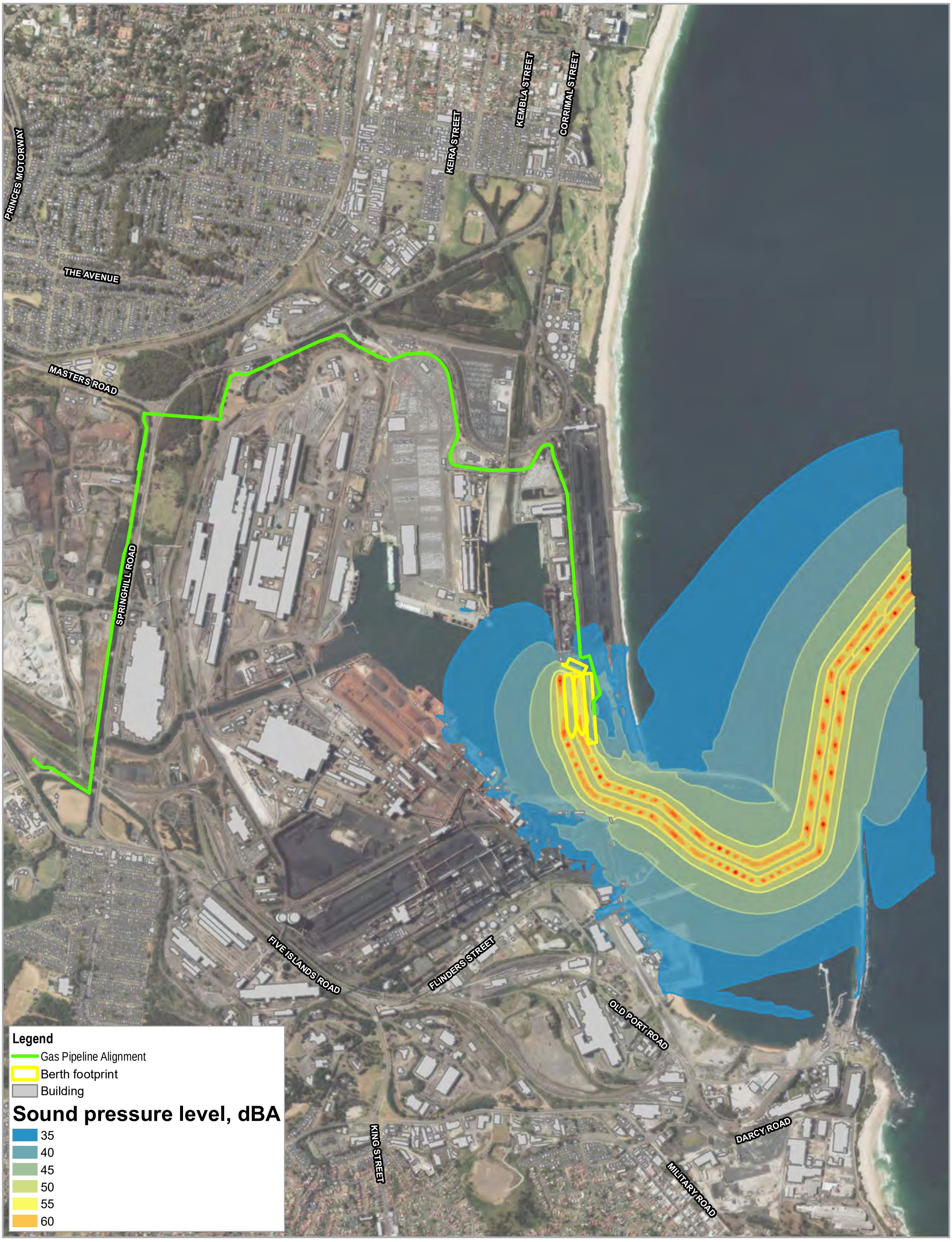
Predicted 1/3 octave band noise levels, dBZ

Receiver ID	1/3 octave centre band frequency, Hz																			
	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500
R001	50	44	40	42	38	34	28	25	22	17	14	12	9	8	7	4	3	2	0	0	0
R002	48	42	38	41	37	34	28	25	22	16	14	12	9	7	6	4	3	3	0	0	0
R003	49	44	39	43	39	35	28	25	23	17	14	12	9	7	6	6	5	4	0	0	0
R004	48	42	38	41	37	34	28	24	22	16	14	12	8	7	6	2	2	1	0	0	0
R005	48	43	38	42	38	34	28	25	23	17	15	13	10	8	7	5	4	4	0	0	0
R006	50	45	40	43	39	36	29	26	23	17	15	13	10	8	7	6	5	5	0	0	0
R007	48	43	38	43	39	35	29	26	23	17	15	13	10	9	8	6	5	4	0	0	0
R008	49	44	39	43	39	35	33	30	27	22	20	18	14	13	11	7	6	6	0	0	0
R009	48	43	38	42	38	34	29	26	23	17	15	13	11	9	8	7	6	6	0	0	0
R010	48	43	38	43	39	35	30	27	24	21	19	17	14	12	11	8	8	7	0	0	0
R011	48	43	38	42	38	34	29	26	23	21	18	16	15	13	12	11	10	10	0	0	0
R012	48	43	38	42	38	34	28	25	23	17	15	13	11	9	8	8	7	6	0	0	0
R013	49	43	38	43	39	35	29	26	23	18	15	13	11	9	8	6	5	4	0	0	0
R014	52	47	42	45	41	38	32	28	26	20	18	16	12	11	9	10	9	8	0	0	0
R015	48	43	38	42	38	35	29	26	23	19	17	15	14	12	11	9	8	8	0	0	0
R016	49	43	39	43	39	35	29	26	23	18	16	14	11	9	8	6	5	4	0	0	0
R017	52	46	41	44	40	37	30	27	24	18	16	14	11	9	8	8	7	6	0	0	0
R018	49	43	39	44	40	37	33	30	27	22	20	18	15	13	12	9	8	8	0	0	0
R019	50	45	40	43	39	35	29	26	24	18	16	14	11	10	8	6	5	5	0	0	0
R020	49	43	39	43	39	35	30	27	24	18	16	14	11	9	8	6	5	5	0	0	0
R021	52	47	42	46	42	38	32	29	26	21	19	17	13	12	10	9	9	8	0	0	0
R022	49	44	39	42	38	35	29	26	23	17	15	13	10	9	7	5	4	3	0	0	0
R023	49	43	39	43	39	35	30	26	24	18	16	14	12	11	9	9	8	8	0	0	0
R024	50	45	40	43	39	36	30	27	24	19	17	15	12	10	9	7	6	6	0	0	0
R025	49	44	39	42	38	35	29	26	23	18	15	13	11	9	8	5	5	4	0	0	0
R026	49	44	39	43	39	35	30	27	24	21	19	17	14	12	11	10	9	9	0	0	0
R027	49	44	39	42	38	35	29	26	23	17	15	13	12	11	9	7	6	5	0	0	0

Receiver ID	1/3 octave centre band frequency, Hz																				
	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500
R028	51	45	41	45	41	37	32	29	26	21	18	16	14	12	11	10	9	8	0	0	0
R029	50	45	40	45	41	37	31	28	25	19	17	15	12	10	9	7	6	6	0	0	0
R030	51	45	41	43	39	36	30	27	24	19	17	15	12	10	9	7	6	6	0	0	0
R031	50	45	40	43	39	35	30	27	24	18	16	14	11	10	8	7	6	6	0	0	0
R032	52	47	42	45	41	37	31	28	25	21	19	17	14	12	11	8	8	7	0	0	0
R033	50	45	40	44	40	36	34	31	28	24	22	20	17	15	14	10	9	9	0	0	0
R034	51	46	41	44	40	36	31	28	25	19	17	15	12	11	10	8	7	6	0	0	0
R036	49	44	39	43	39	35	30	27	24	18	16	14	12	10	9	7	6	5	0	0	0
R037	50	45	40	43	39	36	30	27	24	19	16	14	14	12	11	8	7	7	0	0	0
R038	51	46	41	44	40	37	30	27	25	19	16	14	12	10	9	6	6	5	0	0	0
R039	50	45	40	43	39	36	30	27	24	19	17	15	12	10	9	7	6	6	0	0	0
R040	50	44	40	46	42	38	32	29	26	21	19	17	14	12	11	10	10	9	0	0	0
R041	52	47	42	46	42	38	32	29	26	23	21	19	16	15	13	13	12	12	0	0	0
R042	50	45	40	49	45	41	35	32	29	24	22	20	17	15	14	12	11	10	0	0	0
R043	50	45	40	44	40	36	31	28	26	20	18	16	15	13	12	12	11	11	0	0	0
R044	48	43	38	44	40	36	30	27	24	18	16	14	13	12	10	9	8	7	0	0	0
R045	49	43	38	43	39	36	30	27	24	18	16	14	11	10	8	8	8	7	0	0	0
R046	51	45	40	43	39	36	29	26	24	18	16	14	11	9	8	5	4	4	0	0	0
R047	51	46	41	43	39	36	30	27	24	19	16	14	12	10	9	8	7	6	0	0	0
R048	47	42	37	39	35	31	23	20	18	10	7	5	0	-2	-3	-8	-9	-9	0	0	0
R049	49	44	39	43	39	35	30	27	24	19	16	14	12	11	9	10	9	8	0	0	0
R050	49	43	39	43	39	35	29	26	23	18	16	14	11	9	8	5	5	4	0	0	0
R051	48	43	38	43	39	35	29	26	24	18	16	14	11	10	8	6	5	4	0	0	0
R052	51	46	41	45	41	37	30	27	25	19	17	15	11	10	9	6	5	5	0	0	0
R053	50	44	40	43	39	36	30	27	24	19	17	15	12	10	9	9	8	7	0	0	0
R054	49	44	39	47	43	40	33	30	28	22	20	18	14	13	11	8	8	7	0	0	0
R055	54	48	43	44	40	37	31	28	25	19	17	15	14	13	11	9	8	7	0	0	0
R056	50	45	40	44	40	36	30	27	24	19	17	15	12	11	9	9	8	8	0	0	0
R057	53	48	43	46	42	38	32	29	26	20	18	16	13	11	10	8	7	6	0	0	0

Receiver ID	1/3 octave centre band frequency, Hz																				
	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500
R058	52	47	42	46	42	38	32	29	26	22	20	18	15	13	12	10	9	9	0	0	0
R059	49	43	39	43	39	35	30	27	24	19	17	15	13	12	10	9	9	8	0	0	0
R060	49	44	39	43	39	36	30	27	24	20	17	15	14	13	11	11	10	10	0	0	0
R061	49	44	39	43	39	36	30	27	25	20	17	15	13	12	11	11	10	9	0	0	0
R062	49	44	39	44	40	36	31	28	25	19	17	15	12	11	9	10	9	8	0	0	0
R063	51	46	41	45	41	37	31	28	25	20	17	15	13	11	10	11	11	10	0	0	0
R064	50	44	40	44	40	36	31	28	25	20	17	15	13	11	10	8	7	7	0	0	0
R065	50	44	40	45	41	37	31	28	26	20	18	16	16	14	13	11	11	10	0	0	0
R066	49	44	39	44	40	37	31	28	25	20	18	16	13	12	10	11	11	10	0	0	0
R067	50	44	40	47	42	39	33	30	27	22	19	17	14	13	11	10	10	9	0	0	0
R068	52	46	41	45	41	37	31	28	26	20	18	16	16	15	13	12	11	10	0	0	0
R069	50	45	40	44	40	36	31	28	25	20	18	15	13	11	10	8	7	7	0	0	0
R070	53	48	43	45	41	38	32	29	26	21	18	16	14	12	11	10	10	9	0	0	0
R071	49	44	39	44	40	36	30	27	25	19	17	15	15	13	12	10	10	9	0	0	0
R072	50	45	40	45	41	37	31	28	26	20	18	16	14	12	11	9	8	7	0	0	0
R073	52	46	42	44	40	36	30	27	25	19	17	15	13	11	10	8	7	6	0	0	0
R074	50	45	40	46	42	39	33	30	27	21	19	17	14	12	11	10	9	9	0	0	0
R075	52	47	42	45	41	37	32	29	26	20	18	16	15	13	12	11	11	10	0	0	0
R076	54	49	44	50	46	42	41	38	35	33	31	29	28	26	25	23	22	21	13	12	12
R077	54	49	44	48	44	40	38	35	32	27	25	23	21	20	18	15	14	13	2	2	2
R078	55	50	45	50	46	42	40	37	35	31	29	27	24	23	21	20	19	18	10	10	10
R079	51	45	41	46	42	38	33	30	27	25	23	21	20	18	17	18	17	17	5	5	4
R080	50	45	40	45	41	38	33	30	27	22	20	18	16	15	13	13	12	12	1	0	0
R081	50	45	40	45	41	37	32	29	26	21	19	17	15	14	12	16	15	15	3	3	2

Appendix H – Predicted operational noise contours, dBA



Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

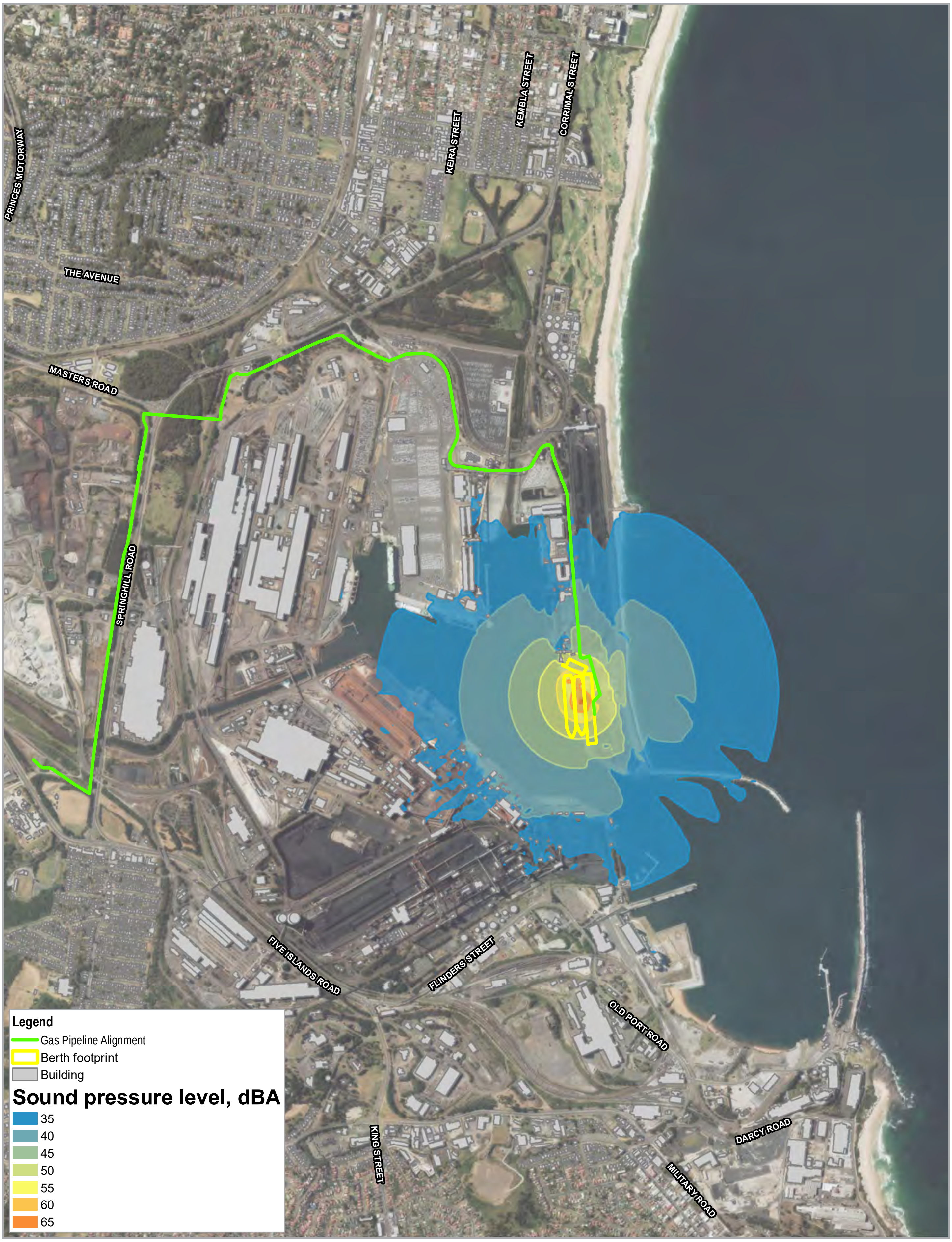
Australian Industrial Energy
Port Kembla Gas Terminal

Project No. **21-27477**
Revision No. **A**
Date **19 Nov 2019**

Predicted operational noise levels, dBA – OS1 (LNG carrier berthing)

Figure H1

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: eibbertson



Paper Size ISO A4

0 260 520 780 1,040

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

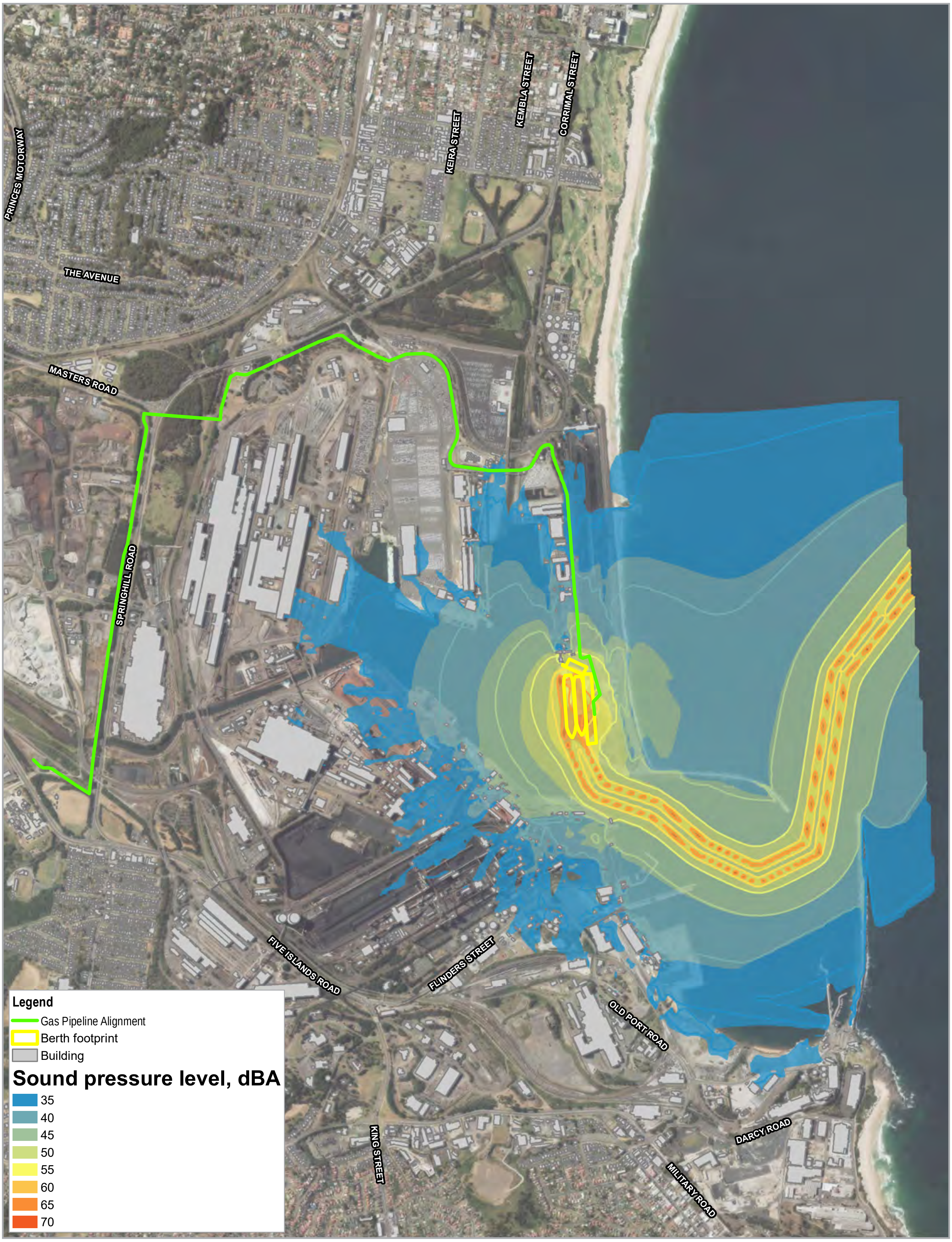
Australian Industrial Energy
Port Kembla Gas Terminal

Project No. **21-27477**
Revision No. **A**
Date **18 Nov 2019**

Predicted operational noise levels, dBA – OS2 (FSRU operation)

Figure H2

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: bahambly



Paper Size ISO A4

0 260 520 780 1,040

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

GHD

Australian Industrial Energy
Port Kembla Gas Terminal

Predicted operational noise levels, dBA – OS1 and OS2

Project No. **21-27477**
Revision No. **A**
Date **18 Nov 2019**

Figure H3

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: bahambly

GHD

Level 3
22 Giffnock Avenue
T: 61 2 9239 7100   F: 61 2 9239 7199   E: sydmail@ghd.com

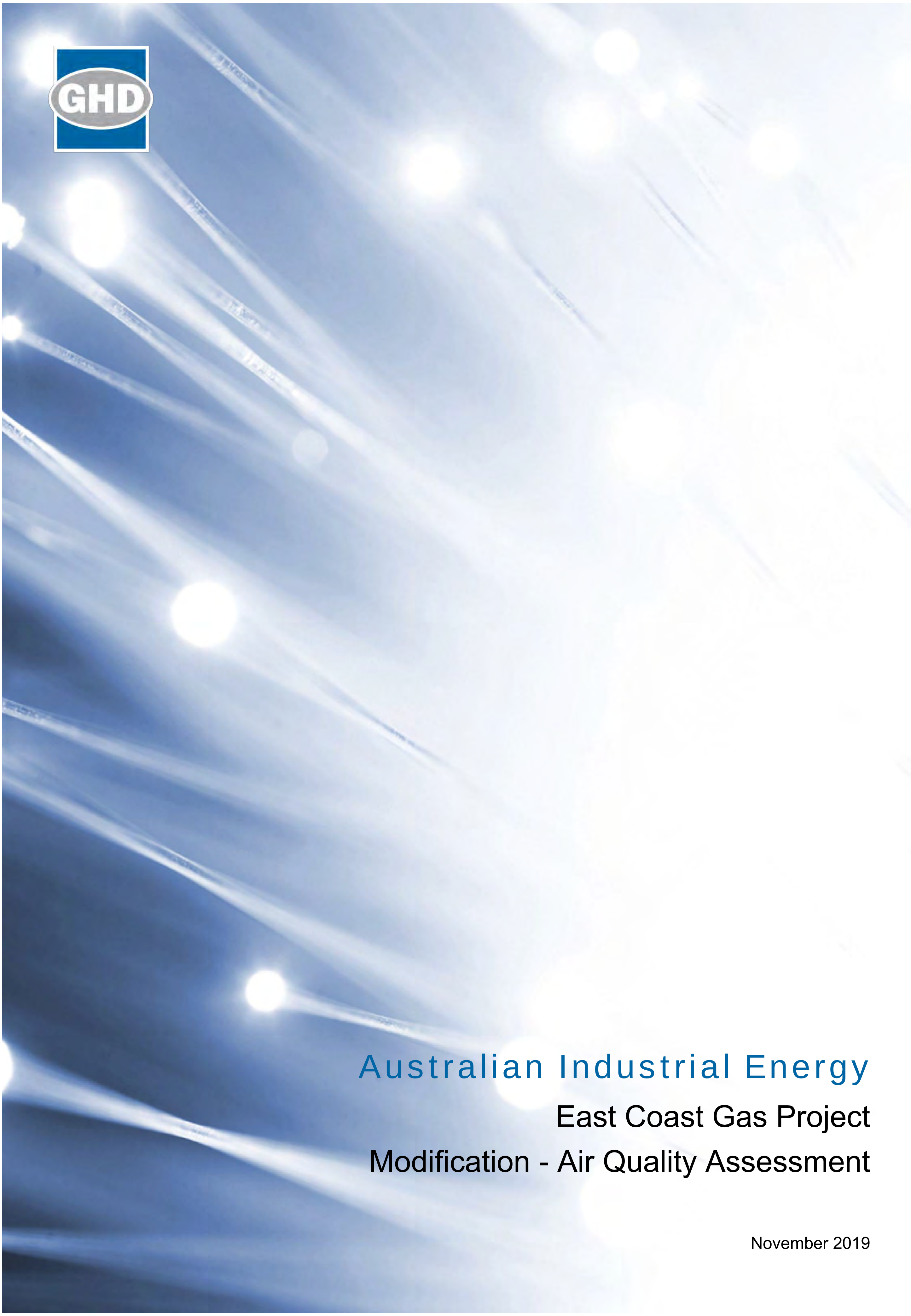
2127477-4878/https://projects.ghd.com/oc/Sydney1/eastcoastlngterminal/Delivery/Documents/2127477-REP_Modification-Noise and Vibration Impact Assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	V Lau	E Milton	On file	K Rosen	On file	25/11/19

www.ghd.com

Appendix D
Air quality assessment



Australian Industrial Energy

East Coast Gas Project

Modification - Air Quality Assessment

November 2019

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

Executive summary

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

Further analysis of market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. This seasonal variation was not considered in the EIS

AIE is therefore seeking a modification of the Minister's approval for the Port Kembla Gas Terminal under section 5.25 of the Environmental Planning and Assessment Act 1979. The modification will seek authorisation to increase capacity of the project and allow for seasonality.

GHD has undertaken an air quality assessment to assess potential air quality impacts resultant from the proposed modification to the project. The air quality assessment considered three potential operating scenarios which were based on worst case seasonal variations. There were no predicted exceedances of the impact assessment criteria at any sensitive receptor location.

It was identified that exhaust NO_x emissions from the operation of the FSRU while using liquid fuel (MDO) could exceed the POEO (Clean Air) Regulation 2010 concentrations limits if operating at 100% capacity. It is AIE's intention to primarily operate both the FSRU and LNG carrier using boil off gas (LNG). Liquid fuel would only be used in unusual emergency situations for short periods of time.

AIE and FSRU provider Hoegh LNG are committed to achieving sustainable operations and reducing greenhouse emissions wherever possible. Given the pace of technological change, it is possible that technology may become available which could reduce NOx emissions when the FSRU is running on marine diesel oil (MDO mode) to a level below the Protection of the Environment Operations (Clean Air) Regulation concentration limits. The proposed modification therefore includes an adjustment to Condition 8 of SSI 9471 to allow the condition to be waived subject to monitoring data demonstrating compliance with the PoEO (Clean Air) Regulation 2010. Based on assumptions as outlined in the assessment, the project would comply with the relevant air quality assessment criteria when assessed in accordance with the Approved Methods (2016).

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Overview

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW.

Port Kembla Gas Terminal consists of four key components:

- LNG carrier vessels — there are hundreds of these in operation worldwide transporting LNG from production facilities all around the world to demand centres.
- Floating Storage and Regasification Unit (FSRU) — a cape-class ocean-going vessel, which would be moored at Berth 101 in Port Kembla.
- Berth and wharf facilities — including landside offloading facilities to transfer natural gas from the FSRU into a natural gas pipeline located on shore.
- Gas pipeline — a Class 900 carbon steel high-pressure pipeline connection from the berth to the existing gas transmission network.

LNG will be sourced from worldwide suppliers and transported by LNG carriers to the Port Kembla Gas Terminal. The LNG will then be re-gasified for input into the NSW gas transmission network. The project will be the first of its kind in NSW and provide a simple, flexible solution to the state's gas supply challenges.

The Project was declared Critical State Significant Infrastructure (CSSI) in accordance with section 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and received Infrastructure Approval from the Minister for Planning and Public Spaces on the 24th of April 2019.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

The EIS stated the project would have the capacity to deliver in excess of 100 petajoules (PJ) per annum and also indicated that the capacity of the project could be increased further to 140–150 PJ per annum in the future. The EIS assumed a relatively flat demand profile throughout the year based upon the predicted demands from a predominantly industrial customer base. The assessment presented in the EIS for operation of the gas terminal was therefore based upon a flat rate of production with two LNG trains operating within the FSRU.

Further analysis of market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. The rate of production will need to respond to this demand and will also be influenced by operational parameters such as the calorific content of LNG delivered to the project. Accordingly, the supply will likely vary from the assumed flat rate of around 300 Terajoules (TJ) per day for any given season or shipment of LNG.

AIE is therefore seeking a modification of the Minister's approval for the Port Kembla Gas Terminal under section 5.25 of the *Environmental Planning and Assessment Act 1979*. The modification will seek authorisation to increase capacity of the project and allow for seasonality.

The modification will also require an increase to the overall number of LNG carrier deliveries per year to accommodate both the seasonality and the increase in capacity. The EIS anticipated the arrival of 24 consistently sized (170,000 cubic metre) vessels. However, with seasonality, incoming vessels may vary considerably in size from approximately 140,000 cubic metres to 180,000 cubic metres.

1.2 Previous assessment

A previous AQA was undertaken for the project in Appendix M Air quality of the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018). The assessment considered the construction and operation of the project.

No change to the project construction methodology and subsequent air quality emissions is proposed as part of the modification. Consequently construction air quality emissions remain the same as identified in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Submissions Report (GHD 2019). Therefore potential construction air quality impacts have not further been considered in this assessment.

The previous assessment conservatively considered a large range of likely, possible and unlikely operational scenarios to account for any operational situation. This air quality assessment refines the previous assessment by assessing the operational scenarios that are proposed as part of the project modification.

1.3 Scope and structure

The purpose of this Air Quality Assessment (AQA) is to assess and document the potential air quality impacts associated with the proposed modifications to the project.

This report has been prepared to support the Environmental Assessment (EA) for the proposed modification. The scope of the AQA is:

- Use existing meteorological modelling for the site for use in dispersion modelling
- Produce an emission inventory for the proposed modifications to operating conditions
- Undertake a cumulative air quality assessment of the site using the 2018 EIS AQIA and the proposed new source of emissions to air
- Assessment of the potential air quality impacts at nearby sensitive receivers
- Provision of mitigation measures where applicable

The structure and content of this report is as follows:

- **Section 2 – Existing environment**: This Section describes the existing environmental characteristics of the site relevant to the air quality assessment
- **Section 3 – Regulatory requirements:** This Section provides an overview of air quality criteria
- **Section 4 – Project emissions**: This Section details the estimated emission rates emitted from the project
- **Section 5 – Meteorology**: This Section outlines the assessment methodology and process followed to synthesize meteorology for the project site
- **Section 6 – Impact Assessment:** This Section presents a summary of the construction and operational pollutant impact assessment results
- **Section 7 – Mitigation**: This Section provides an overview of the proposed air quality mitigation measures to be undertaken during the project
- **Section 8 – Conclusion**: This Section presents a summary of the air quality findings and sets out the principal conclusions for the assessment.

1.4 Assumptions

This air quality assessment relied upon the following assumptions:

- Operational emission rates were calculated using data sheets supplied by AIE, NPI emissions factors and the US EPA (2017) Tier 2 emissions limits
- Operational characteristics and likely operational scenarios of the FSRU and LNG carrier were supplied by AIE
- Modelling assumptions are outlined in Section 6 of this report

2. Existing environment

2.1 Location

Port Kembla is a deep water harbour located in the Illawarra region, approximately 3km south of the Wollongong Central Business District and 80km south of Sydney. The port operates across two harbours, consisting of the Inner Harbour and Outer Harbour. NSW Ports is responsible for port infrastructure at the port, while the NSW Port Authority manage functions including harbour control, vessel tracking, pilotage and navigation.

There are a total of 18 berths at Port Kembla with services ranging from motor vehicle imports, grain and coal exports, general cargo facilities, dry bulk and break bulk facilities and bulk liquid facilities as shown on Figure 2-1.

B101 is proposed for use as part of the project and is located between B102 and “The Cut” shipping channel providing access to the Inner Harbour. B101 is currently operated by the PKCT and was most recently utilised as an off-loading wharf for materials handling equipment, but does not currently have any regular use with the majority of coal exports operating out of B102.

Land use surrounding B101 is predominantly heavy industrial or special uses associated with port operations. Wollongong Sewage Treatment Plant is located to the north of the coal export facility.

The closest residential properties to Berth 101 are located approximately 2km to the north in Coniston, to the west in Cringila and to the south at Port Kembla and Warrawong.

2.2 Existing air quality

The NSW OEH operates ambient air quality monitoring stations in selected areas around NSW. The nearest station to the site is Kembla Grange, however Wollongong has been included as it contains background data for SO_2, $PM_{2.5}$ and CO.

Maximum pollutant ambient concentrations for the modelled year (2014, see Section 5.2 for a discussion on why 2014 was selected as the most appropriate representative year) are presented in Table 2-1.

Table 2-1 Maximum recorded ambient air quality concentrations (µg/m^3, 2014)

Pollutant	Average period	OEH monitoring station	
		Wollongong	Kembla grange
SO^2	Hourly	49.8	-
	Daily	13.1	-
	Annual	2.0	-
NO^2	Hourly	71.4	58.3
	Annual	14.8	7.8
CO	Hourly	1725.0	-
PM_{10}	Daily	45.3	99.2
	Annual	17.7	17.3
$PM_{2.5}$	Daily	17.3	-
	Annual	7.0	-

‘-‘ denotes data not sampled at the site

The top 10 measured $PM_{2.5}$ levels (from Wollongong) and PM_{10} concentrations (from Kembla Grange) are provided below in Table 2-2. These are used for a contemporaneous assessment of operational particulate impacts.

Table 2-2 Top ranked PM_{10} and $PM_{2.5}$ concentrations

Rank	PM_{10} concentration (Kembla Grange)	$PM_{2.5}$ concentration (Wollongong)
1	99.2	17.3
2	43.6	16.8
3	42.2	16.1
4	41.5	15.8
5	40.8	15.5
6	37.8	15.2
7	37	14.9
8	36.8	14.8
9	36.8	14.4
10	36.2	14.3

2.2.1 Sensitive receptors

The location of the nearest identified sensitive receptors to the site are presented in Table 2-3 along with the address and receptor type. *The Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2016) (the Approved Methods) defines sensitive receptors as locations where people are likely to work or reside and may include a dwelling, school, hospital, office or recreation area. A figure showing the location of the site with representative receptors is supplied in Figure 2-1.

Table 2-3 Sensitive receptors locations

ID	X coordinate (m)	Y coordinate (m)	Address	Description
R01	306857	6187485	179 Corrimal St	Residential
R02	306232	6187186	398 Keira St	Baby Bounce (Commercial)
R03	306812	6186504	Port Kembla Rd	Industrial
R04	306396	6185950	Tom Thumb Rd	Incitec Pivot Fertilisers (industrial)
R05	305723	6184571	Port Kembla	Port Kemble steelworks (industrial)
R06	304834	6184104	41 Five Island Rd	GM fabrication (Commercial)
R07	305975	6183350	Port Kembla	Meatworks central (industrial)
R08	306606	6183717	16 Flinders St	Caltex (Commercial)
R09	306853	6184327	Christy Dr	Near Gabriella Memorial (Industrial)
R10	307390	6182968	Port Kembla	Port Kembla Station
R11	308190	6183101	Gloucester Blvd	Breakwater Battery Museum

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Site and sensitive receptor Location

Figure 2-1

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 15:12 (SMA record: 2) (SMA record: 39)

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: sross2

3. Regulatory requirements

3.1 Legislative and policy context to the assessment

The Protection of the Environment Operations (POEO) Act 1997 provides the statutory framework for managing pollution in NSW, including the procedures for issuing licences for environmental protection on aspects such as waste, air, water and noise pollution control. Companies and property owners are legally bound to control emissions (including particulates and deposited dust) from construction sites under the POEO Act. Activities undertaken onsite must not contribute to environmental degradation, and pollution and air emissions must not exceed the standards. Where an environment protection licence applies, air quality requirements (including criteria) may be specified by the licence.

The *Protection of the Environment Operations (Clean Air) Regulation 2010* (the POEO Clean Air Regulation) provides regulatory measures to control emissions from motor vehicles, fuels, and industry.

The National Environment Protection Council of Environmental Ministers, now the National Environment Protection Council (NEPC), set uniform national standards for ambient air quality in February 2016. These are known as the *National Environment Protection (Ambient Air Quality) Measure* (‘the Air NEPM’). The Air NEPM sets non-binding standards and ten-year goals (for 2026). The Air NEPM contains goals for the identified relevant pollutants inclusive of particulates such as PM_{10} and $PM_{2.5}$ and toxic pollutants including carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). The Air NEPM contains concentration limits, averaging periods and number of allowed exceedances for each of the identified pollutants.

The Air NEPM standards apply to regional air quality as it affects the general population. The standards do not apply in areas impacted by localised air emissions, such as industrial sources, construction activity, and heavily trafficked streets and roads.

The Approved Methods lists the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in NSW. It considers the above mentioned legislation and acts to construct pollutant assessment criteria. The Approved Methods assess the cumulative (background plus incremental site emissions) pollutant impact at the site boundary or the nearest existing or likely future off-site sensitive receptor depending on pollutant. Background concentrations of air pollutants are ideally obtained from ambient monitoring data collected at a proposal site in accordance with the Approved Methods. The Approved Methods recognises that this data is rare, and that data is typically obtained from monitoring sites as close as possible to a proposal site, where sources of air pollution resemble the existing sources at the project site.

3.2 Project impact assessment criteria

Assessment criteria has been taken from the Approved Methods to set the impact assessment criteria for the project. To ensure that environmental outcomes are achieved, the emissions impact from the project must be assessed against the assessment criteria shown in Table 3-1.

Note, the values of some of these pollutants have been converted from milligram (mg) to µg in order to be consistent. Impact assessment criteria included in the assessment are based on the pollutants listed in the supplied engine data from AIE.

Table 3-1 Impact assessment criteria

Pollutant	Averaging period	Percentile	Assessment criteria ($\mu g/m^3$)
TSP (total suspended particulates)	Annual	100th	90
PM_{10}	24 hour	100th	50
	Annual	100th	25
$PM_{2.5}$	24 hour	100th	25
	Annual	100th	8
CO	1 hour	100th	30000
	8 hour	100th	10000
NO_2	1 hour	100th	246
	Annual	100th	62
SO_2	1 hour	100th	570
	24 hour	100th	228
	Annual	100th	60
Benzene	1 hour	99.9th	29
Formaldehyde	1 hour	99.9th	20
Total PAHs (polycyclic aromatic hydrocarbons)	1 hour	99.9th	0.4

3.3 POEO Clean Air Emission standards

The POEO Clean Air Regulation provides exhaust air emission concentration limits for gas and liquid fuelled engines typically applicable in NSW are summarised in Table 3-2.

Table 3-2 NSW POEO emission limits

Pollutant	NSW emission limit (mg/m^3)	
	Gas fuelled engines	Liquid fuelled engines
PM_{10}	50	50
$PM_{2.5}$	50	50
NO_x	450	450
CO	125	5880
SO_2	1000	1000
Benzene	40[1]	1140[1]
Formaldehyde	40[1]	1140[1]
PAH	N/A	N/A

[1] Shown limit is for VOCs as n propane

4. Project emissions

4.1 Emissions overview

Air quality may be impacted by a number of pollutants, each of which has different emission sources and effects on human health and the environment. This air quality assessment focuses on the highest-risk impacts with the potential to as a result of the modification to the project.

This Section details the estimated air emissions from the project.

4.2 Project operational activities

The primary emission source associated with the operation of the project are the engines on board the FSRU and LNG carrier. These engines are used to power all other operational activities on board the FSRU and LNG carrier and are the primarily source of air quality emissions for each vessel. These emissions are released via a stack on each vessel. Engine details from the FSRU and LNG carrier have been supplied by AIE.

It is understood that the FSRU and the LNG carrier can be operated using gas (LNG) or liquid fuel known as marine diesel oil (MDO). It is AIE's intention to primarily operate both the FSRU and LNG carrier using boil off gas (LNG) as an energy source. Liquid fuel would only be used in emergency situations for a short amount of time. It is worth noting that:

- if there is an engine failure, one of the other remaining engines could be operated on LNG
- If there is no LNG, there would be no operations. Hence, all engines would be turned off.
- If there is LNG and for some reason a spare engine can't be used and marine oil must be used, it would be for a very short period of time until repairs or LNG could be obtained

The emergency generator and auxiliary boiler on board the FSRU have the potential to produce emissions. AIE have stated that the auxiliary boilers are not expected to operate as recovered heat from the main engines will be used. Additionally it was mentioned that the emergency generator will be operated for 30 minutes every week for test purposes only. It is assumed the generator will not be tested while the LNG carrier is docked. The emissions from these sources are not considered significant as they are not intended to be used during everyday operations and are not expected to exceed emissions from the assessed scenarios in this assessment.

The following sections outline the air quality emissions from the FSRU and LNG carrier while operating on gas and liquid to account for any operational scenario. The number of engines operating has been assessed over a range of scenarios and is discussed in Section 6.

4.3 FSRU emissions

The FSRU is to be powered using four WARTSILA 8L50DF engines. A summary of engine specifications are provided in Table 4-1. The engines, when in use, have been assumed to operate continuously at 100 % capacity to conservatively predict worst-case emissions.

The WARTSILA engines on the FSRU are used to power all on board operations including:

- Operation of the LNG Trains which are used to perform regasification operations. Each LNG Train consists of 2 High Pressure LNG Booster Pumps and heat exchangers / vaporizers.
- Power to accommodation (hotel load)
- Cargo handling and crane operations

Table 4-1 FSRU engine specifications

Engine no.	1		2		3		4	
Engine make and model	Wartsila W8L50DF		Wartsila W8L50DF		Wartsila W8L50DF		Wartsila W8L50DF	
Power rating (kW)	7800		7800		7800		7800	
Rotational speed (RPM)	514		514		514		514	
Fuel type	MDO	Gas	MDO	Gas	MDO	Gas	MDO	Gas
Outlet diameter (m)	1		1		1		1	
Exhaust flowrate (m^3/s)	26.8	22.9	26.8	22.9	26.8	22.9	26.8	22.9
Exhaust temp (ºC)	343	373	343	373	343	373	343	373

4.3.1 FSRU emissions (gas fuelled)

The emission to air for the gas fuelled FSRU scenario are presented in Table 4-2. The emission rates have been calculated using exhaust gas emission data supplied by AIE provided in Appendix A. Sulfur dioxide (SO_2 emissions were calculated assuming a fuel sulfur content of 3.5 parts per million which is typical for LNG. Benzene and polycyclic aromatic hydrocarbons (PAH) emission rates were scaled off the provided formaldehyde emission rate using the ratio between emission factors from the *National Pollutant Inventory emission estimation technique manual for combustion engines version 3.0 (2008)* table 54.

Table 4-2 FSRU emissions (gas fuelled)

Pollutant	Engine number and emission rate (g/s)			
	1	2	3	4
Particles (PM_{10})	0.14	0.14	0.14	0.14
NO_x	2.60	2.60	2.60	2.60
CO	1.95	1.95	1.95	1.95
SO_2	0.0023	0.0023	0.0023	0.0023
Benzene	0.0042	0.0042	0.0042	0.0042
Formaldehyde	0.5	0.5	0.5	0.5
PAH	0.0000016	0.0000016	0.0000016	0.0000016

4.3.2 FSRU emissions (liquid fuelled)

The emissions to air for the liquid fuelled scenario are presented in Table 4-3.

Particulate (PM_{10} and $PM_{2.5}$) emissions factors were sourced from the *National Pollutants Inventory Emission estimation technique manual for Maritime operations version 2.1, table 9*. Sulfur dioxide (SO_2) emissions were calculated assuming a fuel sulfur content of 0.5 % (by mass [m/m]) as per the International Maritime Organisations fuel sulfur limit that is applicable on or after 1 January 2020.

Nitrogen oxides (NO_x), carbon monoxide (CO) and Volatile organic compound (VOCs) emission rates were calculated based on the US EPA (2017) Tier 2 emission limits.

Given the pace of technological change, it is possible that technology may become available which could reduce NOx emissions when the FSRU is running on MDO mode to comply with the US EPA (2017) Tier 3 emissions limit and be below the Protection of the Environment Operations (Clean Air) Regulation 2010 limit.

Benzene, formaldehyde and PAH emission rates were scaled off the VOC emission rate using the ratio of emission factors from the *National Pollutant Inventory emission estimation technique manual for combustion engines version 3.0 (2008)* table 43.

Table 4-3 FSRU emissions (liquid fuelled)

Pollutant	Engine no. and emission rate (g/s)			
	1	2	3	4
PM_{10}	0.91	0.91	0.91	0.91
$PM_{2.5}$	0.50	0.50	0.50	0.50
NO_x	22.7	22.7	22.7	22.7
CO	10.8	10.8	10.8	10.8
SO_2	3.7	3.7	3.7	3.7
VOCs	4.33	4.33	4.33	4.33
Benzene	0.043	0.043	0.043	0.043
Formaldehyde	0.0043	0.0043	0.0043	0.0043
PAH	0.00000063	0.00000063	0.00000063	0.00000063

4.4 LNG carrier emissions

The LNG carrier will tether alongside the FSRU temporarily while the LNG carrier is unloading LNG to the FSRU. An LNG carrier, for the purposes of this assessment has been modelled as being powered by three WARTSILA 8L50DF engines and one WARTSILA 6L50DF. A maximum of two engines are required to be operational to power the LNG carrier during this process. This assessment assumed engines 1 and 2 of the LNG carrier will operate at 100 % capacity. Engine specifications are provided in Table 4-4.

Table 4-4 LNG carrier engine specifications

Engine no.	1			2		3		4	
Engine make and model	Wartsila W8L50DF			Wartsila W8L50DF		Wartsila W8L50DF		Wartsila W6L50DF-B	
Power rating (kW)	7300			7300		7300		5850	
Rotational speed (RPM)	514			514		514		514	
Fuel type	MDO	Gas	MDO	Gas	MDO	Gas	MDO	Gas	
Outlet diameter (m)	1			1		1		1	
Exhaust flowrate (m^3/s)	26.8	22.9		26.8	22.9	26.8	22.9	26.8	22.9
Exhaust temp (ºC)	343	373		343	373	343	373	343	373

4.4.1 LNG carrier emissions (gas fuelled)

The emission to air for the gas fuelled LNG carrier scenario are presented in Table 4-5.

The emission rates have been calculated using exhaust gas emission data supplied by AIE. Sulfur dioxide (SO_2) emissions were calculated assuming a fuel sulfur content of 3.5 ppm which is typical for LNG. Benzene and PAH emission rates were scaled off the provided formaldehyde emission rate using the ratio between constituent emission factors from the *National Pollutant Inventory emission estimation technique manual for combustion engines version 3.0 (2008)* table 54.

Table 4-5 LNG carrier emissions (gas fuelled)

Pollutant	Engine number and emission rate (g/s)			
	1	2	3	4
Particles (PM_{10})	0.14	0.14	0.14	0.10
NO_x	2.60	2.60	2.60	1.95
CO	1.95	1.95	1.95	1.46
SO_2	0.0023	0.0023	0.0023	0.0017
Benzene	0.0042	0.0042	0.0042	0.0031
Formaldehyde	0.50	0.50	0.50	0.37
PAH	0.0000016	0.0000016	0.0000016	0.0000012

4.4.2 LNG carrier emissions (liquid fuelled)

The emissions to air for the liquid fuelled scenario are presented in Table 4-6.

Particulate (PM_{10} and $PM_{2.5}$) emissions factors were sourced from the *National Pollutants Inventory Emission estimation technique manual for Maritime operations version 2.1, table 9*. Sulfur dioxide (SO_2) emissions were calculated assuming a fuel sulfur content of 0.5 % (m/m) as per the International Maritime Organisations fuel sulfur limit that is applicable on or after 1 January 2020.

Nitrogen oxides (NO_x), carbon monoxide (CO) and Volatile organic compound (VOCs) emission rates were calculated based on the US EPA (2017) Tier 2 emission limits.

Benzene, formaldehyde and PAH emission rates were scaled off the total VOC emission rate using the ratio of constituent emission factors from the *National Pollutant Inventory emission estimation technique manual for combustion engines version 3.0 (2008)* table 43.

Table 4-6 LNG carrier emissions (liquid fuelled)

Pollutant	Engine number and emission rate (g/s)			
	1	2	3	4
PM_{10}	0.91	0.91	0.91	0.68
$PM_{2.5}$	0.50	0.50	0.50	0.37
NO_x	22.68	22.68	22.68	17.01
CO	10.83	10.83	10.83	8.13
SO_2	3.74	3.74	3.74	2.80
VOCs	4.33	4.33	4.33	3.25
Benzene	0.043	0.043	0.043	0.033
Formaldehyde	0.0043	0.0043	0.0043	0.0033
PAH	0.00000063	0.00000063	0.00000063	0.00000048

4.4.3 Assumptions

The following assumptions were applied to the operational modelling:

- Engine exhaust outlets were modelled as stacks. Stack properties have been provided by AIE.
- Emission factors for the gas fuelled scenarios were supplied by AIE. Emissions factors for the liquid scenarios were taken from the US EPA Tier 2 emissions limits, the *National Pollutant Inventory emissions estimation technique manual for Combustion engines Version 3 (2008)* and the *National Pollutant Inventory emissions estimation technique manual for Maritime operations version 2.1 (2012).*

- One or two engines (based on seasonal fluctuation) on board the FSRU are assumed to operate at 100 % capacity 24 hours a day. Two of the four engines on board the LNG carrier have been assumed to be operational during docking activities and while the carrier is unloading its cargo to supply power.

4.5 Exhaust concentrations against POEO Clean Air Emission standards

Modern LNG carriers and FSRUs are typically powered by natural gas instead of marine diesel or other fossil fuels and consequently emit significantly lower levels of carbon dioxide, nitrogen oxides and particulates, and almost no sulphur oxides.

The FSRU is equipped with 4 x Wartsila engines (W8L50DF). In normal operating mode (gas mode) the FSRU engines will be fuelled by the LNG on-board and will comply with the NSW Clean Air Emission Standards outlined in Table 3-2.

However, the engines are however designed to have dual fuel capabilities, meaning they can also run on marine diesel oil (MDO) if there is no LNG available for use in engine. It was identified during the determination of the original Infrastructure Approval that there was potential for exceedance of NSW Clean Air Emissions Standards when the engines were operating on MDO.

Air emissions from discharge points on marine vessels (including the FSRU) are also regulated under the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and the emission standards of the PoEO Regulation would not apply where there is inconsistency with Commonwealth legislation.

It was noted that situations where the FSRU would run in MDO mode would be highly unusual / emergency type situations and it was therefore the Infrastructure Approval includes a restriction to the use of MDO as a fuel to 72 hours cumulative over a calendar year. During these periods the FSRU would need to comply with Commonwealth legislative requirements.

Increasingly, international and national air emissions standards are reducing the levels of permissible NOx emissions from marine transportation vessels. AIE and FSRU provider Hoegh LNG are committed to achieving sustainable operations and reducing greenhouse emissions wherever possible. Given the pace of technological change, it is possible that technology may become available which could reduce NOx emissions when the FSRU is running on marine diesel oil (MDO mode) to a level below the Protection of the Environment Operations (Clean Air) Regulation 2010 limit. The proposed modification therefore includes an adjustment to Condition 8 of SSI 9471 to allow the condition to be waived subject to monitoring data demonstrating compliance with the PoEO (Clean Air) Regulation 2010.

It is noted that the air quality assessment demonstrates that even if liquid fuelled engines were utilised, under worst-case scenarios the ground level criteria at nearby sensitive receptors will be achieved.

5. Meteorology

5.1 Overview

Site specific meteorology for the project was produced using CALMET. The CALMET simulation produced a 3D wind field for the modelled year. Prognostic TAPM data was used alongside observations taken at two NSW Bureau of Meteorology (BoM) sites as inputs into the CALMET model. Details of the procedure undertaken to produce the site specific meteorology is outlined in the following sections.

5.2 Methodology

The characterisation of local wind patterns generally requires accurate site-representative hourly recordings of wind direction and speed over a period of at least a year.

Existing observational data is available from the following locations:

- Port Kembla (BoM)
- Albion park (BoM).

In order to produce a representative site-specific meteorological data set encompassing the meteorological data from all the observational sites, the following methodology was carried out:

- Production of a 3D gridded dataset with the prognostic model TAPM.
- Utilising the TAPM 3D gridded dataset as an initial guess field for the CALMET meteorological model.
- Utilising data from all observation sites (Port Kembla and Albion park BoM sites) for surface level observations.

An analysis of meteorology from the years from 2013 to 2017 was conducted to select a period considered to be most representative of ‘normal’ conditions. The analysis shows that the year 2014 is the most representative year based on a review of temperature, wind speed and wind direction. Meteorological characteristics of the 2014 year closely followed the average of all years from 2013 to 2017 suggesting 2014 represents a typical year.

Summary charts of the representative year analysis are provided in Appendix B.

5.3 TAPM modelling

The TAPM prognostic model was run to obtain a coarse meteorological 3D gridded dataset for the site for the selected model period. This dataset is based on synoptic observations, local terrain and land use information with a resolution of 1,000m. The TAPM model parameters are summarised in Table 5-1 and are selected in accordance with the Approved Methods

Table 5-1 TAPM model parameters

Parameter	Value
Modelled period	1 December 2013 to 1 January 2015
Domain centre	UTM: 56H 300,727 mE, 6,178,414 mS Latitude = -34° 31' Longitude = 150° 49.5'
Number of vertical levels	25
Number of easting grid points	25
Number of northing grid points	25
Outer grid spacing	30,000 m x 30,000 m
Number of grid levels	4
Grid level horizontal resolution	Level 2 – 10,000 m Level 3 – 3,000 m Level 4 – 1,000 m

5.4 CALMET modelling

The US EPA Approved version of CALMET (Version 5) was used to resolve the wind field around the subject site to a 200m spatial resolution. The application of CALMET for this purpose is an approved modelling approach in NSW as per the Approved Methods with model guidance documentation provided in *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'* (Barclay, J & Scire, J, 2011).

Upon completion of the broad scale TAPM modelling runs, a CALMET simulation was set up to run for the model period, combining the three dimensional gridded data output from the TAPM model with the site specific surface data from the Port Kembla and Albion park south BoM stations. This approach is consistent with guidance documentation.

All model settings were selected based on the recommendations provided in the model guidance documentation (with the exception that O'Brien vertical velocity adjustments was enabled) CALMET was run using the "Hybrid" mode with the TAPM data provided as an initial guess field.

The southwest corner of the CALMET domain, or the origin, was located at UTM Zone 56 coordinates 288.227 kilometre east and 6165.914 kilometre north. The CALMET domain extended 23 kilometre to the east and north.

The CALMET domain consisted of 115 grids in both the east and north directions, with a grid resolution of 0.2 kilometre.

CALMET settings were selected as per the model guidance document for "Hybrid" mode

The TERRAD, RMAX and R variables were set to the values presented in Table 5-2 based on an inspection of the terrain elevations in the immediate vicinity of the subject site, based on model guidance. The CALMET model parameters are summarised in Table 5-2.

Terrain and land use data used for the CALMET modelling are presented in Figure 5-1 and Figure 5-2.

Table 5-2 Summary of CALMET model parameters

Parameter	Value
Modelled period	1 January 2014 to 31 December 2014
Mode	Hybrid (NOOBS = 1)
UTM zone	56
Domain origin (south-west corner)	Easting: 288.227 km Northing: 6165.914 km
Domain size	115 x 115 at 0.2 km resolution (23.0 km x 23.0 km)
Number of vertical levels	11
Vertical levels (m)	20, 40, 60, 90, 120, 180, 250, 500, 1000, 2000, 3000
CALMET settings for hybrid mode Settings selected in accordance with (OEH, 2011)	TERRAD = 10.0 km RMAX1 = 15.0 km RMAX2 = 15.0 km RMAX3 = 15 km RMIN = 0.1 km R1 = 10.0 km R2 = 10.0 km
Initial guess field	TAPM .m3d file used as an initial guess field for CALMET.
Surface data	Port Kembla E: 308.220 km N: 6183.373 km Albion Park E: 297.251 km N: 6173.109 km
Upper air data	No site specific upper air data is utilised. Upper air data is included within the TAPM .m3d initial guess field.
Land use and terrain data	Land use data was manually developed through assessment of aerial imagery to accurately reflect the land use in the area. High-resolution terrain data was sourced from the STRM 1-second (~30 m) database.

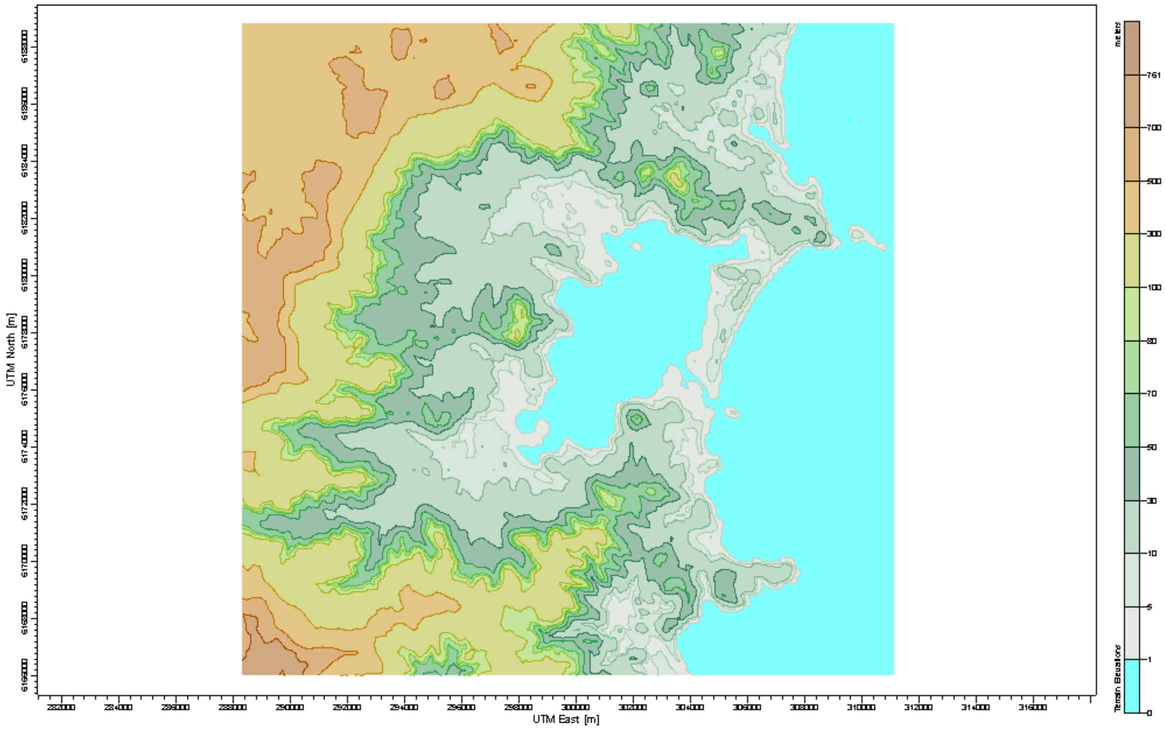


Figure 5-1 Terrain data used for CALMET modelling

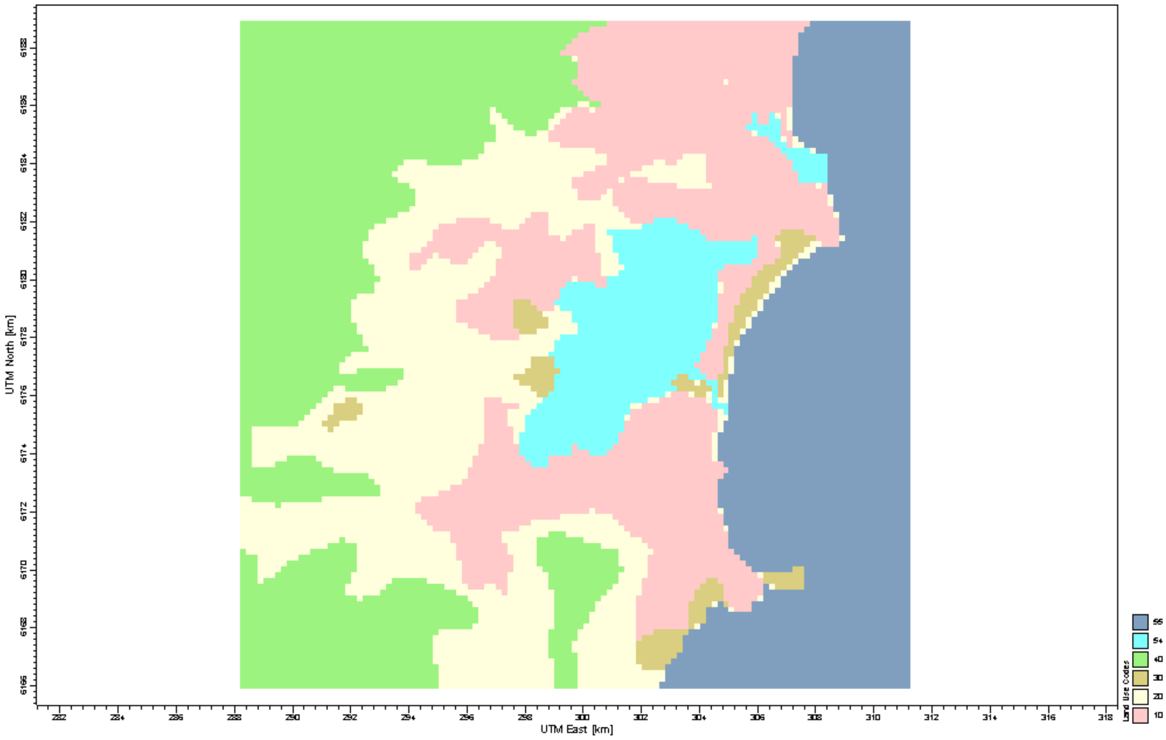


Figure 5-2 Land use data used for CALMET modelling

The local meteorology largely determines the pattern of off-site air quality impact on receptors (houses, businesses and industry). The effect of wind on dispersion patterns can be examined using the wind and stability class distributions at the site from the dataset that is produced by CALMET. The winds at the site are most readily displayed by means of wind rose plots, giving the distribution of winds and the wind speeds from these directions.

The features of particular interest in this assessment are: (i) the dominant wind directions and (ii) the relative incidence of stable light wind conditions that yield minimal mixing (defines peak impacts from ground-based sources).

5.4.1 Annual pattern in wind

The average wind rose for the entire data period taken at the project site is shown in Figure 5-3 and shows the following features:

- The predominant annual average wind directions are from the west and northeast
- The average wind speed measured was 3.94m per second
- Calms (winds speeds less than 0.5m per second) occurred 0.82 % of the time

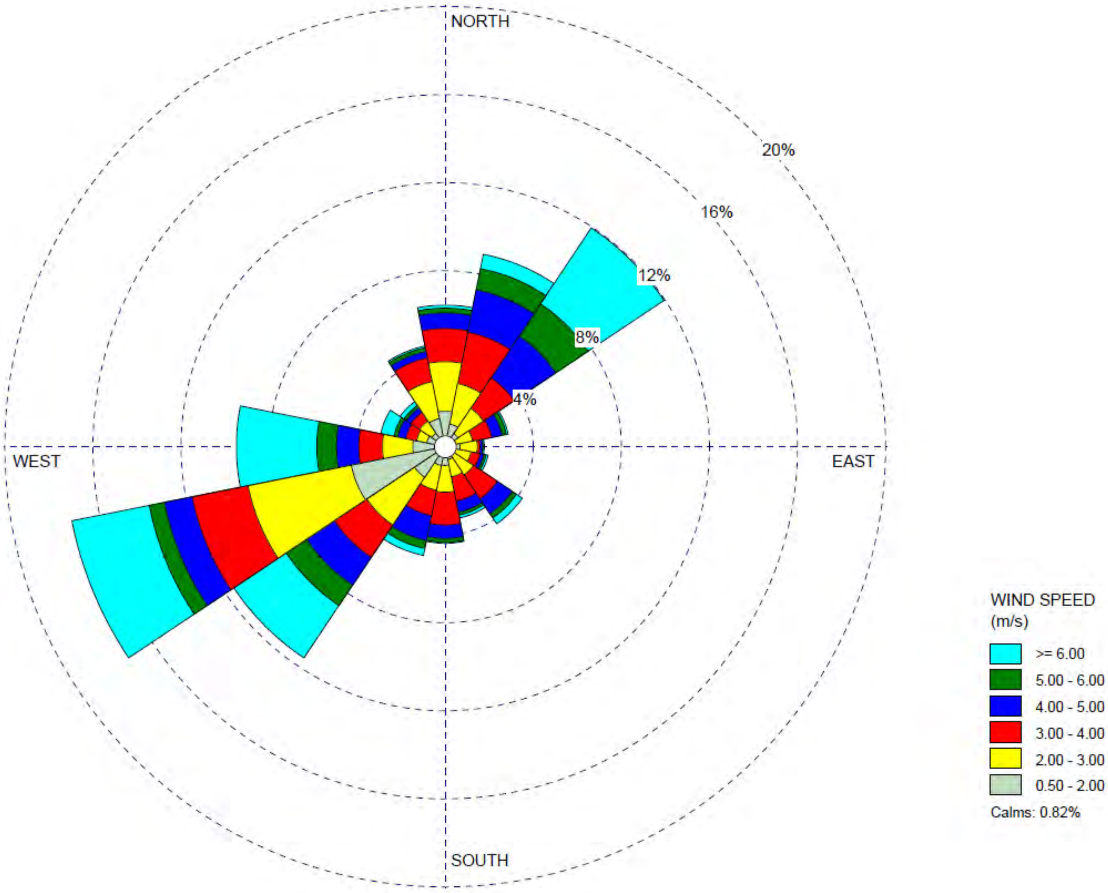


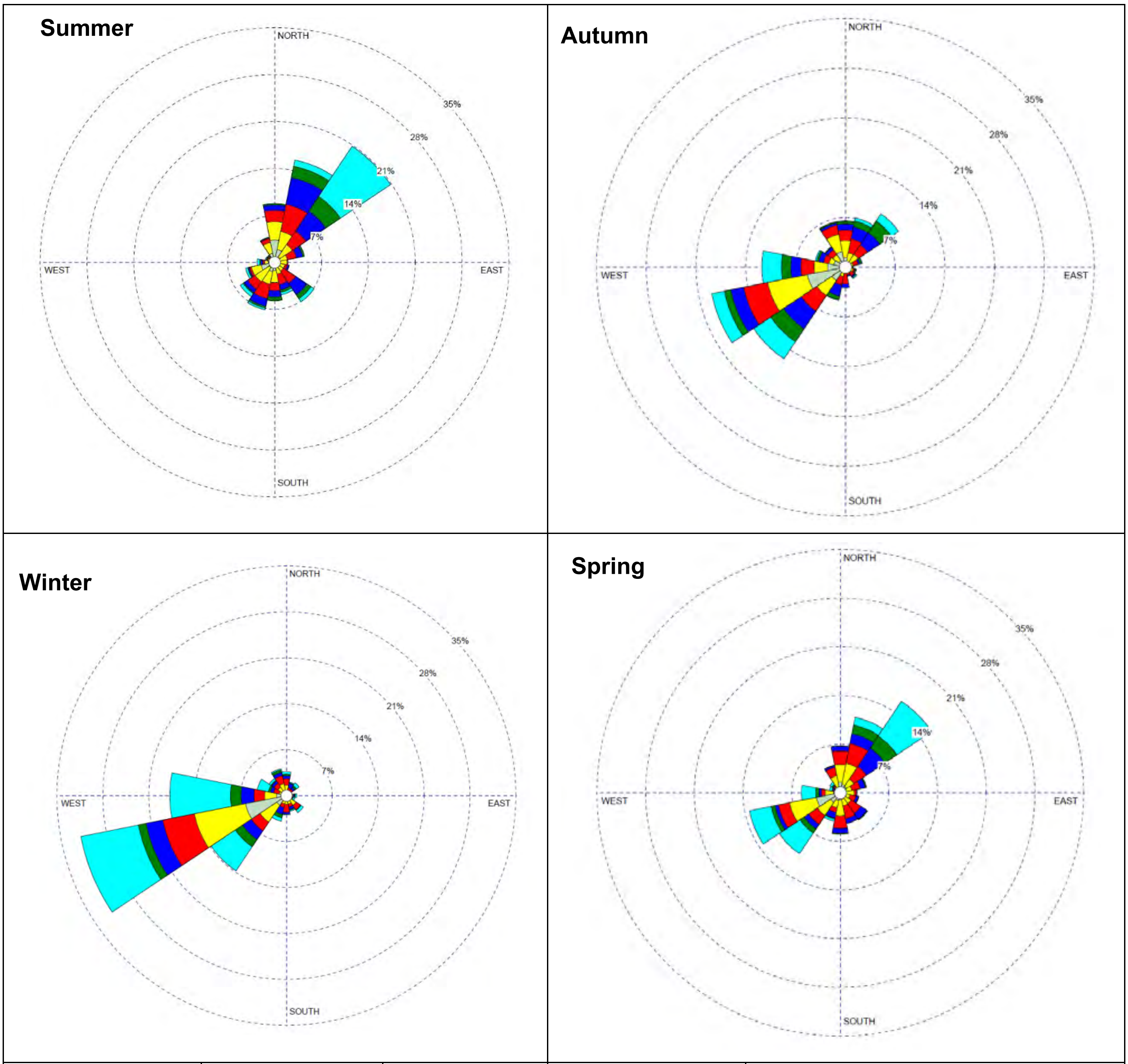
Figure 5-3 Wind rose for CALMET for 2014

5.4.2 Seasonal variation in wind pattern

The seasonal wind roses for 2014 are presented in Figure 5-4 and show that:

- During summer the predominant wind direction is from the northeast.
- During winter, westerly and south westerly winds are the most dominant.

- Autumn and spring are transitional periods. During these seasons both summer and winter patterns are observed. Autumn wind patterns are characteristically similar to winter, generally consisting of westerly winds. Spring displays a higher percentile of northeast winds.



Season	%Complete Record	Average WS (m/s)	Calms Frequency (%)
Summer	100%	3.62	1.34
Autumn	100%	3.58	0.68
Winter	100%	4.66	0.27
Spring	100%	3.91	1.01

WIND SPEED (m/s)

- >= 6.00
- 5.00 - 6.00
- 4.00 - 5.00
- 3.00 - 4.00
- 2.00 - 3.00
- 0.50 - 2.00

Figure 5-4 Seasonal wind roses for 2014

5.5 Pattern of atmospheric stability

Atmospheric stability substantially affects the capacity of a pollutant such as gas, particulate matter or odour to disperse into the surrounding atmosphere upon discharge and is a measure of the amount of turbulent energy in the atmosphere.

There are six Pasquill–Gifford classes (A-F) used to describe atmospheric stability, and these classes are grouped into three stability categories; stable (classes E-F), neutral (class D), and unstable (classes A-C). The climate parameters of wind speed, cloud cover and solar insolation are used to define the stability category as shown in Table 5-3, and as these parameters vary diurnally, there is a corresponding variation in the occurrence of each stability category.

Stability is most readily displayed by means of stability rose plots, giving the frequency of winds from different directions for various stability classes A to F.

Table 5-3 Stability category relationship to wind speed, and stability characteristics

Stability category	Wind speed range (m/s) [a]	Stability characteristics
A	0 – 2.8	Extremely unstable atmospheric conditions, occurring near the middle of day, with very light winds, no significant cloud
B	2.9 – 4.8	Moderately unstable atmospheric conditions occurring during mid-morning/mid-afternoon with light winds or very light winds with significant cloud
C	4.9 – 5.9	Slightly unstable atmospheric conditions occurring during early morning/late afternoon with moderate winds or lighter winds with significant cloud;
D	≥6	Neutral atmospheric conditions. Occur during the day or night with stronger winds. Or during periods of total cloud cover, or during the twilight period
E	3.4 – 5.4 [b]	Slightly stable atmospheric conditions occurring during the night-time with significant cloud and/or moderate winds
F	0 – 3.3 [b]	Moderately stable atmospheric conditions occurring during the night-time with no significant cloud and light winds

a Data sourced from the Turner's Key to the P-G stability Categories, assuming a Net Radiation Index of +4 for daytime conditions (between 10:00 am and 6:00 pm) and –2 for night-time conditions (between 6:00 pm and 10:00 am)

b Assumed to only occur at night, during Net Radiation Index categories of –2.

Figure 5-5 shows the frequency of stability class for all hours of the model generated dataset. The following observation were made:

- Stable atmosphere conditions (classes E and F) are the dominant stability state of the atmosphere occurring 40 % of the time.
- Neutral stability (class D) occurs 29 % of the time.
- Unstable atmospheres (classes A, B and C) occur about 31 % of the time.

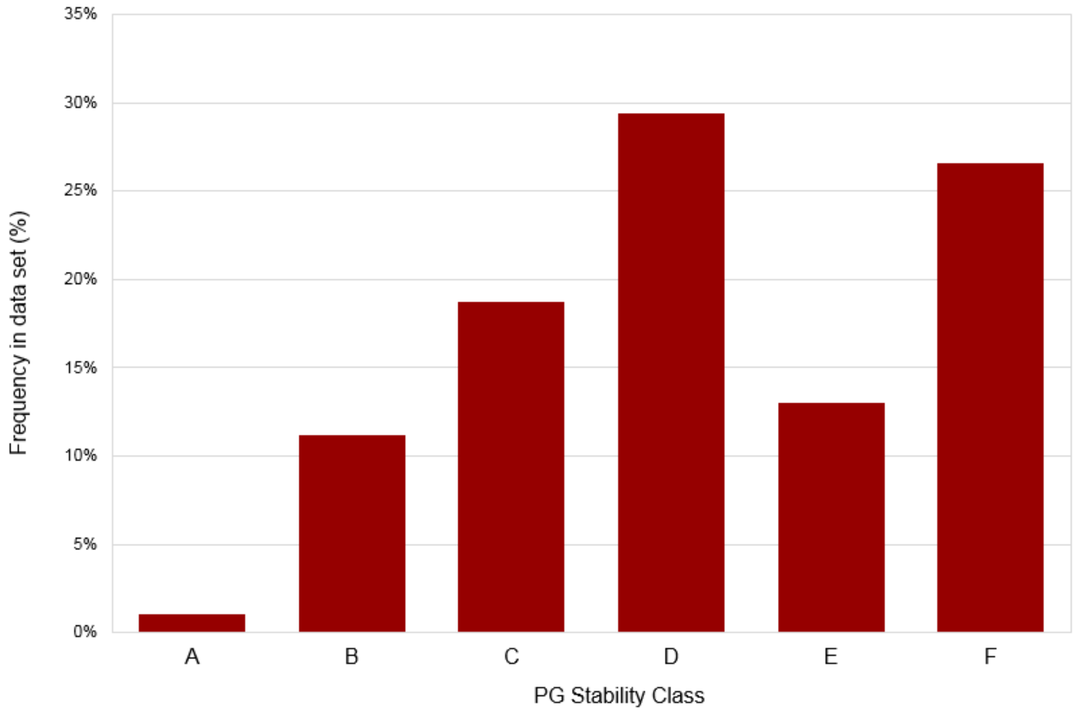


Figure 5-5 Distribution of stability class for the model period

6. Impact Assessment

This Section presents the predicted worst case air quality impacts for operation of the project with respect to the proposed modification.

6.1 Model settings

Atmospheric dispersion modelling was carried out using the CALPUFF version 6 dispersion model. CALPUFF is a non-steady-state, Lagrangian puff dispersion model. It is accepted for use by the Office of Environment and Heritage and NSW Environment Protection Authority for application in environments where wind patterns and plume dispersion is strongly influenced by complex terrain, the land-sea interface or where there is a high frequency of stable calm night-time conditions.

All model settings were selected based on the recommendations provided in the *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia (2011)*.

For this assessment, the CALPUFF dispersion model was used to predict ground-level concentrations of pollutants from the proposal. The grid size used in the CALPUFF model was equivalent to the CALMET domain. The same grid resolution of 200 metre used for the CALMET model run was used in CALPUFF.

Chemical transformations were not modelled within CALPUFF, however as discussed in more detail below, the formation of NO_2 from NO from combustion has been assessed using Method 2 in the Approved Methods (NSW EPA, 2016). Method 1 (Section 8.1.1) in the Approved Methods assumes 100 % of NO will be converted to NO_2. This is considered extremely conservative as in reality, only a fraction of NO will be converted to NO_2. Therefore, a more detailed assessment has been undertaken for all receptors using Method 2 (Section 8.2.2) of the Approved Methods. Method 2 is based on NO reacting with ozone in the atmosphere to form NO_2. Background ozone data was sourced from Kembla Grange for the year 2014.

6.2 Operational impacts

6.2.1 Scenarios

An LNG carrier entering Port Kembla to offload its LNG cargo will be present in the local environment for a limited time. In most instances the carrier will enter and leave the port within 2 – 3 days. It takes between 24 – 36 hours to offload and LNG carrier and it will seek to immediately travel to another location for further deliveries. At present, a LNG carrier is expected to arrive around once per week.

To conservatively assess the cumulative impact from the project, the FSRU and LNG carrier have been modelled together to account for worst case emissions. During both the tethering and the unloading processes, only two engines on board the LNG carrier will be operational.

The FSRU and LNG carrier can be operated using gas (LNG) or liquid fuel (MDO). AIE has advised that the FSRU and LNG carrier will likely consume gas as their primary energy source.

Seasonal demand scenarios have been developed to predicted variations in output throughout the year. The operational requirements of the predicted high and low seasonal variations are shown in Table 6-1.

Table 6-1 Proposed seasonal operational emissions sources

Operational emissions source	Low season (approx. 6 months)	High season (approx. 6 months)
FSRU emissions		
LNG Trains	1	2
LNG booster pumps	1	4
FSRU engines required	1	2
LNG carrier emissions		
LNG carrier	2	2

During the low season, one engine on board the FSRU would be required and during the high season, two engines would be required. The LNG carrier, while docked infrequently for short periods of time, would require two engines to be operational regardless of seasonal variation.

As more engines on board the FSRU are required to operate during the high season, emissions to air would be greater during the high season. Therefore, to account for worst case possible air borne emissions, operational scenarios during the high season have been conservatively modelled to occur over the entire year.

The following scenarios have been modelled (all scenarios assumed two engines are active on board the FSRU and two engines are active on board the LNG carrier):

- Scenario 1 – gas fuelled FSRU and liquid fuelled LNG carrier (possible operating scenario)
- Scenario 2 – liquid fuelled FSRU and liquid fuelled LNG carrier (possible operating scenario)
- Scenario 3 – gas fuelled FSRU and gas fuelled LNG carrier (likely operating scenario)

6.2.2 Calculation of cumulative impacts

The cumulative assessment prioritised the use of background monitoring data from Kembla Grange OEH monitoring site as it is closer to the project location and hence provides a more representative prediction of background concentrations. However, where data was unavailable from Kembla Grange (not all pollutants are monitored at Kembla Grange OEH station), background data from Wollongong OEH station was used.

Cumulative particulate matter (PM_{10} and $PM_{2.5}$) was calculated via a contemporaneous approach using background PM_{10} data from Kembla grange OEH station and background $PM_{2.5}$ data from Wollongong OEH station. Any recorded background PM_{10} or $PM_{2.5}$ concentration that exceeded the assessment criteria was disregarded as recommended in the Approve Methods (2016).

Incremental and cumulative NO_2 was calculated using Method 2 (described in Section 6.1) from the Approved Methods (NSW EPA, 2016). Background O_3 and NO_2 concentrations were taken from Kembla grange OEH station.

Cumulative CO and SO_2 concentrations were calculated using maximum background concentration recorded at Wollongong OEH station.

No background concentrations for Benzene, Formaldehyde or PAH are available from either OEH monitoring station. As the predicted incremental concentrations are significantly below the assessment criteria (refer Table 3-1 and results tables below), cumulative impacts for these pollutants are not expected.

6.2.3 Scenario 1 – gas fuelled FSRU and liquid fuelled LNG carrier

Scenario 1 is composed of a gas fuelled FSRU (two engines are active) and a liquid fuelled LNG carrier (two engines are active). The predicted incremental and cumulative pollutant concentration for Scenario 1 are presented on Table 6-2 and Table 6-3 respectively.

No incremental or cumulative criteria exceedances are predicted at the sensitive receptor locations.

Benzene, formaldehyde and PAH concentrations are presented as 99.9th percentiles, which is consistent with their assessment criteria. All other pollutants are presented as the maximum 100th percentiles predicted concentrations.

Table 6-2 Scenario 1 predicted incremental pollutant concentrations (µg/m³)

Receptor	Predicted incremental pollutant concentrations (µg/m³)									
	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	Formaldehyde	PAH
	24 hour	Annual	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour
Criteria	50	25	25	8	246	30000	570	29	20	0.4
R01	1.3	0.08	0.60	0.04	81	123	36	0.3	3	0.00002
R02	1.7	0.09	0.83	0.04	102	226	59	0.4	4	0.00004
R03	1.1	0.10	0.50	0.05	97	98	29	0.3	3	0.00002
R04	2.1	0.14	0.98	0.07	125	192	50	0.3	4	0.00004
R05	1.3	0.10	0.62	0.05	98	216	57	0.3	3	0.00004
R06	1.0	0.06	0.50	0.03	77	167	44	0.2	3	0.00002
R07	0.9	0.17	0.43	0.08	71	80	23	0.2	3	0.00002
R08	1.0	0.17	0.50	0.08	82	141	44	0.2	3	0.00003
R09	0.9	0.07	0.46	0.03	134	176	57	0.3	4	0.00004
R10	1.4	0.15	0.65	0.07	84	139	40	0.3	4	0.00003
R11	1.5	0.12	0.72	0.06	98	195	58	0.4	4	0.00004

Table 6-3 Scenario 1 predicted cumulative pollutant concentrations (µg/m³)

Receptor	Predicted cumulative pollutant concentrations (µg/m³)									
	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	Formaldehyde	PAH
	24 hour	Annual	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour
Criteria	50	25	25	8	246	30000	570	29	20	0.4
R01	43.6	16.9	17.3	6.5	85	1848	86	0.3	3.00	0.00002
R02	43.6	16.9	17.3	6.5	105	1951	109	0.4	4.00	0.00004
R03	43.6	16.9	17.4	6.5	101	1823	79	0.3	3.00	0.00002
R04	43.6	16.9	17.5	6.5	129	1917	100	0.3	4.00	0.00004
R05	43.6	16.9	17.3	6.5	102	1941	107	0.3	3.00	0.00004
R06	43.6	16.8	17.4	6.5	82	1892	94	0.2	3.00	0.00002

Receptor	Predicted cumulative pollutant concentrations (µg/m^3)									
	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	Formaldehyde	PAH
	24 hour	Annual	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour
R07	43.8	17.0	17.4	6.5	86	1805	73	0.2	3.00	0.00002
R08	43.9	16.9	17.6	6.5	105	1866	94	0.2	3.00	0.00003
R09	43.7	16.9	17.8	6.5	153	1901	107	0.3	4.00	0.00004
R10	44.2	16.9	17.6	6.5	102	1864	90	0.3	4.00	0.00003
R11	43.7	16.9	17.3	6.5	103	1920	108	0.4	4.00	0.00004

6.2.1 Scenario 2 – liquid fuelled FSRU and liquid fuelled LNG carrier

Scenario 2 is composed of a liquid fuelled FSRU (two engines are active) and a liquid fuelled LNG carrier (two engines are active). The predicted incremental and cumulative pollutant concentration for Scenario 2 are presented on Table 6-4 and Table 6-5 respectively.

No incremental or cumulative criteria exceedances are predicted at the sensitive receptor locations.

Benzene, formaldehyde and PAH concentrations are presented as 99.9th percentiles, which is consistent with their assessment criteria. All other pollutants are presented as the maximum 100th percentiles predicted concentrations.

Table 6-4 Scenario 2 predicted incremental pollutant concentrations (µg/m^3)

Receptor	Predicted incremental pollutant concentrations (µg/m^3)									
	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	Formaldehyde	PAH
	24 hour	Annual	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour
Criteria	50	25	25	8	246	30000	570	29	20	0.4
R01	2.0	0.1	1.2	0.07	89	192	66	0.5	0.05	0.00001
R02	3.0	0.2	1.5	0.08	123	400	125	0.7	0.07	0.00001
R03	2.0	0.2	1.0	0.09	113	172	59	0.5	0.05	0.00001
R04	4.0	0.2	2.0	0.13	136	296	88	0.5	0.05	0.00001
R05	2.0	0.2	1.1	0.09	105	341	107	0.6	0.06	0.00001
R06	1.0	0.1	0.7	0.06	89	197	59	0.4	0.04	0.00001
R07	2.0	0.3	0.9	0.16	90	135	46	0.4	0.04	0.00001
R08	2.0	0.3	1.0	0.16	125	218	75	0.4	0.04	0.00001
R09	2.0	0.1	1.0	0.07	142	346	119	0.5	0.05	0.00001
R10	2.0	0.3	1.3	0.14	99	236	82	0.6	0.06	0.00001
R11	3.0	0.2	1.4	0.11	109	341	117	0.7	0.07	0.00001

Table 6-5 Scenario 2 predicted cumulative pollutant concentrations (µg/m^3)

Receptor	Predicted cumulative pollutant concentrations (µg/m^3)									
	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	Formaldehyde	PAH
	24 hour	Annual	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour
Criteria	50	25	25	8	246	30000	570	29	20	0.4
R01	43.6	16.9	17.4	6.5	91	1917	116	0.5	0.05	0.00001
R02	43.6	16.9	17.3	6.5	127	2125	175	0.7	0.07	0.00001
R03	43.6	16.9	17.4	6.5	117	1897	109	0.5	0.05	0.00001
R04	43.6	17.0	18.1	6.6	140	2021	138	0.5	0.05	0.00001
R05	43.6	16.9	17.3	6.5	109	2066	157	0.6	0.06	0.00001
R06	43.6	16.9	17.4	6.5	103	1922	109	0.4	0.04	0.00001
R07	43.9	17.1	17.4	6.6	103	1860	96	0.4	0.04	0.00001
R08	44.1	17.1	18.0	6.6	154	1943	125	0.4	0.04	0.00001
R09	43.7	16.9	17.9	6.5	161	2071	169	0.5	0.05	0.00001
R10	44.7	17.0	18.0	6.6	116	1961	132	0.6	0.06	0.00001
R11	43.7	17.0	17.4	6.6	112	2066	167	0.7	0.07	0.00001

6.2.2 Scenario 3 – gas fuelled FSRU and gas fuelled LNG carrier

Scenario 3 is composed of a gas fuelled FSRU (two engines are active) and a gas fuelled LNG carrier (two engines are active). The predicted incremental and cumulative pollutant concentration for Scenario 3 are presented on Table 6-6 and Table 6-7 respectively.

No incremental or cumulative criteria exceedances are predicted at the sensitive receptor locations.

Benzene, formaldehyde and PAH concentrations are presented as 99.9th percentiles, which is consistent with their assessment criteria. All other pollutants are presented as the maximum 100th percentiles predicted concentrations.

Table 6-6 Scenario 3 predicted incremental pollutant concentrations (µg/m^3)

Receptor	Predicted incremental pollutant concentrations (µg/m^3)							
	PM_{10}		NO_2	CO	SO_2	Benzene	Formaldehyde	PAH
	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour
Criteria	50	25	246	30000	570	29	20	0.4
R01	0.4	0.02	45	38	0.04	0.05	6	0.00002
R02	0.4	0.02	57	74	0.08	0.06	8	0.00002
R03	0.3	0.03	40	39	0.04	0.05	5	0.00002
R04	0.7	0.04	70	65	0.07	0.06	7	0.00002
R05	0.3	0.03	48	65	0.07	0.05	7	0.00002
R06	0.2	0.02	31	42	0.04	0.04	5	0.00002
R07	0.3	0.05	30	28	0.03	0.04	5	0.00001
R08	0.3	0.05	52	56	0.07	0.04	5	0.00002
R09	0.4	0.02	61	98	0.12	0.05	6	0.00002
R10	0.4	0.04	46	47	0.05	0.06	7	0.00002
R11	0.5	0.03	37	88	0.10	0.07	8	0.00003

Table 6-7 Scenario 3 predicted cumulative pollutant concentrations (µg/m^3)

Receptor	Predicted cumulative pollutant concentrations (µg/m^3)							
	PM_{10}		NO_2	CO	SO_2	Benzene	Formaldehyde	PAH
	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour
Criteria	50	25	246	30000	570	29	20	0.4
R01	43.6	16.8	58	1763	50	0.1	6.00	0.00002
R02	43.6	16.8	59	1799	50	0.1	8.00	0.00002
R03	43.6	16.8	58	1764	50	0.1	5.00	0.00002
R04	43.6	16.8	70	1790	50	0.1	7.00	0.00002
R05	43.6	16.8	58	1790	50	0.1	7.00	0.00002
R06	43.6	16.8	58	1767	50	0.0	5.00	0.00002
R07	43.6	16.8	63	1753	50	0.0	5.00	0.00001
R08	43.7	16.8	63	1781	50	0.0	5.00	0.00002
R09	43.6	16.8	80	1823	50	0.1	6.00	0.00002
R10	43.8	16.8	58	1772	50	0.1	7.00	0.00002
R11	43.6	16.8	58	1813	50	0.1	8.00	0.00003

Contour plots of each assessed pollutant for the most likely operational scenario (Scenario 3) are presented in Figure 6-1 to Figure 6-7.

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

Predicted 24 hour incremental PM10 concentrations (Scenario 3, 100th percentile, µg/m3)

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Figure 6-1

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 14:52 (SMA record: 2) (SMA record: 40)

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Australian Industrial Energy
Port Kembla Gas Terminal

Predicted 1 hour incremental NOX concentrations (Scenario 3, 100th percentile, µg/m3)

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Figure 6-2

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 14:52 (SMA record: 2) (SMA record: 42)

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: sross2

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

Predicted 1 hour incremental CO concentrations (Scenario 3, 100th percentile, μg/m3)

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Figure 6-3

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 14:52 (SMA record: 2) (SMA record: 43)

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: sross2

Australian Industrial Energy
Port Kembla Gas Terminal

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Predicted 1 hour incremental SO2 concentrations (Scenario 3, 100th percentile, µg/m3)

Figure 6-4

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 14:52 (SMA record: 2) (SMA record: 44)

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: sross2

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Predicted 1 hour incremental Benzene concentrations (Scenario 3, 99.9th percentile, µg/m3)

Figure 6-5

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 14:52 (SMA record: 2) (SMA record: 45)

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: sross2

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Predicted 1 hour incremental Formaldehyde concentrations (Scenario 3, 99.9th percentile, µg/m3)

Figure 6-6

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 14:53 (SMA record: 2) (SMA record: 46)

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

Project No. 21-27477
Revision No. A
Date 27 Nov 2019

Predicted 1 hour incremental PAH concentrations
(Scenario 3, 99.9th percentile, µg/m3)

Figure 6-7

G:\21\27477\GIS\Maps\Deliverables\EIS\21_27477_EIS_Z010_NoiseSMA.mxd
Print date: 27 Nov 2019 - 14:53 (SMA record: 2) (SMA record: 47)

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: sross2

7. Mitigation

Operational air quality impacts are not anticipated and no specific mitigation is provided. It is recommended that the project remains compliant with IMO legislation and domestic air quality guidelines to ensure future operations comply with air quality standards.

AIE and FSRU provider Hoegh LNG are committed to achieving sustainable operations. Given the pace of technological change, it is possible that technology may become available which could reduce NOx emissions when the FSRU is running on MDO mode to a level below the Protection of the Environment Operations (Clean Air) Regulation 2010 limit.

This would significantly reduce NOx emission from the FSRU below POEO limits and reduce NOx concentrations at the sensitive receptors.

AIE will continue to monitor the potential to reduce NOx emissions when operating in MDO mode and if achieved would seek to remove the 72 hour per annum operating restriction from the Infrastructure approval.

8. Conclusion

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

Further analysis of market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. This seasonal variation was not considered in the EIS

AIE is therefore seeking a modification of the Minister's approval for the Port Kembla Gas Terminal under section 5.25 of the Environmental Planning and Assessment Act 1979. The modification will seek authorisation to increase capacity of the project and allow for seasonality.

GHD has undertaken an air quality assessment to assess potential air quality impacts resultant from the proposed modification to the project. The air quality assessment considered three potential operating scenarios which were based on worst case seasonal variations. There were no predicted exceedances of the impact assessment criteria at any sensitive receptor location.

Based on assumptions as outlined in the assessment, the project would comply with the relevant air quality assessment criteria when assessed in accordance with the Approved Methods (2016).

9. References

National Pollutant Inventory, Emission estimation technique manual for Combustion engines Version 3 (2008), Australian government, Department of Environment, Water, Heritage and the Arts.

National Pollutant Inventory, Emission estimation technique manual for Maritime operations Version 2.1 (2012), Australian government, Department of Sustainability, Environment, Water, Population and Communities.

NSW EPA. (2016). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. *NSW Government Gazette of 26 August 2005, minor revisions Novemeber 2016*. Sydney, NSW: Department of Environment and Conservation NSW (DEC).

Barclay, J & Scire, J, 2011, *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'*, prepared for NSW Office of Environment and Heritage, Sydney, March 2011

Appendix A – Exhaust gas emission data

EXHAUST GAS EMISSION DATA

Gas operation with LFO as pilot fuel

Constant speed: 500 rpm and 514 rpm

Emissions *(Note 1)*	Unit	Load [%]				
		100	90	75	50	30
Concentration at 15% O2						
NOx	vol-ppm, dry	90	90	90	90	90
CO	vol-ppm, dry	113	120	127	314	721
THC (as CH4)	vol-ppm, dry	779	759	746	1213	2888
NMHC (as CH4) *(Note 2)*	vol-ppm, dry	108	105	103	-	-
Formaldehyde	vol-ppm, dry	27	27	26	42	101
Particles *(Note 3)*	mg/Nm3, dry	10	10	10	15	19
Typical measured O2 concentration	vol-%, dry	11,8	11,7	11,5	11,9	12,6
Specific emissions						
NOx (as NO2) *(Note 4)*	g/kWh	1,2	1,2	1,2	1,3	1,5
CO	g/kWh	0,9	1,0	1,1	2,8	7,3
THC (as CH4)	g/kWh	3,6	3,5	3,6	6,3	16,8
NMHC (as CH4) *(Note 2)*	g/kWh	0,49	0,48	0,49	-	-
Formaldehyde	g/kWh	0,23	0,23	0,23	0,41	1,10
Particles *(Note 3)*	g/kWh	0,064	0,065	0,067	0,11	0,16
SO2 *(Note 5)*	g/kWh	-	-	-	-	-
Typical CO2 *(Note 6)*	g/kWh	430	-	-	-	-
Mass concentration at 5% O2 *(Note 7)*						
NOx (as NO2)	mg/Nm3, dry	500	500	500	500	500
CO	mg/Nm3, dry	380	407	428	1061	2437
THC (as CH4)	mg/Nm3, dry	1508	1468	1444	2348	5589
NMHC (as CH4) *(Note 2)*	mg/Nm3, dry	203	203	200	-	-
Formaldehyde	mg/Nm3, dry	98	98	94	152	366
Particles *(Note 3)*	mg/Nm3, dry	27	27	27	41	52

FPP curve for 500 and 514 rpm

		Load [%]				
Specific emissions		100	90	75	50	30
NOx (as NO2) (Note 4)	g/kWh	1,1	1,1	1,0	5,0	6,0
CO	g/kWh	0,9	1,0	1,1	2,8	7,3
THC (as CH4)	g/kWh	3,6	3,5	3,6	4,0	4,5
NMHC (as CH4) (Note 2)	g/kWh	0,49	0,48	0,49	-	-
Formaldehyde	g/kWh	0,23	0,23	0,23	0,41	1,10
Particles (Note 3)	g/kWh	0,064	0,065	0,067	0,11	0,16
SO2 (Note 5)	g/kWh	-	-	-	-	-
Typical CO2 (Note 6)	g/kWh	430	-	-	-	-

Tolerances:

LOAD %	100-75	50	30
NOx	+/- 0%	+/- 25%	+/- 50%
CO	+/- 15%	+/- 25%	+/- 50%
THC	+/- 15%	+/- 25%	+/- 50%
NMHC	+/- 32%	+/- 32%	+/- 60%
formaldehyde	+/- 20%	+/- 30%	+/- 60%
particles	+0% or less then the tabled values		

Note 1 At ISO 3046 - 1:1995(E) standard reference conditions. Except for LT-water temperature, which is 35 °C for the Wärtsilä 50DF engine in gas operation.

Note 2 NMHC (non-methane hydrocarbon) emissions are highly dependent on used gas composition and are calculated case by case if needed. The values are valid for the following gas composition: methane: 93 vol-%, ethane: 5 vol-%, propane: 1.5 vol-%, butane: 0.5 vol-%

Note 3 Particles measured as "dry dust" according to ISO 9096-03 or alternatively EPA method 17 measurement standards under steady state conditions.

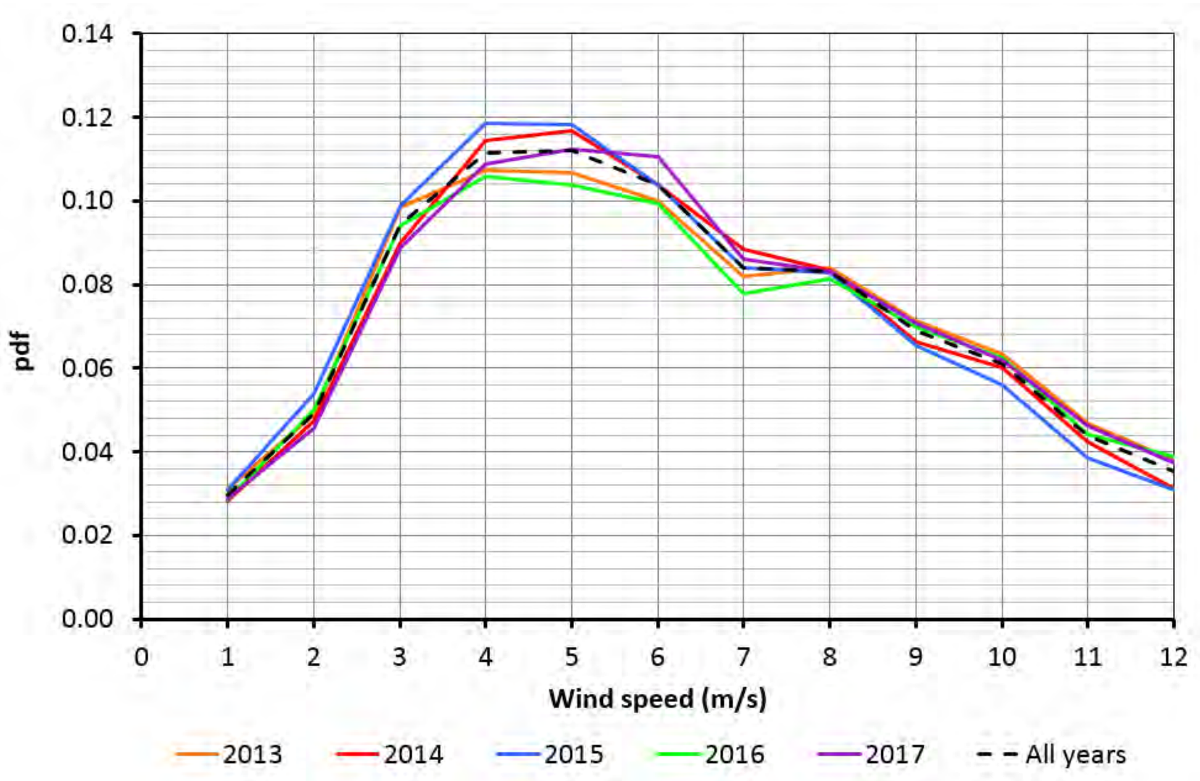
Note 4 Recommended guarantee value for marine engines is 3 g/kWh weighted Nox

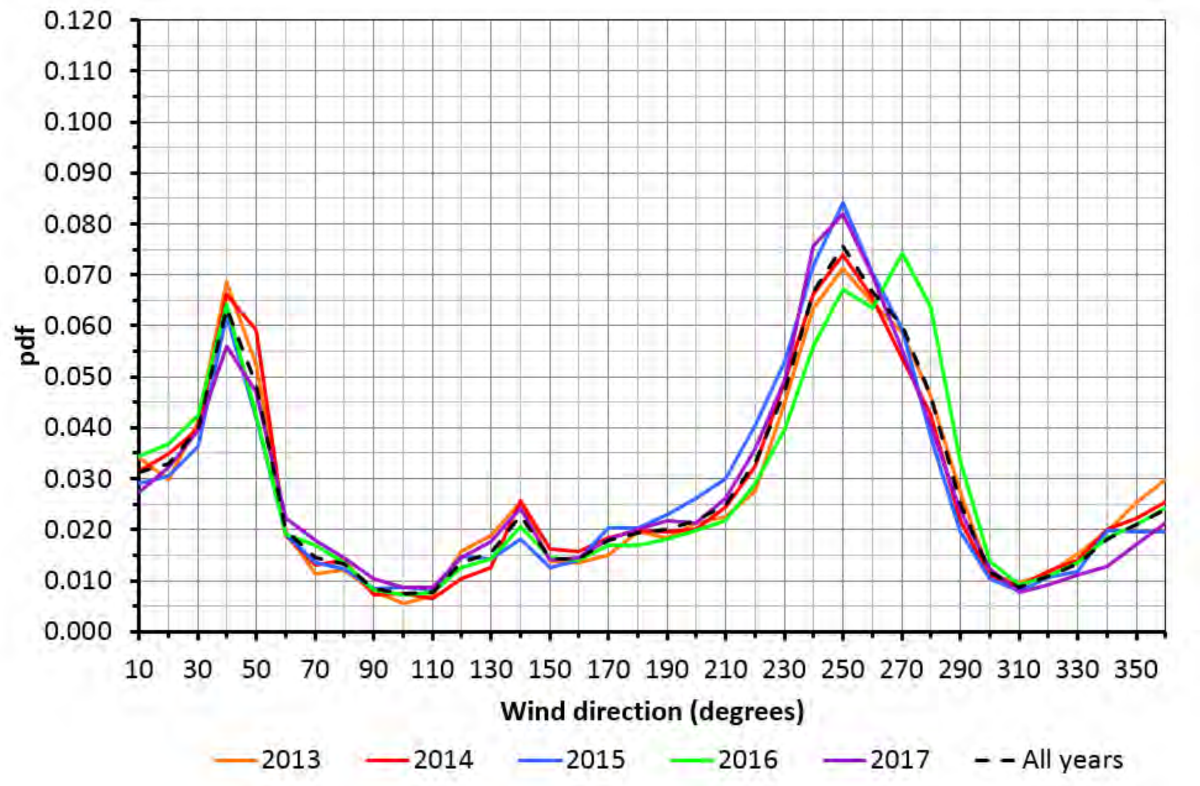
Note 5 SO2 emissions depend on the sulphur content of the fuel gas, pilot fuel and lube oil and can be calculated as follows:
SO2 [g/kWh] = ((fuel consumption [kJ/kWh])/(LHV,real [MJ/kg])(fuel sulphur content [w-%])+(1.2g/kWh)*(pilot fuel sulphur content [w-%])+(0.3g/kWh)*(lube oil sulphur content [w-%]))/100*64/32*

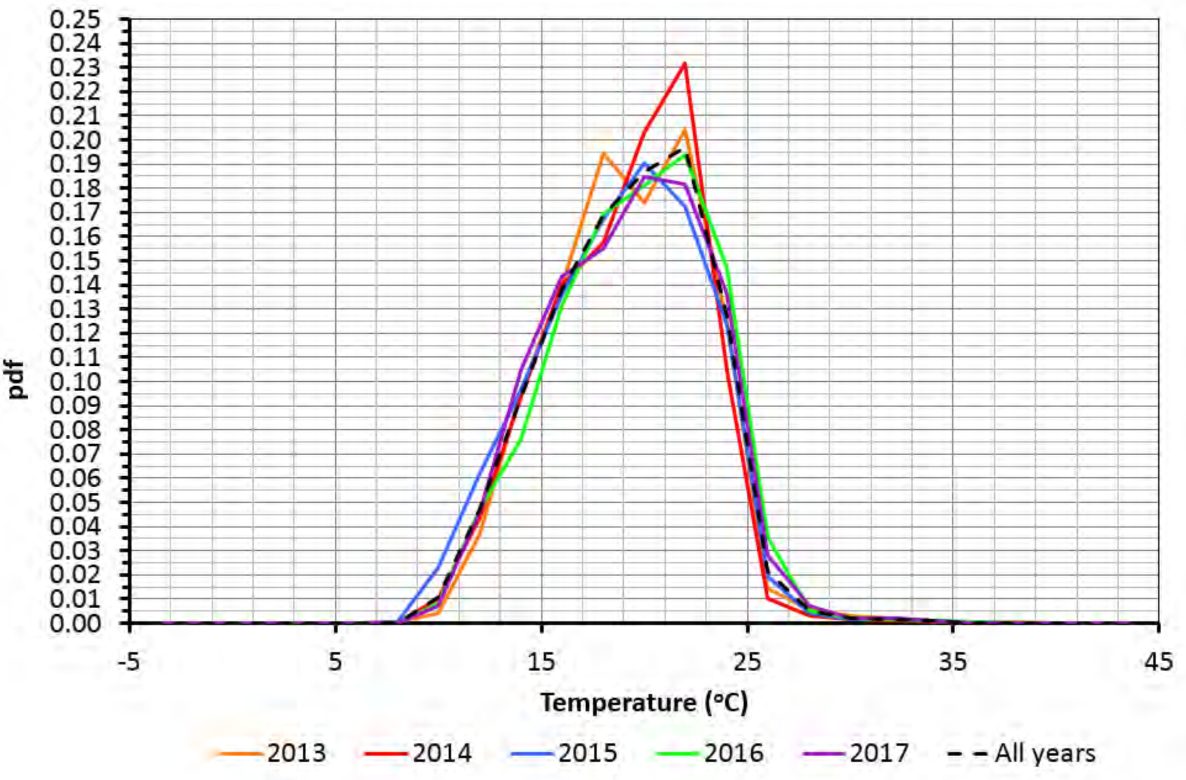
Note 6 CO2 emissions depend on engine efficiency and fuel carbon content and can be calculated as follows:
CO2 [g/kWh] = (fuel consumption [kJ/kWh])/(LHV,real [MJ/kg])(fuel carbon content [w-%])/100*44/12*

Note 7 Values given in Nm3 is at 0 °C and 101.3 kPa.

Appendix B - Selection of representative year






0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
pdf
-5
5
15
25
35
45
Temperature (°C)
2013
2014
2015
2016
2017
All years

GHD

Level 15
133 Castlereagh Street
T: 61 2 9239 7100   F: 61 2 9239 7199   E: sydmail@ghd.com

2127477-77701/https://projects.ghd.com/oc/Sydney1/eastcoastlngterminal/Delivery/Documents/2127477-REP_Modification-Air quality assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	N Spurrett	E Smith	On file	K Rosen	On file	25/11/2019

www.ghd.com

https://projects.ghd.com/oc/Sydney1/eastcoastlngterminal/Delivery/Documents/Modification/03 Modification report/2127477 Modification report.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	M Goodall	K Rosen	On file	K Rosen	On file	3/9/19
B	M Goodall	K Rosen	On file	K Rosen	On file	12/9/19
C	M Goodall	K Rosen	On file	K Rosen	On file	25/10/19

www.ghd.com