SMITH BAY WHARF

DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX N

PREPARED FOR KANGAROO ISLAND PLANTATION TIMBERS BY ENVIRONMENTAL PROJECTS

JANUARY 2019

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APPENDIX **N**

APPENDIX N – NOISE AND VIBRATION

Appendix N – Environmental Noise Impact Assessment – Resonate Consultants

Resonate

Kangaroo Island Plantation Timbers EIS

Environmental Noise Impact Assessment

A17557RP1 Revision B

Monday, 17 December 18

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Document Information

Project	Kangaroo Island Plantation Timbers EIS
Client	Environmental Projects Pty Ltd
Report title	Environmental Noise Impact Assessment
Project Number	A17557
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Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Ambient sound	Background environmental noise not of direct interest during a measurement or observation
Continuous noise level	A-weighted noise level of a continuous steady sound that, for the period over which the measurement is taken using fast time weighting, has the same mean square sound pressure as the noise level which varies over time when measured in relation to a noise source and noise-affected premises in accordance with the Noise EPP
Day	Between 7 am and 10 pm as defined in the Noise EPP
dB	Decibel—a unit of measurement used to express sound level. Decibels express the ratio of sound relative to a reference level on a logarithmic scale. For airborne noise the reference level is 20 µPa, while for underwater noise the reference level is typically 1 µPa.
dB(A)	Units of the A-weighted sound level.
dB_{peak}	Peak sound pressure over the measurement period, expressed in dB re 1 µPa.
dB_{rms}	Root mean square sound pressure over the measurement period, expressed in dB re 1 µPa.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second.
L_{90}	Noise level exceeded for 90 % of the measurement time. The L_{90} level is commonly referred to as the background noise level.
L_{95}	Noise level exceeded for 95 % of the measurement time.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
L_{Max}	The maximum instantaneous noise level.
M-weighting	Frequency weightings designed to best reflect the hearing sensitivity of marine mammals, similar to the use of the A-weighting for measuring noise impacts on humans. Noise levels for Low frequency cetaceans are expressed in decibels using the Low Frequency M-weighting function, annotated as $dB(M_{lf})$
Night	Between 10.00 p.m. on one day and 7.00 a.m. on the following day as defined in the Noise EPP
Noise source	Premises or a place at which an activity is undertaken, or a machine or device is operated, resulting in the emission of noise
PTS	Permanent Threshold Shift. Irreversible and permanent reduction in auditory sensitivity.
SEL	Sound Exposure Level. Sound energy over the measurement period expressed in dB re 1 $µPa^2s$. SEL is commonly used for impulsive underwater noise sources such as impact pile driving because it allows a comparison of the energy contained in impulsive signals of different duration and peak levels. The measurement period for impulsive signals is usually defined as the time period containing 90% of the sound energy.
SEL_C	Cumulative Sound Exposure Level. Total sound energy over an exposure period.
SL	Source Level. The intensity of underwater noise sources is compared by their source level, expressed in dB re 1 µPa for SPLs and dB re 1 $µPa^2s$ for SELs. The source level is defined as the sound pressure (or energy) level that would be measured at 1 meter from an ideal point source radiating the same amount of sound as the actual source being measured.
SPL	Sound Pressure Level. The sound pressure averaged over the measurement period, expressed in dB re 1 µPa for underwater sound. Continuous noise sources such as vibro-piling and dredging are commonly characterized in terms of an SPL.

TTS	Temporary Threshold Shift. Short-term reversible reduction in auditory sensitivity. TTS will be gradually reversed upon removing exposure to the high noise levels that cause the change in hearing sensitivity.

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Executive Summary

Kangaroo Island Plantation Timbers Ltd (KIPT) propose to construct and operate a deep-water port at Smith Bay, Kangaroo Island, which would be capable of exporting both log and woodchip product harvested on the island.

Resonate have been engaged by KIPT to provide an Environmental Noise Impact Assessment in relation to the proposal, including assessment of terrestrial (airborne) and underwater noise associated with both construction and operation of the port.

Terrestrial Noise Assessment

Terrestrial noise impacts have been assessed in accordance with the Kangaroo Island Council Development Plan and Environmental Protection (Noise) Policy 2007 (the Noise EPP), at all noise affected premises. The assessment considers baseline noise levels measured at and around the site in December 2017.

Operational noise emissions have been modelled based on a ‘daytime’ operating scenario with all equipment and vehicles operating simultaneously, and a ‘night time’ scenario without trucks entering or exiting the site. The modelling takes into account attenuation of noise due to distance; barrier effects from buildings, topography and the like; air absorption; ground effects; and worst-case meteorological conditions.

Without mitigation, noise emissions are expected to comply with the applicable daytime and night time criteria, with the exception of a 2 dB exceedance of the night time criterion at one location.

In order to mitigate noise emissions, KIPT may consider construction of a 3m high noise barrier to the south of the re-chipper and chip stacking plant, and a restricted operating area for log handlers during night time hours. With the implementation of this mitigation option, noise emissions are predicted to comply with daytime and night time criteria at all noise sensitive receiver locations.

Airborne noise levels associated with construction of the port are expected to be similar to operational noise levels. Provided the majority of construction work is carried out during standard construction hours, and reasonable and practicable steps are taken to minimise noise, compliance with Division 1 of the Noise EPP can be readily achieved.

KIPT may consider preparing and implementing a Construction Noise and Vibration Management Plan prior to the commencement of any construction works.

Underwater noise assessment

A risk assessment of the environmental impacts has been conducted based on the existing conditions (e.g. ambient noise environment, local bathymetry, wave and wind climate), the marine species of significance present in the study area, the significance of the area as a habitat for marine species, the sensitivity to sound of marine species, the characteristics of the identified noise sources in terms of duration, source level and frequency content, and the sound propagation characteristics of the marine study area. Significant underwater noise sources associated with construction and operation of the port are dredging, piling and marine vessels.

The potential impacts that have been considered in the risk assessment are, in increasing order of severity, behavioural change, temporary threshold shift in hearing, permanent threshold shift in hearing, and organ damage (possibly leading to death). To assess the impacts of the construction and operational sources, noise criteria have been established for each of the considered impact levels.

The adopted underwater noise criteria are based on NOAA Marine Mammal Acoustic Technical Guidance (2018), and the Sound Exposure Guidelines for Fishes and Sea Turtles (Popper et al., 2014). These represent the most up to date research and approach for the species considered in this assessment, and are generally more stringent than the DPTI Underwater Piling Noise Guidelines (2012).

Without mitigation, the overall risk of adverse noise effects on the relevant marine species is Low, with the exception of a Medium level of risk associated with impact piling potentially resulting in PTS in Southern Right Whales.

To minimise the environmental impacts of underwater noise, the following mitigation and management strategies could be adopted as part of a reasonable and practicable approach:

- Use of alternative piling methods
- Implementing a soft start procedure at the commencement of piling
- Control of construction programme to avoid noise exposure, including scheduling piling to occur outside of the months when migrating cetaceans may be present in the area
- Establishment of shut-down zones, with trained marine mammal observers used to monitor the presence of relevant species.

With the appropriate combination of mitigation strategies in place, the impacts from underwater noise associated with construction and operation are likely to be minimal.

1 Introduction

This report outlines the results of the environmental noise assessment for the proposed Kangaroo Island Plantation Timbers (KIPT) Wharf Project (the Project). The nearest terrestrial noise sensitive receivers are located approximately 500 m south southwest of the Project and approximately 700 m to the south east of the Project.

The potential airborne and underwater noise emissions from both construction and operation the project have been assessed against the requirements of the following:

- *Development Assessment Commission (DAC) Guidelines for the preparation of an Environmental Impact Statement (EIS) – Deep water port facility at Smith Bay, Kangaroo Island (June 2017);*
- *South Australian Environment Protection (Noise) Policy 2007; and*
- *The Kangaroo Island Council Development Plan.*

2 Project Description

A brief overview of the Project is given below. A detailed description of the Project is provided in the report *Kangaroo Island Plantation Timbers Ltd: Proposed Smith Bay Wharf – Project Description (Rev F).*

2.1 Project overview

Kangaroo Island Plantation Timbers Ltd (KIPT) owns approximately 25,700 ha of land on Kangaroo Island, comprising 46 properties and 56 titles. Approximately 14,400 ha is plantation timber, of which 12,000 ha is planted with the hardwood Tasmanian blue gum *(Eucalyptus globulus),* 1,840 ha is the softwood Monterey, or radiata, pine *(Pinus radiata)*, and 400 ha is the hardwood Shining gum *(Eucalyptus nitens).* A further 190 ha of plantation land is leased to a third party and operated independently. The remaining (unplanted) areas consist of native vegetation, firebreaks and plantation access roads.

KIPT's standing timber assets on the Island currently exceed 3.6 million tonnes and are expected to grow to at least 5.4 million tonnes by the time of harvest. The KIPT resource is sufficient to establish a sustainable plantation forestry industry on the Island based on the export of timber products (i.e. softwood log and hard wood woodchips) to markets in Asia.

The export of harvested timber directly to markets overseas requires the development of Kangaroo Island's first deep-water port – to be called the KI Seaport. KIPT has acquired land at Smith Bay considered suitable for the construction and operation of such a facility, which would be capable of exporting both logs and woodchips using Panamax Bulk Carriers of up to 60,000 deadweight tonnes (DWT) and a draft of up to 11.75 metres. Smaller Handymax Bulk Carriers may also be used, subject to operational requirements.

KIPT expects the new facility would be used for 30 to 50 days a year for timber exports, which would be sufficient for the sustainable yield of the entire Kangaroo Island forestry estate, including trees owned by other parties. Based on current plantation species and yields, this equates to between 12 and 18 shipments a year in perpetuity.

The Smith Bay facility would consist of a floating wharf, held in place by restraint dolphins —piled steel structures that extend above the water level and are not connected to shore. The wharf would be 168 metres long and 42 metres wide, with mooring structures required for vessel head and stern lines. The berth face of the wharf would be positioned approximately parallel to shore along the 10-metre depth contour. The 300 x 40 metre berth pocket along the seaward edge of the wharf would be dredged to approximately 13.5 metres, and the approaches dredged to approximately 13 metres to accommodate Panamax vessels. The wharf would be accessed by an approach consisting of a solid rock armoured causeway and suspended jetty deck structure which connects the approach to the floating wharf via a linkspan bridge at its seaward end.

The on-shore timber storage area would be divided into two terraces to provide around 4.1 ha of flat space on the otherwise gently sloping site. This arrangement would be used to stockpile about 56,250 tonnes of logs within the southern storage area (equal to around 150 per cent of anticipated vessel capacity) and 80,000 tonnes of woodchips (chipped off site at the plantation or another off-site location) in the northern storage area. The southern storage area may also be used to store bulk agricultural cargo such as grain, and general container cargo destined for export in periods when timber was not being shipped.

As proposed, timber export vessels would enter and leave Australia at an international port before and after loading at Smith Bay. The new Smith Bay facility would be developed to comply with the *Maritime Transport and Offshore Facilities Security Act 2003* (Cwlth) which defines the regulatory framework for assessing the operational security risks at ports, and preparing a security plan to counter these identified risks.

To support the plantation operations and the Smith Bay facility, KIPT would also establish:

- An operations base at the existing Timber Creek Road sawmill site to manage and maintain the mobile vehicle fleet (comprising the haul trucks and site materials handling equipment) and oversee fleet operations.
- A truck parking area with limited facilities on KIPT's Yerda North property on McBrides Road. This facility would allow the staging of heavy vehicle movements along the transport corridor, and provide an overnight parking area and refuelling depot for these vehicles away from the plantations and Smith Bay. Logs not chipped within the plantations may also be chipped at Yerda North before transport to Smith Bay for export.

These supporting activities and associated infrastructure are outside of the scope of the EIS, and are subject to separate approvals processes.

2.2 Assessment scope

This environmental noise impact assessment relates to noise from construction and operation of the Smith Bay Wharf, presented in Sections 2.5 and 2.6 respectively. To put the proposed Smith Bay Wharf in context, related KIPT operations on Kangaroo Island are also briefly described.

The boundary limits for the purpose of describing construction and operation noise emissions at the Smith Bay Wharf are the KIPT land parcel at Smith Bay, including off-shore activities associated with the development of the wharf and berthing area (during construction) and the manoeuvring, berthing and loading of vessels (operations).

Noise from plantation and harvest operations, and off-site transport and logistics does not form part of this assessment.

2.3 Project Background

Silviculture commenced on Kangaroo Island in 1980 with the establishment of a plantation of 20.6 ha of *Pinus radiata*. The intention was to build a sawmill to process this timber for local and mainland Australian markets. A sawmill was established at the site of the former Government Research Station on Timber Creek Road in 2004. It was operated sporadically from 2005 to 2013, when a fire damaged the infrastructure and halted milling. It has not operated since then.

Trial plantings of *Eucalyptus globulus* were established in the early 1990s, with more extensive trials undertaken in the early 2000s. These were sufficiently encouraging that extensive *Eucalyptus* plantations were established from 2005 to 2008. KIPT (previously RuralAus Ltd) acquired the majority of plantations on KI in April 2017. In addition to the plantations, KIPT also owns 11.2 ha of land at Smith Bay, and 29.2 ha at Ballast Head.

2.4 Project Location

KIPT owns the vast majority of KI plantations, which are all on the western part of the Island. The proposed wharf facility at Smith Bay is on the north coast of the Island, approximately 18 km north-west of Kingscote. This is the most suitable deep-water location close to the plantations and outside the boundaries of the Southern Spencer Gulf Marine Park.

The nearest noise-sensitive receiver is a residence located approximately 500m to the southwest of the site, while a bed and breakfast style accommodation provider is located approximately 700m to the southeast. Yumbah Aquaculture Kangaroo Island abalone farming venture is located approximately 100 m from the eastern edge of the proposed Project location at its nearest point.

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Figure 1: Site and location of nearest noise sensitive receivers.

2.5 Construction phase

The main offshore construction activities will include:

- Dredging of the berth pocket using a combination of grab dredging and cutter suction dredging
- Installation of barge restraint dolphins by pile driving from a jack-up barge, located approximately 350 – 400m from the shoreline
- Towing the floating barge wharf to site and securing to the restraint dolphins
- Construction of a causeway to approximately 250m from shore, using a combination of consolidated dredge spoil material, with rock armouring to provide the appropriate level of stability and damage resistance
- Approximately 90m of piled suspended jetty structure from the end of the end of the causeway to approximately 340m from shore
- Installation of the linkspan bridge from the suspended jetty to the floating barge wharf.

The main on-shore construction activities will include:

- Site clearance and earthworks using balanced cut and fill, with no externally sourced material required
- Construction of truck access route
- Delivery and assembly of materials handling infrastructure
- Construction of site offices and ablutions
- Electricity distribution infrastructure
- Onshore storage and dewatering of dredge spoil
- Shore-based works for causeway construction.

2.6 Operational phase

Timber products (logs and woodchips) would be transported to Smith Bay for shipping from a dedicated export wharf. The facility would consist of a deep-water wharf and associated on-shore facilities suitable for the handling and loading of logs and woodchips into Panamax-class vessels, with the option to load to smaller Handymax-class vessels as operational and/or customer requirements dictate.

The export wharf and key infrastructure are summarised in Table 1.

Table 1: Export Wharf Key Project Components

Parameter	Description
Port/off-shore components	Dredged berth pocket and dredged approach areas
	Navigation aids
	Floating barge wharf with wharf furniture (fenders, bollards, kerbs, etc).
	Guide/restraint dolphins for restraint of floating barge wharf
	Mooring dolphin at either end of wharf for vessel head and stern lines
	Linkspan bridge and ramp on barge
	Access causeway (rockfill)
On-shore components	Storage areas for logs and woodchips, including any battered edges of the areas to achieve required tier storage area levels
	Internal access roads
	Site access road to North Coast Road. The intersection between this access road and North Coast Road designates the project battery limits (including the intersection itself)
	Stormwater drainage and retention system
	Site security fencing and lighting
	Site offices, product testing room and crib/lunchroom
	Generator, diesel tanks and associated spill bunding
Materials handling components	Stockpile reclaim and export conveyor system, including: • reclaim hopper/s • export/causeway conveyor • shiploader feed conveyor • mobile shiploader
	Truck weighbridge
	Truck wash facilities (if required)

Site access

Access to the site is from North Coast Road via Smith Bay Road to the KIPT land parcel. The wharf facility incorporates an internal ring route to allow for single-lane traffic. On access to the site, a truck would be weighed at the weighbridge on the south-western corner of the site and travel down the western road. The truck would then travel clockwise on the site, unload at the storage yards and be weighed again on the weighbridge before exiting the site. Separate light vehicle access may be provided via a second site entry point to the south-east of the facility, providing direct access to the site offices and limiting interactions with log and woodchip haul trucks. This would be determined during detailed design.

Log and Woodchip Storage Areas

Log and woodchip storage areas would be established for the on-site storage of timber products pending export. The storage areas would be sized to accommodate the following:

- 2.5 ha of hardstand area for the storage of up to 56,250 tonnes of logs
- 1.7 ha of concrete apron for the storage of up to 80,000 tonnes of woodchips.

The nominated woodchip stockpile area would be a concrete pavement designed in accordance with relevant standards and guidelines for the management of surface water run-off.

Materials handling

Logs would be delivered directly to the vessel on designated roads, with logs loaded by the vessel's cranes and woodchips loaded by a system of conveyors and a shiploader. The key components include:

- Woodchip reclaim hopper
- Causeway conveyor and vehicle access ways
- Shiploader feed conveyor
- Shiploader
- Vessel cranes.

Logs would be delivered to the site by truck and offloaded by mobile material handling machines (Sennebogen or similar). The log bundles would be loaded in the log yard onto purpose-built trailers, which would transport them to the berth face for the vessel cranes to load them into the cargo hold.

Woodchips would be delivered to the site by truck and unloaded into hoppers. They would then be conveyed to a chip screening facility to be measured to ensure they were within specification. Woodchip within specification would be stockpiled by a stacking conveyor and bulldozer.

A rechipper would be installed on-shore to ensure all woodchips were a uniform size. Oversize material (estimated to be about 5 per cent of the total) would be directed to the rechipper for resizing, then delivered to the woodchip stockpile.

Vessels would be loaded by a separate reclaim and conveyor path, using a reclaim hopper (fed by bulldozer) and belt conveyor/shiploader path. Once the chips were in the ship's hold, a small bulldozer would push them into the corners and to compact them for efficient use of the cargo space.

Hours of operation

It is understood that delivery trucks would be likely be operated during daylight hours only (approximately 12 hours per day), while the materials handling system would operate 24 hours a day, for up to 30-50 days per year.

There is a possibility that truck deliveries may occur on a 24/7 basis. Although this is not KIPT's preferred option, we have adopted this worst-case truck delivery scenario for the purposes of this assessment.

3 EIS Guidelines

On 16 February 2017, the Minister for Planning declared the Project is to be assessed as a Major Development pursuant to Section 46 of the Development Act 1993 (the Act) (published in the Government Gazette on 23 February 2017).

Section 46 of the Act ensures that matters affecting the environment, the community or the economy to a significant extent, are fully examined and taken into account in the assessment of this proposal.

The Development Assessment Commission (DAC) has determined that the proposal will be subject to the processes of an Environmental Impact Statement (EIS), as set out in Section 46B of the Act, and have issued *Guidelines for the preparation of an EIS* ('the EIS Guidelines') in relation to the Project.

The EIS guidelines related to the noise assessment are:

1) *An acoustic report prepared by a suitably experienced, professional acoustic engineering consultant which demonstrates that noise from the proposed development is predicted to meet the 'relevant indicative noise levels' applicable to the proposed development under Clause 20 of the Environment Protection (Noise) Policy 2007 (Noise Policy) at all existing or future noise affected premises. The noise assessment should include vehicles entering, leaving and moving on site and predictions should include worst case acoustic and meteorological conditions for the transmission of noise from source to receivers (including CONCAWE meteorological category 5 day and CONCAWE meteorological category 6 night) and at maximum operating potential. The report should also consider the impacts of construction noise on marine organisms, especially marine mammals.*
2) *Describe the impacts of drilling or screw piling activities on marine communities, in particular turbidity, disturbance (including of any harmful soil types or contaminants), vibration and underwater noise on vulnerable or sensitive receptors and any mitigating measures that may be used.*
3) *It is expected that both underwater and terrestrial noise pollution will occur during the construction phase as a result of securing the mooring and retaining structures to the seabed, the use of earthmoving equipment and physical construction of the structures. Post construction, the movement of vehicles to and from the proposed site, stockpiling and ship-loading operations onsite at Smith Bay will also generate noise. If construction and/or operations are to occur at night, there will also be light pollution impacts on the surrounding area:*
    a. *Detail the expected levels of environmental noise associated with the construction and operation of the development, identifying all potential noise sources, and describe the impact upon the immediate and wider locality (include sensitive receivers).*
    b. *Identify if the predicted noise from ongoing operational sources associated with the project will meet the noise goals in the Environment Protection (Noise) Policy 2007 (Noise Policy) at the nearest noise sensitive receivers.*
    c. *Detail how noise emissions will be reduced and contained (such as via building design/materials, noise barriers and buffers, and/or implementing operational procedures) to meet the requirements of the Noise Policy and minimise impacts upon the immediate and wider locality, including the effects from increased transport.*
    d. *Detail how construction noise will meet the mandatory construction noise requirements of Part 6, Division 1 of the Noise Policy.*
    e. *Detail what reasonable and practicable measures will be taken pursuant to Clause 23(1)(c) of the Noise Policy to minimise construction noise.*

Terrestrial Noise Assessment

4 Noise criteria

4.1 Operational noise criteria

Environmental noise emissions from the proposed development are required by the EIS Guidelines to comply with the *Environment Protection (Noise) Policy* 2007 (Noise EPP), which is also the most relevant guideline to address the requirements of the overarching *Environment Protection Act 1993*.

The noise goals in the Noise EPP are based on the zoning of the proposed development and the closest noise affected premises in the relevant development plan. The land uses primarily promoted by the zones are used to determine the indicative noise factors shown in Table 2.

Table 2: Indicative noise factors for various land use categories

Land use category	Indicative noise factor dB(A)	
	Day (7 am to 10 pm)	Night (10 pm to 7 am)
Rural living	**47**	**40**
Residential	52	45
Rural industry	**57**	**50**
Light industry	57	50
Commercial	62	55
General industry	65	55
Special industry	70	60

In this case, the Project is located in a Coastal Conservation Zone, while the most affected residences are located in a Primary Production Zone under the Kangaroo Island Council Development Plan. The Yumbah Aquaculture facility to the east of the Project site is also within the Coastal Conservation Zone.

The following types of development are envisaged in the Coastal Conservation Zone:

- coastal protection works
- conservation works
- interpretive signage and facilities
- tourism/visitor facilities
- tourist accommodation.

The *Guidelines for use of the Environment Protection (Noise) Policy 2007* note that the Rural Living land use category may be assigned to a locality that principally promotes a park or reserve set aside for public recreation or enjoyment in a country or non- urban setting. On this basis the *Rural Living* land use category is therefore the best fit for this locality.

However, we note that the noise limits for this zone are primarily intended to protect rural-residential and recreational amenity. They are therefore not appropriate for assessing the impact of noise of the existing Yumbah Aquaculture facility, where is not used for residential or recreational purposes.

The following types of development are envisaged in the Primary Production Zone in the Kangaroo Island Council Development Plan:

- bulk handling and storage facility
- conference facility (in association with tourist accommodation or tourism facilities)
- dairy farming
- farming
- farm building
- home based industry

- horticulture
- intensive animal keeping
- land-based aquaculture
- tourist accommodation (including through the diversification of existing farming activities and conversion of farm buildings)
- tourism activities and facilities
- wind farm and ancillary development
- wind monitoring mast and ancillary development.

The *Guidelines for use of the Environment Protection (Noise) Policy 2007* state that:

> The title 'Rural Industry' is not intended to create a link to the term 'industry' as defined in the Development Act 1993. The term 'industry' has been used in the Policy to indicate that the locality principally promotes a primary industry or associated activity. For example, in general farming zones, where the land use principally promoted is agriculture and residences are contemplated, the Rural Industry land use category would be assigned.

The *Rural Industry* land use category therefore applies to this zone.

Clause 5(5) of the Noise EPP requires that if the noise source and the noise sensitive premises are located in zones where different land use categories are promoted, then the indicative noise level is the average of those relevant indicative noise factors. In this case, the indicative noise level for receivers in the Primary Production Zones is the average of Rural Living and Rural Industry factors, i.e. 52 dB(A) during the daytime and 45 dB(A) during the night.

In accordance with Part 5 of the Noise EPP, the relevant planning assessment criteria for this development is the determined indicative noise level minus 5 dB(A), as shown in Table 3 below. The *Guidelines for use of the Environment Protection (Noise) Policy 2007* note that the more stringent criteria which are applied to assessment of development applications is in recognition of a range of factors, including increased sensitivity to noise from a new noise source, the increased scope for inclusion of reasonable and practicable noise reduction measures to new development, and the cumulative effect of noise.

The planning criteria apply to external noise levels predicted at the facade of any noise sensitive receiver.

Table 3: Planning noise criteria

Land use category	Planning noise criteria dB(A) L_{eq}	
	Day (7 am to 10 pm)	Night (10 pm to 7 am)
Rural Industry	47	40
Rural Living	42	35

Penalties can also be applied to a noise source for a variety of characteristics, such as impulsive, low frequency, modulating or tonal characters. For a characteristic penalty to be applied to a noise source it must be fundamental to the impact of the noise and dominate the overall noise impact. Application of the characteristic penalty is discussed in the noise emission assessment.

We note that under Part 5, Clause 20(6) of the Noise EPP, exceedance of the recommended criterion does not necessarily mean that the development will be non-compliant. The following matters must be considered when considering compliance:

- the amount by which the criterion is exceeded (in dB(A))
- the frequency and duration for which the criterion is exceeded
- the ambient noise that has a noise level similar to the predicted noise level
- the times of occurrence of the noise source
- the number of persons likely to be adversely affected by the noise source and whether there is any special need for quiet.
- Land uses existing in the vicinity of the noise source.

4.2 Construction noise criteria

Division 1 of the Noise EPP contain provisions in relation to noise from construction, demolition and related activities. The following provisions apply to construction activity resulting in noise with an adverse impact on amenity:

a) subject to paragraph (b), the activity—
  i) must not occur on a Sunday or other public holiday; and
  ii) must not occur on any other day except between 7.00 a.m. and 7.00 p.m.;

b) a particular operation may occur on a Sunday or other public holiday between 9.00 a.m. and 7.00 p.m., or may commence before 7.00 a.m. on any other day—
  i) to avoid an unreasonable interruption of vehicle or pedestrian traffic movement; or
  ii) if other grounds exist that the Authority or another administering agency determines to be sufficient;

c) all reasonable and practicable measures must be taken to minimise noise resulting from the activity and to minimise its impact, including (without limitation)—
  i) commencing any particularly noisy part of the activity (such as masonry sawing or jack hammering) after 9.00 a.m.; and
  ii) locating noisy equipment (such as masonry saws or cement mixers) or processes so that their impact on neighbouring premises is minimised (whether by maximising the distance to the premises, using structures or elevations to create barriers or otherwise); and
  iii) shutting or throttling equipment down whenever it is not in actual use; and
  iv) ensuring that noise reduction devices such as mufflers are fitted and operating effectively; and
  v) ensuring that equipment is not operated if maintenance or repairs would eliminate or significantly reduce a characteristic of noise resulting from its operation that is audible at noise-affected premises; and
  vi) operating equipment and handling materials so as to minimise impact noise; and
  vii) using off-site or other alternative processes that eliminate or lessen resulting noise.

Construction noise with an adverse impact on amenity is defined as that which results in a noise level greater than 45 dB(A) L_{eq} (continuous noise level) or 60 dB(A) L_{max} (maximum noise level) at a noise-affected premises such as a residence. However, Clause 23(4) of the Noise EPP also states that:

> *(a) if measurements of ambient noise at the noise-affected premises show that the ambient noise level (continuous) exceeds 45 dB(A), the construction activity does not result in noise with an adverse impact on amenity unless the source noise level (continuous) exceeds the ambient noise level (continuous);*
>
> *(b) if measurements of ambient noise at the noise-affected premises show that the ambient noise level (maximum) consistently exceeds 60 dB(A), the construction activity does not result in noise with an adverse impact on amenity unless the source noise level (maximum) exceeds the ambient noise level (maximum) or the frequency of the occurrence of the ambient noise level (maximum).*

The above provisions recognise that construction noise is inherently noisy, with limited opportunity for mitigation. However, given the temporary nature and limited duration of construction noise, it is considered acceptable provided it is undertaken within reasonable hours and all reasonable and practicable measures to mitigate noise are implemented.

5 Baseline noise and vibration measurements

Baseline noise and vibration monitoring was conducted in the area surrounding the site, between the 7th and 16th of December 2017. Attended ambient noise measurements were also undertaken in the area on the 7th and 8th of December 2017. Figure 2 below shows the measurement locations. The measurement locations were selected to be representative of the ambient noise environment at noise sensitive receiver locations and surrounding area.

Figure 2: Baseline noise and vibration measurement locations

5.1 Instrumentation

5.1.1 Noise measurements

The noise measurements were taken with a calibrated sound level meters, as detailed in Table 4 below. The sound level meters were calibrated both before and after the measurements using a Type 1 Brüel & Kjær 4231 sound level calibrator, and the calibration was found to have not drifted. Sound level meters and calibrator carry current calibration certificates from a NATA accredited laboratory. Copies of the calibration certificates are available on request.

Table 4: Noise measurement instrumentation details

Measurement location	Sound Level Meter	Serial Number	Calibration Date
B1	Rion NL-21	409176	6/12/2016
B2	Rion NL-42	00946973	15/11/2016
B3	Rion NL-21	00862934	17/08/206

Measurement location	Sound Level Meter	Serial Number	Calibration Date
Attended measurements	B&K 2250	3001238	02/05/2017

5.1.2 Vibration measurements

The equipment used to conduct baseline vibration measurements is detailed in Table 5 below.

Table 5: Vibration measurement equipment details

Equipment item	Serial Number	Calibration date
AvaTrace M80	3111	05/07/2017
Ava Geophone G3 Floor	1009	02/07/2017

5.2 Procedure

Noise measurements were undertaken in accordance with the following:

- The microphone of the sound level meter was at a height of approximately 1.2 metres above the ground and at least 3.5 metres away from any wall or facade.
- The axis of maximum sensitivity of the microphone of the sound level meter was directed towards the noise source.
- A wind shield was used during all measurements.
- Weather data was collected from the Bureau of Meteorology for the duration of the measurements. Measurement periods with rainfall or wind speeds higher than 5 m/s were excluded from the results.
- Care was taken to avoid any effect on the measurement of extraneous noise, acoustic vibration or electrical interference.
- Noise measurements were undertaken in 15 minute periods.

5.3 Results

5.3.1 Attended noise measurements

Attended noise measurements were undertaken at a number of locations as shown in Figure 2, on the afternoon of 7th of December and early morning of the 8th of December 2017.

Significant noise sources at the time of measurement included wave noise, wind induced noise (from foliage), birds, and insects. A SODAR (Sonic Detection and Ranging) instrument deployed at the Project site at the time of measurements was also audible at some locations, but subjectively did not contribute significantly to measured noise levels. Vehicle movements in the surrounding area were observed to be infrequent, and did not occur during attended measurements at any location. No significant noise from the Yumbah Aquaculture facility was observed at the time of measurements.

The results of attended noise measurements are summarised in Table 6 below.

Table 6: Attended measurement results

Location	Date and time	Measured Noise Level, dB(A)			Noise sources at the time of measurement
		L_{max}	L_{eq}	L_{90}	
A1	7/12/17 13:43	58	46	39	Wind noise, SODAR
A2	8/12/17 6:26	53	42	37	Wind noise, birds, insects, waves, SODAR
A3	8/12/17 6:36	69	45	29	Birds, waves, wind noise
A4	8/12/17 6:43	55	33	26	Birds
A5	8/12/17 6:53	58	40	34	Birds, insects

5.3.2 Unattended noise measurements

The results of the unattended baseline noise monitoring are summarised below in Table 7. Noise levels in dB(A) L_{eq} have been averaged over the daytime and night time periods for each day. L_{max} values are the 95th percentile value, while the L_{90} values are the mean for each daytime and night time period.

Results are also presented as graphs in Appendix A.

Table 7: Baseline noise monitoring summary

Location		Measured Noise Level, dB(A)								
Date	Period	B1			B2			B3(1)		
		L_{max}	L_{eq}	L_{90}	L_{max}	L_{eq}	L_{90}	L_{max}	L_{eq}	L_{90}
7/12/17	Day(2)	69	48	35	78	50	37	77	47	30
	Night	68	40	24	72	40	31	83	44	32
8/12/17	Day	79	48	30	78	52	38	-	-	-
	Night	68	40	23	77	45	36	-	-	-
9/12/17	Day	71	45	32	78	53	41	-	-	-
	Night	76	42	25	75	44	31	-	-	-
10/12/17	Day	75	51	29	79	51	36	-	-	-
	Night	70	43	27	72	43	31	-	-	-
11/12/17	Day	64	41	31	79	52	37	-	-	-
	Night	68	42	32	70	44	35	-	-	-
12/12/17	Day	69	40	29	80	50	38	-	-	-
	Night	69	43	32	76	46	38	-	-	-
13/12/17	Day	66	41	29	77	50	40	-	-	-
	Night	63	41	26	64	42	31	-	-	-
14/12/17	Day	80	51	31	77	53	38	-	-	-
	Night	73	47	24	80	44	30	-	-	-
15/12/17	Day(2)	77	44	30	76	52	41	-	-	-
Overall	**Day**	**74**	**47**	**31**	**79**	**52**	**39**	**77**	**47**	**30**
	Night	**70**	**43**	**27**	**75**	**44**	**33**	**83**	**44**	**32**

(1) Measurement period at this location truncated due to equipment issue.

(2) Averages based on partial data for this period.

Measured baseline noise levels were relatively low at all locations, particularly during the night time, and are consistent with expected noise levels in a rural area.

5.3.3 Vibration measurements

Vibration measurement results are shown in Figure 3. Baseline vibration levels were generally very low in all three axes, with the exception of occasional events generating PPV of up to 1.6 mm/s, during the night time period. These were possibly due to wildlife moving in close proximity to the geophone.

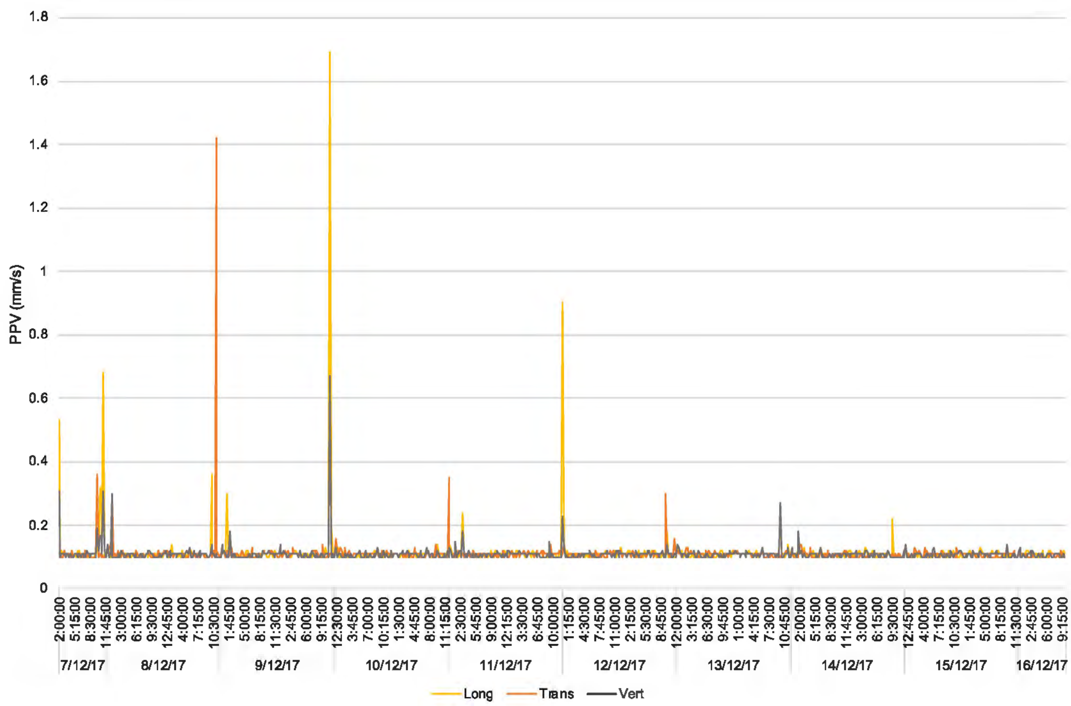

Figure 3: Vibration measurement results

6 Noise assessment

6.1 Noise modelling

Noise emissions from site have been modelled in SoundPLAN Environmental Software v8.0 program, using the CONCAWE method. The model takes into consideration:

- attenuation of noise source due to distance
- barrier effects from buildings, topography and the like
- air absorption
- ground effects
- meteorological conditions

CONCAWE has six difference weather categories—CONCAWE weather category 1 represents weather conditions that are least conducive to noise propagation (best case situation with the lowest predicted noise levels), CONCAWE weather category 4 represents neutral weather conditions, and CONCAWE weather category 6 represents weather conditions that are the most conducive to noise propagation (the worst case situation with the highest predicted noise levels).

In accordance with the EIS Guidelines and the *Guidelines for the use of the Environmental Protection (Noise) Policy 2007*, CONCAWE weather Category 6 has been used for night time noise emissions, and Category 5 has been used for daytime noise emissions.

A ground absorption factor of 0.0 (completely reflective) has been adopted for water areas, while all on shore areas have been modelled with a ground absorption factor of 0.5.

6.2 Noise sources

Significant operational noise sources, quantity on site (operating simultaneously at any one time) and sound power level per unit are presented in Table 8 below. Sound power levels have been determined based on BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*, and Resonate's database of equipment. Noise source locations are shown in Figure 4.

Table 8: Operational noise sources, quantity, and sound power level

Noise source	Quantity	Sound power level, dB(A) per unit
Bulldozer	1	105
Trucks (idling)	2 on site at any one time	91
Trucks (moving)	3 trucks in a worst-case 15 minute period	99
Log handlers	2	99
Re-chipper	1	100(1)
Generator	1	93
Conveyer	1	105
Woodchip stacker	1	105
Shiploader	1	109
Crane	1	95

(3) Assuming the re-chipper is housed in an acoustic enclosure with a sound pressure level of no more than 75 dB(A) L_{eq} at 7m distance.

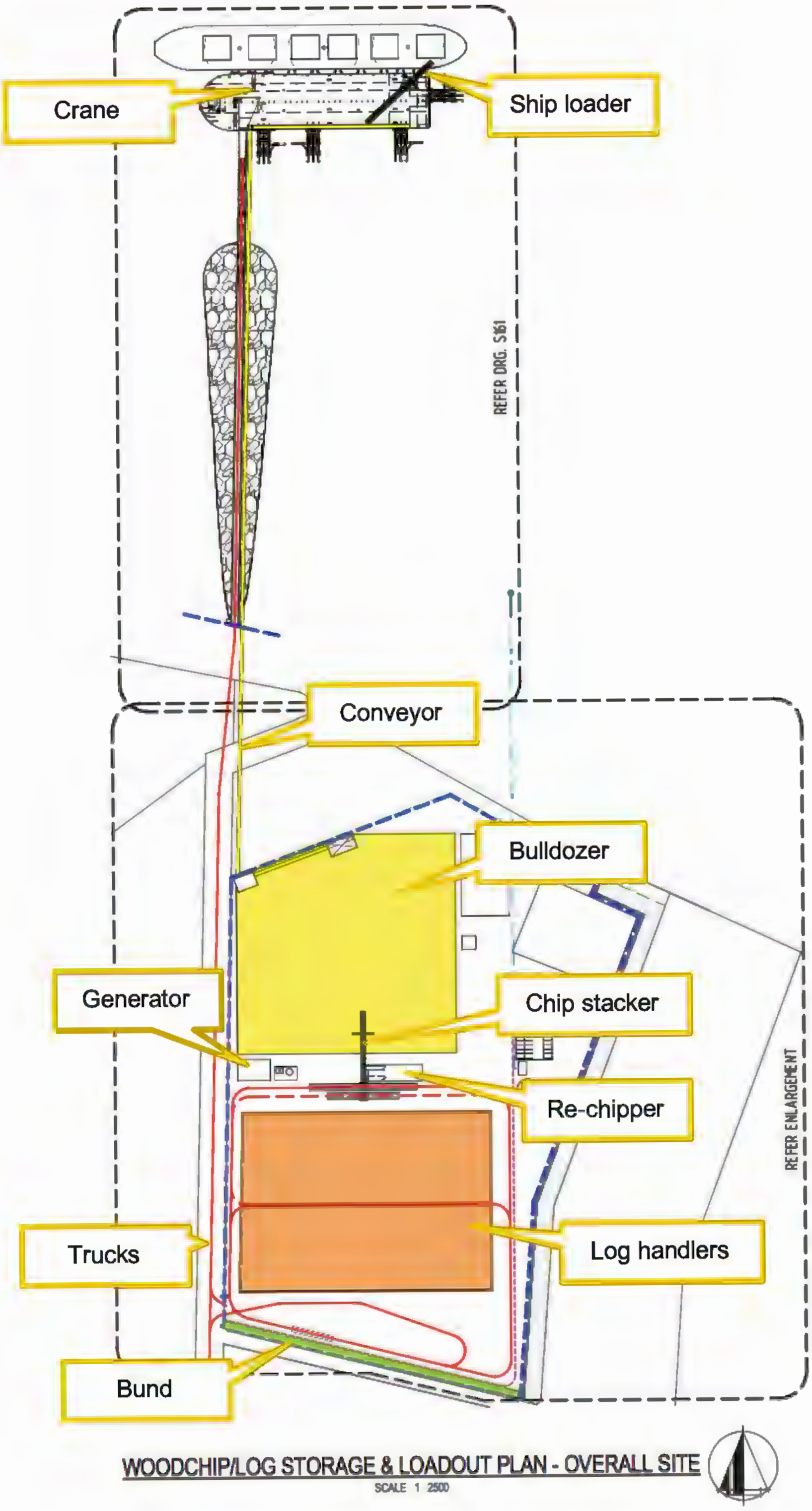

Figure 4: Location of noise sources

We note that stockpiles of woodchips and logs will provide noise mitigation where they block line of site between noise sources and receivers. However, because the quantity and locations of materials stored on site will vary, this mitigation has not been relied on in the noise modelling. The modelling therefore represents a conservative approach in this regard.

Using excavated material and dredge spoil, KIPT will construct an approximately 3m high bund, for visual and noise screening purposes along the southern site boundary. This has been included in the noise model.

It is assumed that all sources are operating simultaneously, representing a conservative (worst-case) scenario.

6.3 Predicted noise levels

Predicted noise levels are shown below in Table 9, while a noise contour plots is presented in Figure 5.

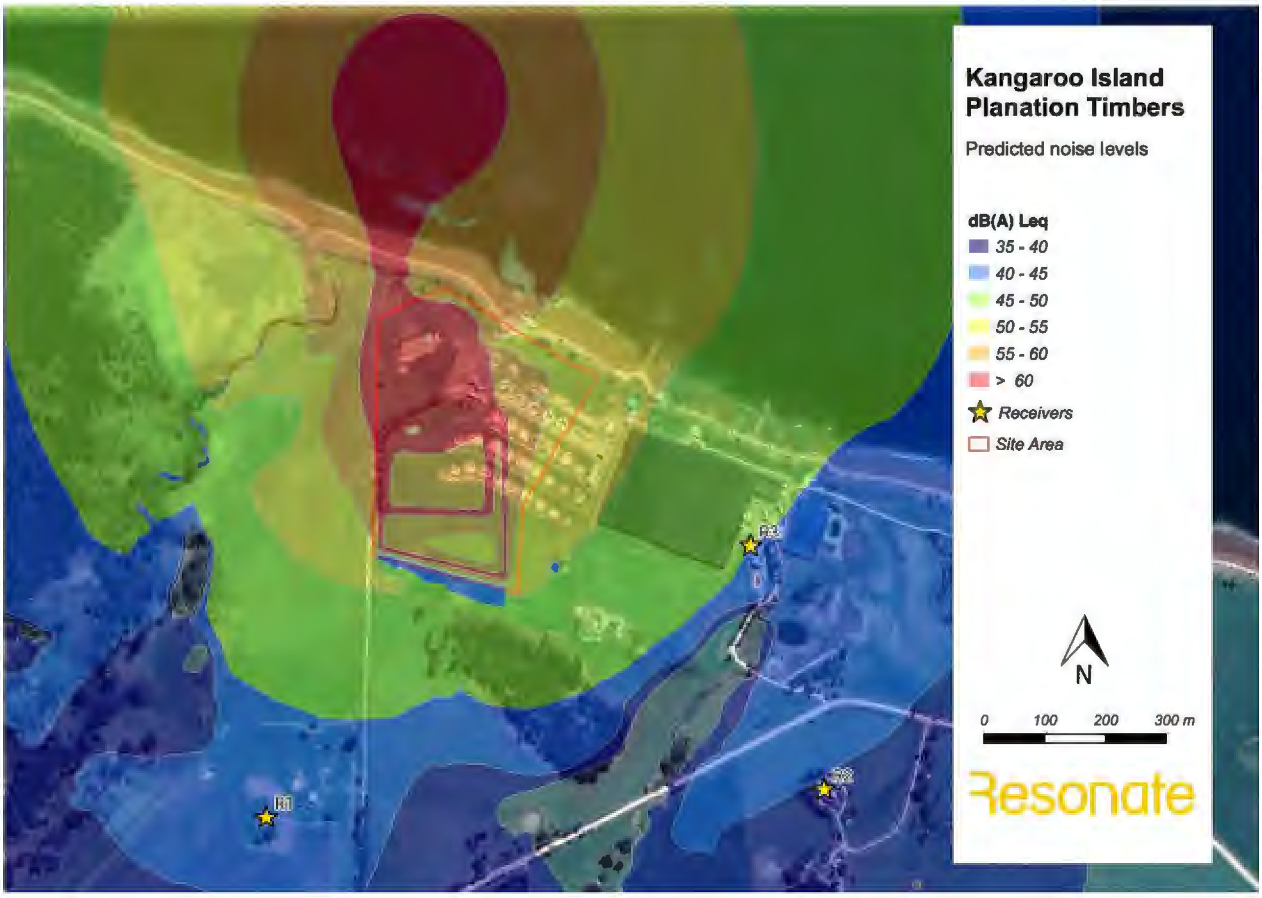

Figure 5: Predicted noise levels

Table 9: Predicted noise levels

Receiver	Predicted noise level, dB(A) L_{eq}	Daytime criteria, dB(A) L_{eq}	Night time criteria, dB(A) L_{eq}
R1	**42**	47	40
R2	40	47	40
R3	**45**(1)	42	35

(1) Noise levels range from 36 to 53 dB(A) at the facades of buildings within this site.

Based on the above results, noise levels are expected to comply with daytime (7am to 10pm) noise criteria at all residential receiver locations (R1 and R2); however, noise levels are expected to exceed the night time criteria by 2 dB at receiver R1. Mitigation that could be considered to address this exceedance is described in Section 6.3.1.

Worst-case noise from the Project may be noticeable in the context of the existing baseline noise environment at this location, but is at similar or lower levels compared to other intermittent noise sources, for example wind or wave noise.

Noise levels at the Yumbah Aquaculture facility (R3) are expected to exceed the relevant daytime and night time criteria. However, as discussed in Section 4.1, the Rural Living criteria are intended for the protection of residential and recreational amenity, and prevention of sleep disturbance, and are not considered appropriate for assessing the impact of noise at this location based on the existing land use.

In accordance with Part 5, Clause 20(6) of the Noise EPP, the following matters should be considered in relation to the predicted exceedance at this location.

Relevant matter for consideration	Comment
Ambient noise that has a noise level similar to the predicted noise level	Average existing ambient noise levels at logger location B2 were 52 dB(A) during the daytime and 44 dB(A) at night. These are similar levels to predicted noise levels. We also note that the Yumbah facility is likely to generate heavy vehicle movements from time to time, which are expected to produce similar or higher noise levels than the noise sources associated with the Project, when received within the Yumbah site.
The number of persons likely to be adversely affected by the noise source and whether there is any special need for quiet.	The predicted noise levels are within the range anticipated within the Noise EPP for industrial or commercial land uses. Our understanding is that no people reside within the Yumbah site. On this basis no persons are likely to be adversely affected by the noise source. There is no established special need for quiet at the Yumbah Aquaculture site.
Land uses existing in the vicinity of the noise source.	Land use at the Yumbah Aquaculture site is generally consistent with Primary Production or Rural Industry. The land use is not consistent with the type of development envisaged in the Coastal Conservation Zone, or with typical activities associated with the Rural Living land use category.

6.3.1 Noise mitigation

To fully comply with night time noise criteria at residential receivers, KIPT could consider a 3m high noise barrier constructed to the south of the re-chipper and chip stacker, to block line-of-sight from this plant to R1, as shown in Figure 6. The barrier may be an earth bund; fence constructed from solid material with no gaps; or a combination of both, provided the total height above the local ground level is a minimum of 3m.

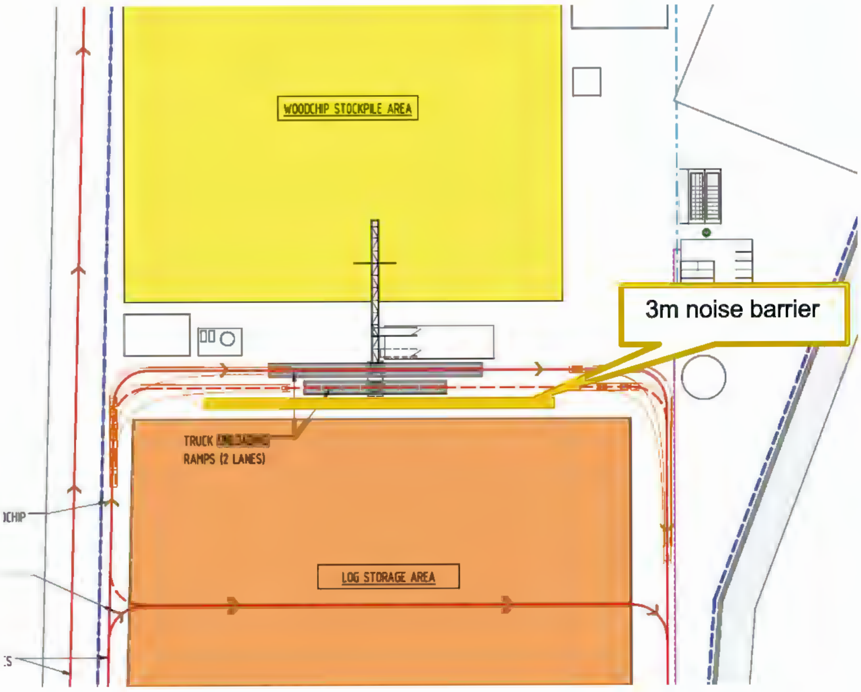

Figure 6: Additional noise mitigation

A noise contour plot showing the mitigated night time noise levels is shown in Figure 7.

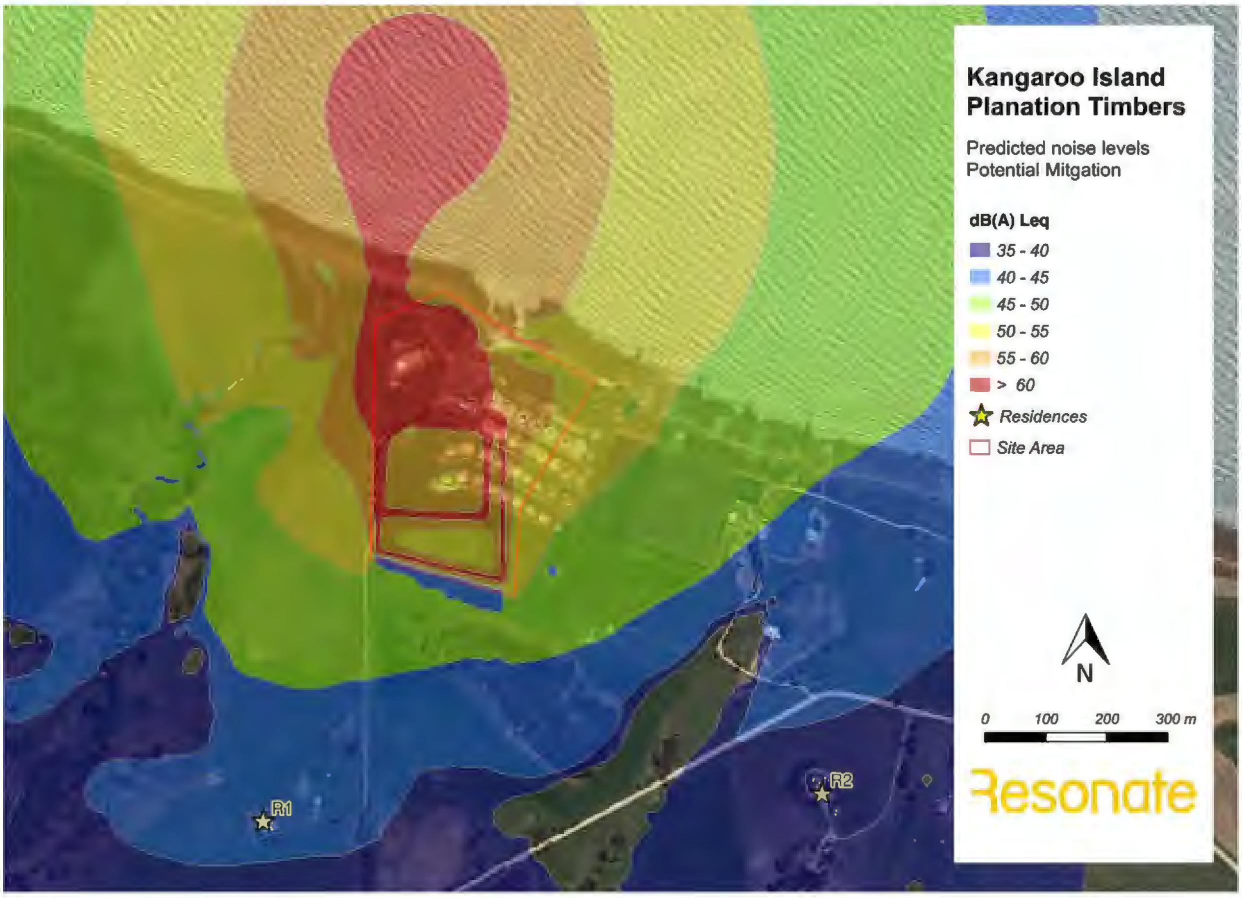

Figure 7: Night time predicted noise levels with additional mitigation

6.4 Construction noise assessment

Construction activities are described in Section 2.5, and will include:

- Dredging of the berth pocket using a combination of grab dredging and cutter suction dredging
- Installation of barge restraint dolphins by pile driving from a jack-up barge, located approximately 350 – 400m from the shoreline
- Towing the floating barge wharf to site and securing to the restraint dolphins
- Construction of a causeway
- Construction of the piled suspended jetty structure
- Installation of the linkspan bridge from the suspended jetty to the floating barge wharf
- Site clearance and earthworks using balanced cut and fill, with no externally sourced material required
- Construction of truck access route
- Delivery and assembly of materials handling infrastructure
- Construction of site offices and ablutions
- Electricity distribution infrastructure
- Onshore storage and dewatering of dredge spoil
- Shore-based works for causeway construction.

Construction equipment associated with off-shore works may include tugboats, barges, dredging vessels, piling rig, and the like. On-shore construction equipment may include trucks, excavators, bulldozers, generators, cranes, concrete pumps, hand tools, dewatering plant (for dredge spoil) and other plant. Typical noise levels associated with these sources are generally expected to be in the same order as operational noise levels.

Provided the majority of construction work is carried out between 7:00am and 7:00pm Monday to Saturday and all reasonable and practicable measures undertaken to minimise noise, construction noise will comply with Division 1 of the Noise EPP as described in Section 4.2.

Some construction activities may need to be undertaken outside of these hours, for example some off-shore activities may require stable sea conditions more likely to occur at night time. Whilst the extent and type of construction activities which may be undertaken outside of standard hours is not known at this stage, it is clear from operational noise modelling than many construction activities can be undertaken at night while maintaining compliance with the criteria of 45 dB(A) L_{eq} and 60 dB(A) L_{max} at the nearest residences.

KIPT may consider preparing and implementing a Construction Noise and Vibration Management Plan (CNVMP) prior to the commencement of any construction works, including, as a minimum, provisions for potential noise management and mitigation as summarised in Table 10 and Table 11 below.

Table 10: Potential Noise and Vibration Management Measures

Control Measure	Accountability
Noisier works will be scheduled with due consideration to the nearest sensitive land uses.	Construction Manager
Induction will cover noise and vibration management and complaints, and this will be reiterated through onsite training such as toolbox talks or pre-starts.	Environment Manager
Effective stakeholder communication is a key mitigation measure.	Community and Stakeholder Engagement Manager
Consider respite periods for longer-term exposed sensitive receivers.	Construction Manager
The potential shielding provided by site topography and intervening buildings will be taken into account in locating equipment.	Site Supervisors
Processes and equipment that generate lower noise levels will be selected where feasible.	Construction Manager Site Supervisors
Noisy plant, site access roads and site compounds will be located as far away as from occupied premises as is practical to allow efficient and safe completion of the task.	Construction Manager
Equipment that emits noise predominantly in a particular direction will be sited such that noise is directed away from occupied premises where feasible.	Site Supervisors Operators
Works planning will consider preventing vehicles and equipment queuing, idling or reversing near occupied premises where practicable	Site Supervisors Operators
Truck movements on local roads will be limited as much as is practicable.	Site Supervisors
Two-way radios will be set to the minimum effective volume where possible for safety reasons	Site Supervisors Operators
Truck operators will ensure tailgates are cleared and locked at the designated points.	Site Supervisors Operators
Truck movements along uneven surfaces will be restricted to minimum speed near sensitive receivers.	Site Supervisors Operators
Plan material haulage routes to minimise impacts to the community where practical.	Construction Manager
Equipment that is used intermittently will be shut down or throttled down to a minimum during periods where it is not in use.	Site Supervisors Operators
Noise associated with packing up plant and equipment at the end of works will be minimised.	Site Supervisors
Equipment will be well maintained and have mufflers and silencers installed that meet the manufacturer's specifications where relevant.	Site Supervisors Operators

Control Measure	Accountability
Where noisy plant is to be fixed in a stationary location such that it may impact on sensitive receivers for a significant length of time (i.e. generator located in a stockpile site for the duration of the Project), an acoustic enclosure will be installed where practical or an appropriately silenced generator or lighting tower used.	Site Supervisors
Low vibration alternatives for plant will be implemented where feasible, such as the smallest vibratory compactor practically capable of completing the task.	Construction Manager Site Supervisors
Works will be planned to minimise the noise from reversing signals from any vehicles that do not have broadband alarms fitted.	Construction Manager Site Supervisors
Avoid metal-to-metal contact where feasible.	Site Supervisors
Avoid dropping material from height into unlined truck trays and barges.	Site Supervisors Operators
For high noise activities, consider the installation of temporary solid hoarding (e.g. plywood) or earth bunds where reasonable and where this would be able to provide a noticeable noise reduction (e.g. blocks line-of-sight to receivers).	Construction Manager Site Supervisors
Plant that has high and low vibration operation settings will be run on the lowest effective vibration setting.	Site Supervisors Operators

Table 11: Potential Night Works Noise and Vibration Management Measures

Control Measure	Accountability
Where reasonable and practicable, works will be programmed such that noisier activities occur prior to 10 pm and after 6 am.	Construction Manager
Where reasonable and practicable, prolonged repeated night time activities will not occur in the vicinity of receivers to provide nights of respite for sensitive receivers.	Construction Manager
Works occurring over several nights will be programmed, where possible, such that works do not occur in close proximity to individual receiver locations for consecutive nights.	Construction Manager
Acoustic enclosures will be installed around above ground equipment where noise levels are predicted to exceed the relevant noise level targets at sensitive land uses, where safe and practical.	Site Supervisors
Where practical all reversing plant used at night will be fitted with broadband reversing alarms, noting that it may not be possible to do so where plant is called in at short notice to replace other plant requiring maintenance. All broadband reversing alarms will be installed and operating in accordance with all relevant Occupational Health and Safety requirements.	Construction Manager Operators
Where it cannot be guaranteed that plant is not to be fitted with broadband reversing alarms (e.g. trucks that only attend the site on occasion) then the site will be setup as far as practicable such that those items do not need to reverse.	Construction Manager Site Supervisors
Materials will not be dropped from a height causing a loud noise wherever possible.	Operators
Where materials are to be dropped into an empty truck tray, barge, or disposal bin and may cause a loud noise, the tray/bin will be lined with soil or an equivalent material to reduce impact noise where feasible.	Site Supervisors Operators
No shacking of buckets near to sensitive receptors by plant used to move earthworks	Site Supervisors Operators

7 Conclusion

Terrestrial noise impacts have been assessed in accordance with the Kangaroo Island Council Development Plan and Environmental Protection (Noise) Policy 2007 (the Noise EPP), at all noise affected premises. The modelling and assessment considers baseline noise levels, attenuation of noise due to distance; barrier effects from buildings, topography and the like; air absorption; ground effects; and worst-case meteorological conditions.

With the potential mitigation option as described above in Section 6.3.1, operational noise emissions are predicted to comply with daytime and night time criteria at all noise sensitive receiver locations.

Airborne noise levels associated with construction of the port are expected to be similar to operational noise levels. Provided the majority of construction work is carried out during standard construction hours, and reasonable and practicable steps are taken to minimise noise, compliance with Division 1 of the Noise EPP can be readily achieved.

KIPT may consider preparing and implementing a Construction Noise and Vibration Management Plan (CNVMP) prior to the commencement of any construction works.

Underwater Noise Assessment

8 Underwater noise overview

8.1 Nature of sound

Sound is an acoustic pressure wave that travels through a medium, such as water or air, and occurs as an oscillatory motion of the water or air particles driven by a vibrating source. The magnitude of the water or air particle motion determines the intensity of the sound. The rate at which the water or air particles oscillate determines its frequency, given in cycles per second or Hertz (Hz).

Sound travels about four-and-a-half times faster in water than in air. The absorption of sound at frequencies where man-made noise generally has the most energy is much smaller in water than in air. As a result, noise is typically audible over much greater ranges underwater than in air. Most sources of noise, including pile driving, and movement of large shipping vessels generate acoustic energy over a broad range of frequencies. Screeching or whistling noises are composed mainly of high frequency sounds while rumbles or booms are composed mainly of low frequency sounds.

Sounds are usually characterized according to whether they are continuous or impulsive in character. Continuous sounds occur without pauses and examples include shipping noise and dredging. Impulsive sounds are of short duration and can occur singularly, irregularly, or as part of a repeating pattern. Blasting represents a single impulsive event whereas the periodic impacts from a pile driving rig results in a patterned impulsive sequence. Impulsive signals typically sound like bangs and generally include a broad range of frequencies.

Sound pressures are measured with a hydrophone when underwater and a microphone when in air. The international standard unit of sound pressure is the Pascal (Pa). Sound pressures encountered underwater and in air range from levels just detectable by the mammal ear (hundreds of micro Pascals (µPa)) to much greater levels causing hearing damage (billions of Pa). Because this range is so enormous, sound pressure is normally described in terms of a sound pressure level (SPL) with units of decibel (dB) referenced to a standard pressure of 1 µPa for underwater and 20 µPa for airborne acoustics.

8.2 Underwater Noise Metrics

Underwater noise metrics commonly used for presenting source, measured or received underwater noise levels include the following:

- *Sound pressure level* (SPL) – Sound pressure is expressed in units of dB re 1 µPa, and in underwater noise is often averaged over a measurement period or provided as a peak level.
  - Continuous sources such as shipping noise and dredging are commonly characterized in terms of a root mean square SPL (denoted dB_{rms}) averaged over the measurement period.
  - Impulsive sources such as impact piling are often characterized in terms of the peak level (denoted dB_{peak}), which is the highest sound pressure over the measurement period.
- *Sound exposure level* (SEL) – Sound energy over the measurement period expressed as an equivalent sound level for a 1-second exposure period, expressed in units of dB re 1 $\mu Pa^2 s$. The SEL is commonly used for impulsive sources such as impact pile driving because it allows a comparison of the energy contained in impulsive signals of different duration and peak levels. The measurement period for impulsive signals, such as impact piling, is usually defined as the time period containing 90% of the sound energy.
- *Source level* –The source level is defined as the sound pressure (or energy) level that would be measured at 1 m from an ideal point source radiating the same amount of sound as the actual source being measured. The intensity of underwater noise sources is compared using the source level (SL) expressed in units of dB re 1 µPa at 1 m.

SPLs and SELs can be presented either as overall levels or as frequency dependent spectral or third-octave band levels indicating the frequency content of a source. Overall SPLs and SELs present the total average noise and energy level, respectively, within a given frequency bandwidth – usually the band that contains most of the energy. Spectral density levels are expressed in units of dB re 1 $\mu Pa^2/Hz$ and provide a greater frequency resolution than third-octave band levels, which are expressed in units of dB re 1 µPa.

8.2.1 SEL accumulation time

SEL is a noise descriptor typically used to provide a comparative measure of sound levels from sources of different durations. SEL achieves this by converting noise levels occurring over varying exposure periods to equivalent sound levels with a standard reference time, which is typically 1 second. It can be thought of as incorporating all the acoustic energy emitted by a source over a time period into an equivalent noise level for a one second period.

Underwater noise sources have significant variation in their duration. For example, impact piling typically consists of short pulses of noise from hammer impacts which occur for 1-2 hours, whereas noise from vessel movements is typically a steady noise level occurring for the duration of the vessel's pass. SEL is a descriptor which allows for comparison of the noise levels from these different sources.

Noise from an impact piling source can be considered on a per-impact time period (approximately 0.1 seconds for 90% of the impact sound energy) or as a cumulative exposure to noise from multiple impacts over the course of pile installation. SEL can therefore be presented as a SEL per-impact level or as a cumulative level for a chosen accumulation time. We have distinguished cumulative SEL levels in this report by using the subscript ‘c’ (SEL_c).

9 Significant Marine Fauna and Hearing

9.1 Significant fauna and habitats

The below information regarding significant fauna and habitats has been summarised from the *Smith Bay Marine Ecological Assessment* prepared by SEA Pty Ltd and dated 6 September 2016; and the Project EPBC Referral, dated July 2016.

Broadly, the marine communities in the vicinity of the site consist of mixed reef and seagrass. The EPBC Protected Matters Search Tool identified the following nationally threatened marine species as potentially occurring or having habitat potentially occurring within the search area:

- 5 mammal species
- 3 reptile species
- 1 shark species.

Table 12: Threatened species listed under the EPBC Act identified from the Protected Matters Search Tool (10 km buffer).

Scientific name	Common name	EPBC Status	Likelihood of occurrence within project site
Mammals			
Balaenoptera musculus	Blue Whale	EN, Mi(Ma)	Unlikely
Eubalaena australis	Southern Right Whale	EN, Mi(Ma)	Possible
Isoodon obesulus obesulus	Southern Brown Bandicoot	EN	Unlikely
Megaptera novaeangliae	Humpback Whale	VU, Mi(Ma)	Unlikely
Neophoca cinerea	Australian Sea-lion	VU, Ma	Likely
Reptiles			
Caretta caretta	Loggerhead Turtle	EN, Mi(Ma)	Unlikely
Chelonia mydas	Green Turtle	VU, Mi(Ma)	Unlikely
Dermochelys coriacea	Leatherback Turtle	EN, Mi(Ma)	Unlikely
Sharks			
Carcharodon carcharias	Great White Shark	VU, Mi(Ma)	Likely

Conservation Codes: CE: Critically Endangered, **EN**: Endangered, **VU**: Vulnerable, **R**: Rare, **Mi (Ma)**: Migratory - Marine, **Ma:** Marine

Of the species identified above, two are likely and one is possibly occurring within the Smith Bay project site. Detailed descriptions of these species are given in Table 13 below.

Table 13: Description of EPBC listed fauna species assessed as having potential to occur within the KIPT Smith Bay Project Site.

Species (and EPBC status)	Description
***Neophoca cinerea (Australian Sea-lion)* – Vulnerable**	Breeding colonies occur on islands or remote sections of coastline. The breeding range extends from the Houtman Abrolhos, Western Australia (WA), to The Pages Island, east of Kangaroo Island, South Australia (SA). Overall, 66 breeding colonies have been recorded to date: 28 in WA and 38 in SA (Shaughnessy 1999). The Australian Sea-lion exhibits high site fidelity and little movement of females between colonies has been observed. There is little or no interchange of females between breeding colonies, even between those separated by short distances (Campbell et al. 2008). About 30% of the population occurs at sites in WA and 70% in SA. The Australian Sea-lion is neither increasing in population numbers nor expanding its range (DAFF 2007). Due to the species' long breeding cycle (17.6 months) the time required to increase population size is longer than for species with shorter breeding cycles (Orsini & Newsome 2005). An analysis of pup production at the Seal Bay colony on Kangaroo Island, SA, indicates a rate of decrease of 0.77% per year (12% decline between 1985–2003) (Shaughnessy et al. 2006). Smaller populations are highly vulnerable to extinction especially in the context of loss to fisheries bycatch and the high site fidelity of females (Goldsworthy et al. 2010). Australian Sea-lions use a wide variety of habitats (Gales et al.1994) for breeding sites (called rookeries) and, during the non-breeding season, for haul-out sites (rest stops, which are also useful for predator avoidance, thermal regulation and social activity) (Campbell 2005). Australian Sea-lions prefers the sheltered side of islands and avoids exposed rocky headlands that are preferred by the New Zealand Fur Seal (*Arctocephalus forsteri*). The Australian Sea-lion has records mainly distributed along the southern coastline of KI (Atlas of Living Australia, http://www.ala.org.au/). It is unlikely that this species would breed within the coastal zone of the project area, given that habitat is unsuitable. However, there is the possibility that this species may pass through the area. Risk to this species is unknown in terms of knowing what impact increased shipping traffic might have on individuals if present in the area. The coastal zone associated with the project area should be micro-sited prior to construction
***Carcharodon carcharias (Great White Shark)* – Vulnerable**	The Great White Shark is the world's largest predatory fish, growing to about 6 meters. It occupies a cosmopolitan range throughout most seas and oceans with concentrations in temperate coastal seas. It is principally known as a pelagic dweller of temperate continental shelf waters. It is found from the intertidal zone to far offshore, and from the surface down to depths over 250 m. One of its most important habitats is along the southern coast of Australia, and in particular off Port Lincoln and Kangaroo Island. Recent tagging and tracking studies have demonstrated that they often undertake long distance coastal movements. Their diet consists of a variety of bony fish, such as snapper and bluefin tuna, sea lions, seals and carrion such as dead whales. Their decline has been attributed to sports-fishing, commercial drumline trophy-hunting and commercial bycatches (IUCN Red List, http://www.iucnredlist.org/details/3855/0).

Species (and EPBC status)	Description
***Eubalaena australis (Southern Right Whale)* – Endangered**	The Southern Right Whale is a baleen whale that feeds on krill in Antarctic waters during summer and migrates to southern Australian waters in winter to calve in winter/spring. Its name derives from early whalers who considered it to be the 'right' whale to hunt as it lives close inshore, floats when dead and produces copious amounts of oil. Consequently, it was hunted during the 19th century to near extinction. Over the last three decades, however, its population has increased significantly with more and more females being observed at calving locations such as Victor Harbor and at the head of the Great Australian Bight (Edgar 1997).

9.2 Marine fauna sounds

Marine animals live in an environment in which vision is not the primary sense because light does not penetrate far beneath the surface of the ocean. As such, marine mammals have become reliant upon sound, instead of light, as their primary sense for communication and being aware of their surrounding environment. Marine mammal communication has a variety of functions such as intra-sexual selection, mother/calf cohesion, group cohesion, individual recognition and danger avoidance.

Baleen whales produce sounds that are primarily at frequencies below 1kHz and have durations from approximately 0.5 to over 1 second and sometimes much longer (Richardson et al. 1995). Humpback whales and some other species produce sounds with frequencies above 1kHz. Many baleen whale sounds are uncomplicated tonal moans or sounds described as knocks, pulses, ratchets, thumps, and trumpet-like. Blue whales for example produce low frequency moans in the frequency range of 10-15Hz.

Pinnipeds, including hair and eared seals and sea lions, produce underwater vocalisations sounding like barks and clicks with frequencies ranging from below 1kHz to 4kHz (Richardson et al. 1995). Pinnipeds are especially vocal during the breeding season.

In summary, baleen whales produce sounds that are dominant at frequencies that overlap with man-made industrial noise (e.g. drilling). In contrast, the social sounds produced by pinnipeds occur above the low-frequency range where most man-made sounds have their dominant energy (with the exception of sonar). Finally, it is noted that the source levels, directionality, maximum detection distances, and functions of most marine animal sounds are unknown or poorly documented (Richardson et al. 1995). It is therefore generally not possible to evaluate the severity of animal sound masking by man-made noise.

9.3 Marine fauna hearing sensitivity

The hearing sensitivity of marine animals generally varies with frequency. Audiograms are therefore used to represent an animal's sensitivity to sounds of different frequencies. An audiogram of a species relates the absolute threshold of hearing (in dB re 1μPa) of that species to frequency. An animal is most sensitive to sounds at frequencies where its absolute threshold of hearing is lowest. As an example, human beings are most sensitive to sounds between 2-4kHz where the absolute threshold is lowest.

9.3.1 Toothed and baleen whales

Behavioural audiograms have been reported for several species of toothed whales (Richardson et al. 1995, Nedwell et al. 2004, Yuen et al. 2008, Popov et al. 2005, Finneran et al. 2008, Finneran et al. 2007, Houser et al. 2008, Hemilä et al. 2001, Szymanski et al. 1999). These species include representatives of the oceanic dolphins, river dolphins, porpoise, and the Narwhal and Belugas, but not the sperm or beaked whales. A number of the reported underwater audiograms are included in Figure 8.

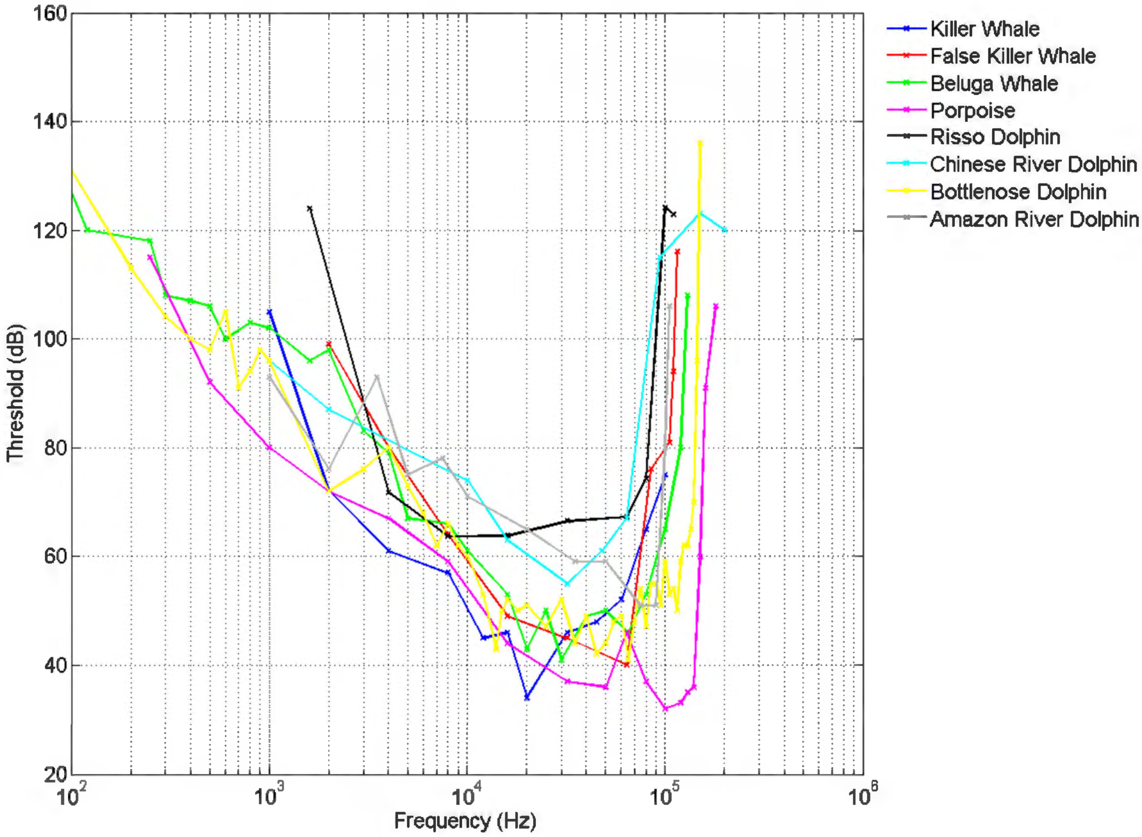

Figure 8: Underwater audiograms of toothed whales (data taken from Nedwell et al., 2004)

The audiograms in Figure 8 indicate that the frequencies where the hearing of toothed whales is most sensitive ranges from 8kHz to 90kHz. The upper limits of auditory sensitivity are believed to range from 100kHz in the killer whale to over 150kHz and sensitivity is typically poor below 1kHz (Richardson *et al.* 1995). The hearing of the beluga and bottlenose dolphin extends at least as low as 40-75Hz but their sensitivity at these low frequencies seems quite poor.

There are no underwater audiograms available for baleen whales, and there is a little data available on their hearing sensitivity. Baleen whale vocalisations are low in frequency content for a number of specie, and the frequency range of acute hearing presumably includes the frequency range of vocalisations. From behavioural observations, it is apparent that baleen whales are quite sensitive to frequencies below 1kHz, but can hear sounds up to a considerably higher but unknown frequency (Richardson et al. 1995).

9.3.2 Seals and sea lions

Underwater audiograms have been obtained for four species of hair seals (monk, harbor, ringed, and harp seals) and two species of eared seals (California sea lion and Northern fur seal). These audiograms are included in Figure 9 (data taken from Nedwell et al. 2004).

In comparison to toothed whales, hair and eared seals (pinnipeds) tend to have lower frequencies of maximum hearing sensitivity, poorer sensitivity at frequencies of maximum hearing sensitivity, and lower high-frequency hearing cut-offs. Some species, however, may have better sensitivity at frequencies below 1kHz than toothed whales (Richardson et al. 1995). The harbour, ringed, and harp seals have relatively flat audiograms from 1kHz to 30-50kHz with thresholds between 60-85dB.

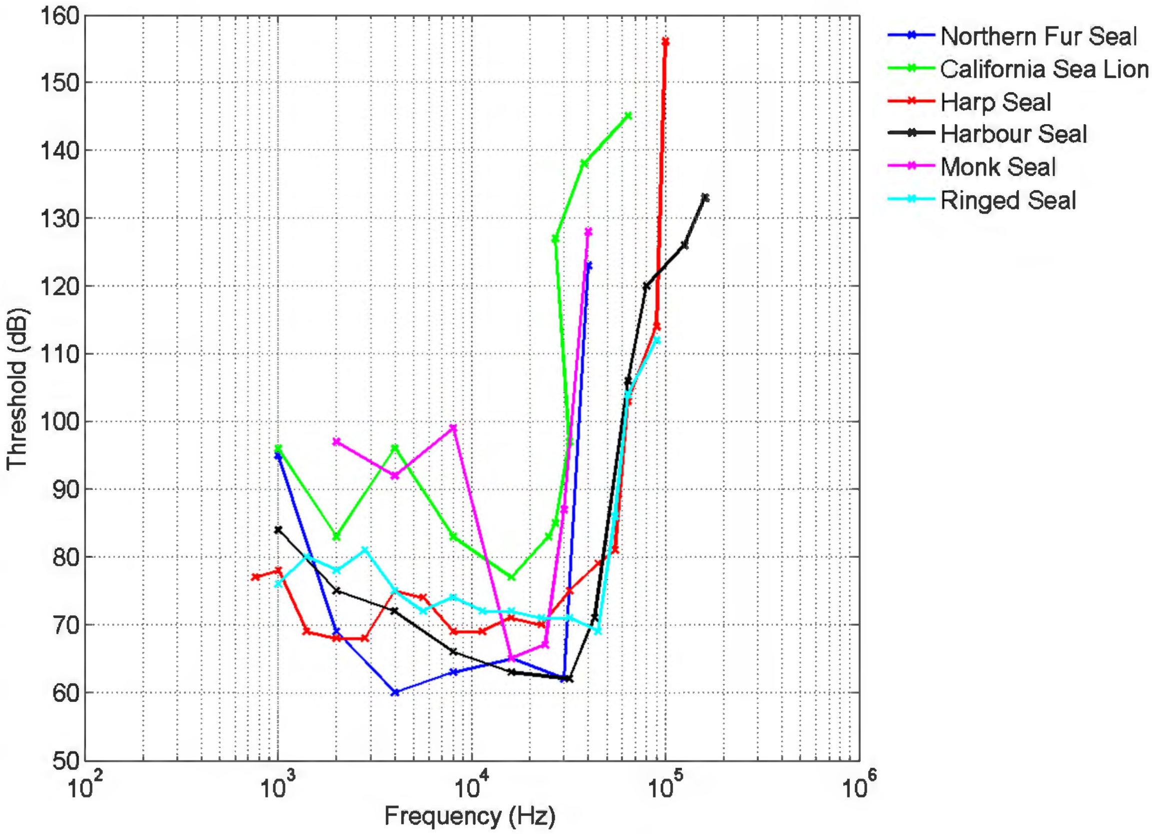

Figure 9: Underwater audiograms for hair and eared seals (data taken from Nedwell et al. 2004).

9.3.3 Fish

All fishes have ears to detect sound and convey sensitivity to gravity and to linear and angular acceleration (Popper et al. 2014). The adaptations that provide fish with additional sensitivity to sound pressure are gas-filled structures near the ear and/or extensions of the swim bladder that functionally affect the ear. The enclosed gas changes volume in response to fluctuating sound pressure, generating particle motion. In fishes where the swim bladder is near the ear (or connected to it mechanically as in the Otophysi), the particle motion radiated from the bladder is sufficiently large to cause the sensory epithelium to move relative to the otolith. Fishes with these adaptations generally have lower sound pressure thresholds and wider frequency ranges of hearing than do the purely particle motion-sensitive species.

Conversely, fish species that lack a gas-filled cavity, including sharks, are not as vulnerable to trauma from extreme sound pressure changes as fish with a gas-filled space. This difference has been demonstrated by comparing the effects of pile driving sounds on fishes with and without a swim bladder (Halvorsen et al. 2012c).

Behavioural audiograms have been published for only a few species of fish and there are concerns about the usefulness of many of these. These concerns arise for two reasons. First, many of these audiograms were obtained under poorly monitored acoustic conditions and it is difficult to determine whether the fish were responding to sound pressure or particle motion. Secondly, many audiograms were determined in conditions where background noise was not measured. Noise can result in the audiograms being masked so that the full hearing sensitivity of the animal cannot be determined.

Hearing abilities among sharks have demonstrated highest sensitivity to low frequency sound (40Hz to approximately 800Hz), which is sensed solely through the particle-motion component of an acoustical field. Free-ranging sharks are attracted to sounds possessing specific characteristics: irregularly pulsed, broad-band (most attractive frequencies: below 80Hz), and transmitted without a sudden increase in intensity. Such sounds are reminiscent of those produced by struggling prey. A sound, even an attractive one, can also result in immediate withdrawal by sharks from a source, if its intensity suddenly increases 20 dB or more above a previous transmission (Myrberg 2001).

9.3.4 Sea turtles

Data on hearing by sea turtles is very limited. Electrophysiological studies on hearing have been conducted on juvenile green sea turtles, juvenile Kemp's Ridleys, and on juvenile loggerheads. Ridgway et al. (1969) obtained an AEP audiogram to aerial and vibrational stimuli that extended from below 100 Hz to 2000 Hz with the lowest threshold at 400 Hz. Other studies using AEPs found similar low-frequency responses to vibrations delivered to the tympanum (the external ear on the surface of the head) for the loggerhead sea turtle, and to underwater sound stimuli for the loggerhead, Kemp's Ridley, and green sea turtles.

Martin et al. (2012) measured underwater thresholds in the loggerhead sea turtle (Caretta caretta) by both behavioural and AEP methods. Behavioural sensitivity showed the lowest thresholds between 100 and 400 Hz, with thresholds at about 100 dB re 1 µPa. AEP measurements on the same individual were up to 8 dB higher; however, both techniques showed a similar frequency response and a high frequency loss of sensitivity above 400 Hz of about 37 dB per octave.

Morphological examinations of green and loggerhead sea turtles (Ridgway et al. 1969; Wever 1978; Lenhardt et al. 1985) describe the sea turtle as having a typical reptilian ear with a few underwater modifications, supporting the proposal that fish hearing, rather than mammalian hearing, is the better model to use for sea turtles until there are much more data.

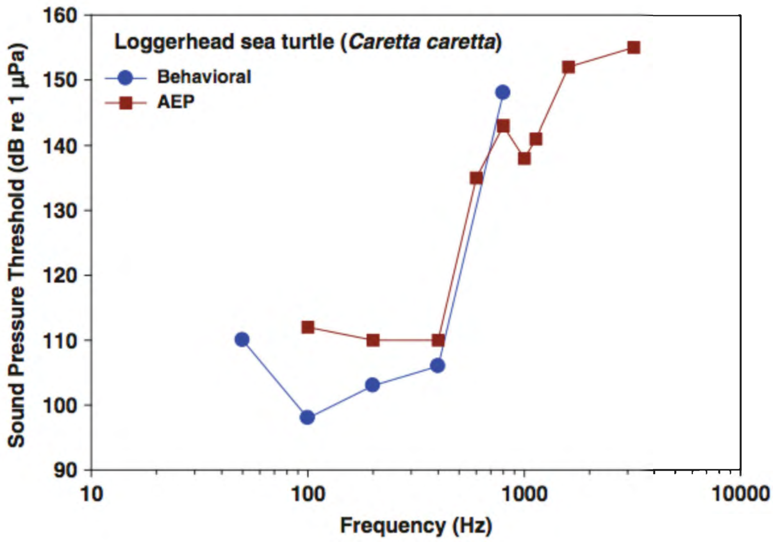

Figure 10: Behavioural and auditory evoked potential thresholds for the Loggerhead sea turtle (Martin et al. 2012)

9.4 Underwater noise impacts

When assessing the effects of underwater noise on marine fauna, there are several levels of impact to consider. In increasing order of severity, these impacts include masking of biologically important sounds, behavioural response, temporary threshold shift (TTS), permanent threshold shift (PTS), and organ damage possibly leading to death.

9.4.1 Cetaceans and pinnipeds

Most studies for cetaceans and pinnipeds generally record a response (behavioural impact) to a noise source without recording the sound level of the source. Availability of information on response to noise levels is very scarce.

There is limited information available on noise levels that cause TTS or PTS in marine mammals. Richardson et al. (1995) extrapolated from information on human threshold levels based on 80dB above threshold causing PTS in humans (exposure of 8 hours a day over about 10 years). This could be used as a rough guideline for sound intensities that could cause TTS in toothed and baleen whales.

The United States (US) National Marine Fisheries Service (NMFS/NOAA 2005) considers that underwater SPLs above 180dB have the potential to injure a marine mammal or marine mammal stock in the wild. The SPL that triggers TTS in harbour seals and sea lions is thought to be 190dB for impulsive sounds. Disruption of behavioural patterns is considered to occur for SPLs above 160dB for impulsive noise and 120dB for continuous noise. The NMFS criteria were set based on behavioural avoidance data for migrating gray whales (Malme et al. 1983;1984).

The background paper to the *EPBC Act Policy Statement 2.1* (DEWR 2007) states that the best estimate currently available for preventing TTS in baleen whales and larger dolphins, such as the killer whale and false killer, is a received SEL threshold of 186dB for a single pulse of sound. To account for the cumulative effect of multiple exposures, the EPBC-policy adopts an SEL threshold of 160dB for a single geophysical survey pulse at 1km. The SEL threshold of 186dB is based on data for the white whale observed (Finneran et al. 2002).

Finneran et al. (2002) reported that peak-to-peak levels of 226dB caused TTS in white whales. Studies of TTS in dolphins suggested that an SEL of 195dB is a reasonable threshold for the onset of TTS in dolphins and white whales (Finneran at al. 2005).

Kastak et al. (2005) predicted that an SEL ranging between 183dB to 206dB causes the onset of TTS in pinnipeds, with the level dependent on absolute hearing sensitivity.

Baleen whales have been shown to respond to drill-ship noise at or above received SPLs of 120dB (Richardson et al. 1990). Based on the literature reviewed in Richardson et al. (1995), it is apparent that most small and medium-sized toothed whales exposed to prolonged or repeated underwater sounds are unlikely to be displaced unless the overall received level is at least 140dB.

9.4.2 Marine mammal frequency-weighting

Species of cetaceans and pinnipeds were assigned to functional hearing groups based on their hearing characteristics by Southall et al. (2007), and adopted by the US National Oceanic and Atmospheric Administration (NOAA) in their *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing.* Each functional hearing group has been assigned an M-weighting function to account for the fact that marine mammals do not hear equally well at all frequencies within their functional hearing range. M-weighting functions de-emphasize frequencies that are near the lower and upper frequency end of the estimated hearing range, where noise levels have to be higher to result in the same auditory effect (Southall et al. 2007).

We note that the latest (2018) Revision to NOAA's guidance incorporates a number of updates to the work of by Southall et al. (2007), including subdivision of Pinnipeds into two groups, and revised M-weighting curves based on the latest data.

Table 14 presents the estimated auditory bandwidth, species relevant to this assessment and the M-weighting function applicable for this functional hearing group.

Resonate

Table 14 Marine mammal functional hearing groups

Functional hearing group	Estimated auditory bandwidth	Relevant species to Project	Functional hearing group M-weighting
Low frequency cetaceans (LF)	7 Hz – 30 kHz	Blue whale Southern Right Whale Humpback Whale	M_{lf}
Mid frequency cetaceans (MF)	150 Hz – 160 kHz	-	M_{mf}
High frequency cetaceans (HF)	200 Hz – 180 kHz	-	M_{hf}
Phocid Pinnipeds (PW)	75 Hz – 100 kHz	-	M_{pw}
Otariid Pinnipeds (OW)	100 Hz – 40 kHz	Australian Sea Lion	M_{ow}

M-weighting curves for marine mammals are presented below in Figure 11 and Figure 12 (from Finneran, 2016).

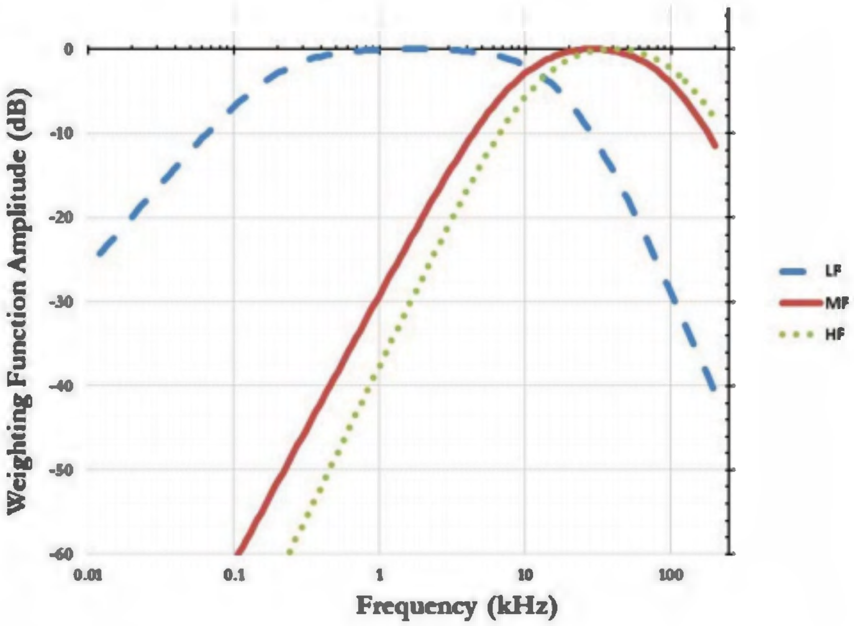

Figure 11: Weighting functions for cetaceans

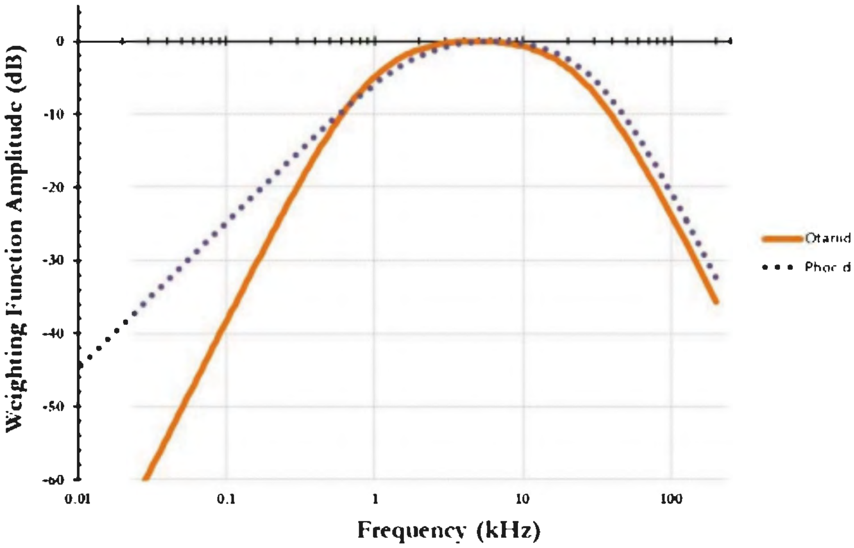

Figure 12: Weighting functions for pinnipeds.

9.4.3 Fish and sea turtles

The *Sound Exposure Guidelines for Fishes and Sea Turtles* (Popper et al., 2014) presents the outcome of a Working Group that was established to determine broadly applicable sound exposure guideline. After consideration of the diversity of fish and sea turtles, guidelines were developed for broad groups of animals, defined by the way they detect sound.

Sharks fall within the category of fish with no swim bladder, and are therefore thought to be less sensitive to noise than species which have a gas-filled cavity. Data on the effects of underwater noise on sea turtles are lacking. Popper et al. (2014) adopts the levels for fish that do not hear well since it is likely these would be conservative for sea turtles. Because of their rigid external anatomy, it is possible that sea turtles are highly protected from impulsive sound effects, for example from pile driving.

Different sound sources were considered in terms of their acoustic characteristics and appropriate metrics defined for measurement of the received levels. The resultant sound exposure guidelines for different noise sources are presented in a set of tables. In some cases, numerical guidelines are provided, expressed in appropriate metrics. When there were insufficient data to support numerical values, the relative likelihood of effects occurring was evaluated, although the actual likelihood of effects depends on the received level.

9.5 Summary

Information on the hearing sensitivity of marine animals is relatively scarce. The hearing sensitivity of differing groups can be broadly described as follows:

- Audiograms for baleen whales have not been measured to date. Baleen whale hearing probably ranges between 20Hz and 20-30kHz. Several of the larger species, such as the blue and fin whales, are thought to hear at infrasonic frequencies as low as 10Hz.
- True seals (pinnipeds) tend to hear higher frequencies underwater than fur seals and sea lions. Some pinnipeds hear moderately well in both water and air, whereas others are better adapted for underwater than in-air hearing. The harbour, ringed, and harp seals have best underwater hearing sensitivity between 1kHz and 30-50kHz.
- Sharks lack a swim bladder, and are therefore not as vulnerable to trauma from extreme sound pressure changes as fish with a gas-filled space, and are thought to have low hearing sensitivity.
- Data on hearing by sea turtles is limited. However, available data for loggerhead, green and leatherback turtles indicate a hearing range of 100Hz to 1kHz, with the highest sensitivity lower than 400Hz.

10 Legislation and policy

10.1 Legislation

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is the central piece of environmental legislation relevant to this assessment. It provides the legal framework to protect and manage nationally and internationally important biota, ecological communities and heritage places, which are defined in the Act as 'matters of National Environmental Significance' (matters of NES). Under the provisions of the Act, it is an offence for any person to take an action that is likely to have a significant impact on matters of NES without approval.

There are nine matters of NES protected by the EPBC Act:

- World Heritage properties
- National Heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Migratory species (listed under international agreements)
- Nationally threatened species and ecological communities (listed under the EPBC Act)
- The Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mining)
- A water resource, in relation to coal seam gas development and large coal mining development.

In this case, the EPBC Act assessment is triggered by two matters of NES, namely migratory species and nationally threatened species and ecological communities.

Matters of NES

Under the EPBC Act, the listed species of concern to the study area are identified in Table 12 Note the status of threatened species as either endangered or vulnerable, and whether the species is also migratory is listed. The EPBC Act provides for an environmental impact assessment to be undertaken for certain activities which are likely to have an impact on matters of NES.

10.2 EPBC Act Policy Statement

Regulation of underwater noise impacts is currently limited to policy outlined by the Department of the Environment and Energy which fall under the EPBC Act, namely the *EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales* (*Department of the Environment and Water Resources, 2008).*

The aim of the *EPBC Act Policy Statement 2.1* is to:

- Provide practical standards to minimise the risk of acoustic injury to whales in the vicinity of geophysical survey operations.
- Provide a framework that minimises the risk of biological consequences from acoustic disturbance from geophysical sources to whales in biologically important habitat areas or during critical behaviours.
- Provide advice to operators conducting geophysical surveys on their legal responsibilities under the EPBC Act.

This policy updates and replaces the previous Guidelines (produced 2001). It is noted that the policy should be read in conjunction with the associated Background Paper.

The policy states: *This Policy has been written with the goal of minimising the likelihood of injury or hearing impairment of whales based on current scientific understanding. Calculations are primarily based on received sound energy levels that are estimated to lead to a temporary threshold shift (TTS[1]) in baleen whale hearing. This Policy is*

[1] Sound at any level can cause hearing damage by decreasing auditory sensitivity. One of the most common mild traumatic effects is a threshold shift. After this level of auditory trauma, the threshold becomes higher and hearing sounds becomes more difficult.

not intended to prevent all behavioural changes, which might occur in response to detectable, but non-traumatic sound levels. In fact, it is likely that whales in the vicinity of geophysical surveying will avoid the immediate area due to an aversive response to the sound.

The Policy Background Paper also recognises the uncertainties related to understanding the sound levels to cause TTS as well as the cumulative effect of multiple exposures in whales. The policy therefore adopts an SEL threshold of 160dB for a single geophysical 'shot' at 1km which should not be exceeded for 95% of the time.

The SEL threshold value is used in the policy to determine whale exclusion zones where geophysical surveys must lower their acoustic power output, or shut down completely, in order to prevent significant exposure to sound levels that could induce TTS. If SELs from air-gun shots fall below this threshold, they can operate with a reduced 1km exclusion zone while if they are above this threshold, the surveys are required to operate with the default 2km exclusion zone.

It is noted that the Policy is intended to minimise the likelihood of injury, rather than behavioural changes in whales, and while the noise policy may be suitable for temporary construction noise sources of a similar impulsive character to airgun noise, it is not considered suitable as a criterion for long term and fixed location industrial noise.

Although industrial related noise is a recognised form of pollution, industrial sources of noise in the marine environment are currently unregulated. Unlike noise propagated in the air, which affects everyday human life and is closely monitored, assessed and regulated, underwater noise and its effects on the marine environment have to date been largely ignored.

10.3 DPTI Underwater piling noise guidelines

The Department of Planning, Transport and Infrastructure (DPTI) has prepared *Underwater Piling Noise Guidelines* (DPTI, 2012) to provide a framework for its staff and contractors to determine practicable mitigation measure that minimise impacts to marine mammals in the vicinity of piling activity. Precaution zones are defined for both impulsive (impact piling) and continuous noise sources based on calculations of sound levels to prevent temporary or permanent hearing threshold shift to marine mammals.

The DPTI guidelines adopt physiological noise exposure (TTS and PTS) criteria based which are based on the study presented by Southall et al. (2007), and interim noise exposure criteria adopted by the NOAA (2011). DPTI 2012 criteria are presented in Table 15 below.

Table 15: Physiological noise exposure (TTS and PTS) criteria, DPTI 2012.

Hearing group	Impact	Physiological noise exposure criteria	
		Impulsive	Non-impulsive
Low Frequency (LF) Cetaceans	TTS	224 dB$_{peak}$ 183 dB(M$_{lf}$) SEL	SPL 180 dB re 1 µPa
	PTS	230 dB$_{peak}$ 198 dB(M$_{lf}$) SEL	230 dB$_{peak}$ 215 dB(M$_{lf}$) SEL
Mid Frequency (MF) Cetaceans	TTS	224 dB$_{peak}$ 183 dB(M$_{mf}$) SEL	SPL 180 dB re 1 µPa
	PTS	230 dB$_{peak}$ 198 dB(M$_{mf}$) SEL	230 dB$_{peak}$ 215 dB(M$_{mf}$) SEL

Threshold shifts may be temporary (TTS) or can be permanent (PTS) with greater intensities of noise. These threshold shifts are caused by hair cell fatigue, hair cell damage or nerve degeneration.

Hearing group	Impact	Physiological noise exposure criteria	
		Impulsive	Non-impulsive
High Frequency (HF) Cetaceans	TTS	224 dB_{peak} 183 $dB(M_{hf})$ SEL	SPL 180 dB re 1 µPa
	PTS	230 dB_{peak} 198 $dB(M_{hf})$ SEL	230 dB_{peak} 215 $dB(M_{hf})$ SEL
Pinnipeds	TTS	212 dB_{peak} 171 $dB(M_{pw})$ SEL	SPL 190 dB re 1 µPa
	PTS	218 dB_{peak} 186 $dB(M_{pw})$ SEL	218 dB_{peak} 203 $dB(M_{pw})$ SEL

SEL noise exposure criteria are M-weighted levels expressed in dB(M) re 1 µPa2·s, while peak levels are expressed as dB re 1 µPa (unweighted).

The DPTI Guidelines also present 'safety zones' for impact piling and vibro-driving activities, together with the estimated zone of behavioural response. The safety zones are sized by comparing expected received noise levels with the following noise exposure thresholds:

- Impact piling – Noise exposure threshold is SEL 150 dB(M) re 1 μPa^2.s for a single impact at either 100 m or 300 m.
- Vibro-driving – Noise exposure threshold is SPL 180 dB re 1 µPa at 10 m for cetaceans and SPL 190 dB re 1 µPa at 10 m for pinniped.

As noted in Section 9.4 above, the above criteria were based on interim (2011) NOAA guidance which has since been updated on a number of occasions to reflect the latest research. The underwater noise criteria for this assessment are based on the latest data and guidance, and are described below.

10.4 Underwater noise criteria

Appropriate noise criteria may be determined by analysing the noise source types and expected activity durations against the potentially affected marine faunal species likely to habituate or migrate through the study area. The noise source durations may be split into two distinct categories, namely construction sources and operational sources.

10.4.1 Construction sources

Construction activities are temporary noise sources which emit noise for specific periods during the project construction phase. It is generally desired that construction noise criteria provide an appropriate balance between noise impact to marine fauna and the economics involved to mitigate noise.

Noise mitigation can be achieved either by implementing source control methods, or strategic planning of activities to avoid known times of potential marine fauna sensitivity (e.g. during whale migration periods). Unnecessary restriction on construction activities can prolong the overall project impact to an area as well as significantly increase costs.

10.4.2 Operational sources

Operational activities are long term noise sources which emit noise over the life of the project. Unlike construction noise sources, they are not temporary and as a consequence the noise emission may have the potential to impact an area for a long period over a number of consecutive years. For this reason, it is desired that the operational noise emission does not significantly add to the existing ambient underwater noise in an area. This approach is similar to that adopted for industrial facilities located nearby to residential areas or other sensitive land uses. Note that air-borne noise assessment criteria have been developed around the annoyance and hearing sensitivity of humans.

10.4.3 Adopted underwater noise criteria

The adopted underwater noise criteria shown below are based on NOAA *Marine Mammal Acoustic Technical Guidance* (2018), and the *Sound Exposure Guidelines for Fishes and Sea Turtles* (Popper et al., 2014). These represent the most up to date research and approach for the species considered in this assessment.

The adopted criteria are generally more stringent than the DPTI *Underwater Piling Noise Guidelines* criteria.

Table 16: Adopted underwater noise criteria

Species	Source character	Organ damage	PTS	TTS	Behavioural Response
Low Frequency (LF) Cetaceans • Blue whale • Southern Right Whale • Humpback Whale	Continuous	> SPL 200 dB	SEL_C 199 dB(M_{lf})	SEL_C 179 dB(M_{lf})	SPL 120 dB
	Impulsive	> SPL 200 dB	Peak 219 dB SEL_C 183 dB(M_{lf})	Peak 213 dB SEL_C 168 dB(M_{lf})	SPL 160 dB
Otariid Pinnipeds • Australian Sea-lion	Continuous	> SPL 200 dB	SEL_C 219 dB(M_{ow})	SEL_C 199 dB(M_{ow})	SPL 120 dB
	Impulsive	> SPL 200 dB	Peak 232 dB SEL_C 203 dB(M_{ow})	Peak 226 dB SEL_C 188 dB(M_{ow})	SPL 160 dB
Fish (no swim bladder) • Great White Shark	Continuous	**N**: Low **I**: Low **F**: Low	**N**: Low **I**: Low **F**: Low	**N**: Moderate **I**: Low **F**: Low	**N**: Moderate **I**: Moderate **F**: Low
	Impulsive	Peak 213 dB SEL_C 219 dB	Peak 213 dB SEL_C 216 dB	SEL_C 186 dB	**N**: High **I**: Moderate **F**: Low
Turtles • Loggerhead Turtle • Green Sea Turtle • Leatherback Turtle	Continuous	**N**: Low **I**: Low **F**: Low	**N**: Low **I**: Low **F**: Low	**N**: Moderate **I**: Low **F**: Low	**N**: High **I**: Moderate **F**: Low
	Impulsive	Peak 207 dB SEL_C 210 dB	**N**: High **I**: Low **F**: Low	**N**: High **I**: Low **F**: Low	**N**: High **I**: Moderate **F**: Low

(1) N (near), I (intermediate), F (far) distance from the noise source.

Popper et al. (2014) note that where insufficient data exist to make a recommendation for guidelines a subjective approach is adopted in which the relative risk of an effect is placed in order of rank at three distances from the source – near (N), intermediate (I), and far (F) (top to bottom within each cell of the table, respectively). While it is not appropriate to ascribe particular distances to effects because of the many variables in making such decisions, "near" might be considered to be in the tens of meters from the source, "intermediate" in the hundreds of meters, and "far" in the thousands of meters. The level of risk for continuous sources is based on typical shipping noise, while the risk for impulsive sources is based on impact piling.

11 Ambient Noise Environment

11.1 Open ocean environment

The ocean is filled with sound that is generated by a variety of natural sources, such as rain, breaking waves, marine life, and man-made sources, such as shipping and sonar activity. The ambient noise levels of open ocean environments are graphically depicted by the Wenz noise curves illustrated in Figure 13 (Wenz, 1962).

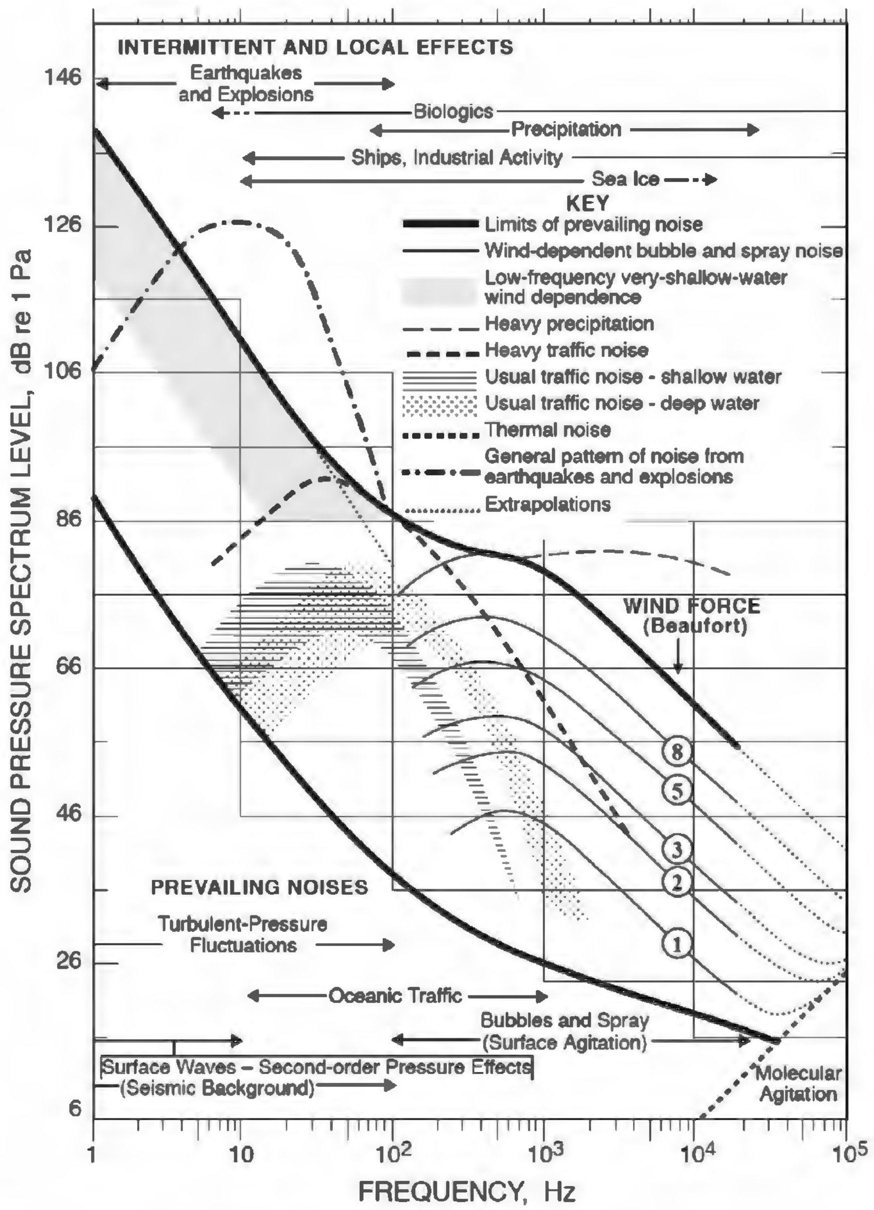

Figure 13: The Wenz noise curves (Wenz, 1962) for ambient noise in open ocean environments.

Figure 13 indicates that between 20Hz and 500Hz, ambient noise is primarily due to noise generated by distant shipping. Even after removing any noise generated by ships close to the receiver, distant ships can be detected. The amount of noise is greater in regions with heavy shipping traffic. There tend to be fewer ships in the southern hemisphere, and low-frequency ambient noise levels are substantially lower as a result.

Between 500Hz and 100kHz, ambient noise is mostly due to spray and bubbles associated with breaking waves, where the noise increases with increasing wind speed. Above 100kHz, ambient noise is dominated by the noise generated by the random motion of water molecules which is called thermal noise.

Physical processes that intermittently generate sound in the ocean include rain, lightning striking the sea surface, cracking sea ice, undersea earthquakes, and eruptions from undersea volcanoes. Some of these phenomena generate extremely loud sounds, such as lightning strikes, which can have source levels of up to 260dB at 1m. Heavy rain can increase noise levels by up to 35dB across a broad range of frequencies extending from several hundred Hertz to greater than 20kHz.

The sounds produced by marine life can also contribute to the ambient noise levels. Marine mammal calls can actually increase ambient noise levels by 20-25dB in some locations at certain times of the year. Certain types of fish and marine invertebrates also produce sounds. For example, sound generated by colonies of snapping shrimp, which inhabit shallow warmer waters having a bottom of rock, shell, or weed that offers some concealment, can dominate other sources of background noise.

11.2 Shallow water environment

The study area is a shallow water coastal environment. Ambient noise levels in shallow water vary widely in frequency and level distributions depending on time and location (Richardson et al. 1995). The three primary sources in most shallow water regions are distant shipping, industrial, or geophysical-survey noise; wind and wave noise; and biological noise.

In comparison to deep water, a wider range of ambient noise levels occurs in shallow water under corresponding wind and wave conditions (Richardson et al. 1995). Above approximately 500Hz, ambient noise levels in coastal areas are often 5-10dB higher than in deep water for the same wind speeds. In the absence of shipping and biological noise, however, low-frequency (<300Hz) ambient noise levels can be lower in shallow water than in deep water.

The Project site is on the northern side of Kangaroo Island within the St Vincent Gulf and therefore sheltered to some extent from strong onshore winds. Ambient noise levels in shallow waters are directly related to wind speed. For wind speeds above 2.5m/s, the ambient noise level in the frequencies range between 50Hz and 20kHz is better predicted by wind speed than by wave height (Richardson et al. 1995).

The main shipping route between Adelaide and Western Australia via Investigator Strait is located at a distance of approximately 20km due north from the study area. Calculations indicate that the noise levels from shipping traffic are likely to be at a similar level to the ambient background, that is approximately 90dB at frequencies below 1kHz.

The marine traffic density in the vicinity of the project site is shown in Figure 14.

Figure 14: Marine traffic density in the vicinity of the project site, 2017 (Source: www.marinetraffic.com)

11.3 Baseline underwater noise measurements

The existing ambient noise environment within the marine study area was measured between the 7th and 16th of December 2017, using a Loggerhead Instruments DSG-ST Ocean Acoustic Datalogger Hydrophone. Data was collected at a sampling rate of 50 kHz.

Measurements were undertaken in the location shown in Figure 15, some 600m north of the shoreline, with the hydrophone at a depth of approximately 14 m.

The hydrophone was deployed from a boat and anchored to the seabed using weights. The instrument was suspended in the water column by a combination of self-buoyancy and a supplementary buoy, such that the transducer was approximately 1.5 m above the sea bed. A surface buoy was used to mark the location for retrieval.

Figure 15: Baseline underwater noise measurement location

11.3.1 Results

Underwater noise data were processed in intervals of 100 seconds. For each interval the overall sound pressure level and spectra were calculated from the raw waveform data.

The variation of overall sound pressure level (SPL dB re 1 μPa) over time is shown in Figure 16, along with wind speed measured at the nearest Bureau of Meteorology (BOM) station (Kingscote). The results show noise levels generally varied between approximately 85 and 130 dB dB re 1 μPa, with the exception of the beginning and end of the measurement period, which were affected by noise from the boat used for deployment and retrieval. A noise level exceeding 130 dB dB re 1 μPa was also measured on the 14th of December. The audio for this period indicates a series of impacts on the hydrophone, possibly from a fish or similar.

A reasonably strong correlation between wind speed and overall sound pressure level was observed as expected from Richardson et al. 1995. The sea state during measurements can be determined from the Beaufort Scale as detailed in Table 2 below. Wind speed was less than 10 m/s for the duration of the measurement period, corresponding to sea state 5 or less.

Table 17: Beaufort wind force scale

Beaufort number	Description	Wind speed, m/s	Wave height, m	Sea conditions
0	Calm	< 0.3	0	Sea like a mirror
1	Light air	0.3 – 1.5	0 – 0.2	Ripples with appearance of scales are formed, without foam crests
2	Light breeze	1.6 – 3.3	0.2 – 0.5	Small wavelets still short but more pronounced; crests have a glassy appearance but do not break
3	Gentle breeze	3.4 – 5.5	0.5 – 1	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses
4	Moderate breeze	5.5 – 7.9	1 – 2	Small waves becoming longer; fairly frequent white horses
5	Fresh breeze	8.0 – 10.7	2 – 3	Moderate waves taking a more pronounced long form; many white horses are formed; chance of some spray
6	Strong breeze	10.8 – 13.8	3 – 4	Large waves begin to form; the white foam crests are more extensive everywhere; probably some spray
7	High wind, moderate gale, near gale	13.9 – 17.1	4 – 5.5	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind; spindrift begins to be seen
8	Gale, fresh gale	17.2 – 20.7	5.5 – 7.5	Moderately high waves of greater length; edges of crests break into spindrift; foam is blown in well-marked streaks along the direction of the wind
9	Strong / severe gale	20.8 – 24.4	7 – 10	High waves; dense streaks of foam along the direction of the wind; sea begins to roll; spray affects visibility
10	Storm whole gale	24.5 – 28.4	9 – 12.5	Very high waves with long overhanging crests; resulting foam in great patches is blown in dense white streaks along the direction of the wind; on the whole the surface of the sea takes on a white appearance; rolling of the sea becomes heavy; visibility affected
11	Violent storm	28.5 – 32.6	11.5 – 16	Exceptionally high waves; small- and medium-sized ships might be for a long time lost to view behind the waves; sea is covered with long white patches of foam; everywhere the edges of the wave crests are blown into foam; visibility affected
12	Hurricane force	≥ 32.7	≥ 14	The air is filled with foam and spray; sea is completely white with driving spray; visibility very seriously affected

We note that during higher wind speeds (above approximately 5 m/s), measurements may have been affected by noise resulting from movement of the surface buoy and rope due to wave activity. Self-noise from current passing over the hydrophone may also generate noise at frequencies typically below 20 Hz.

Resonate

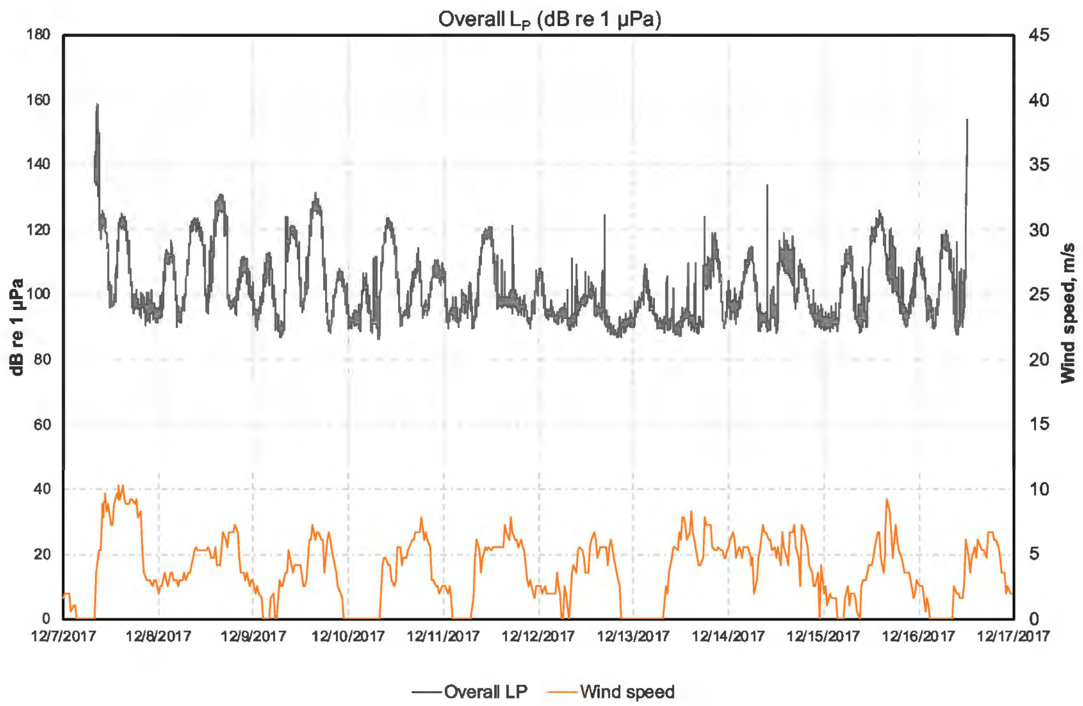

Figure 16: Overall sound pressure level variation over time

One third octave spectra and power spectral density were also determined for periods with the maximum, minimum, and average overall sound pressure levels, which are shown in Figure 17 and Figure 18 respectively. The average period was determined both as an energy (L_{eq}) average and a linear average of overall sound pressure levels.

Averaged spectra are within the expected limits of prevailing noise as depicted in Figure 13.

Resonate

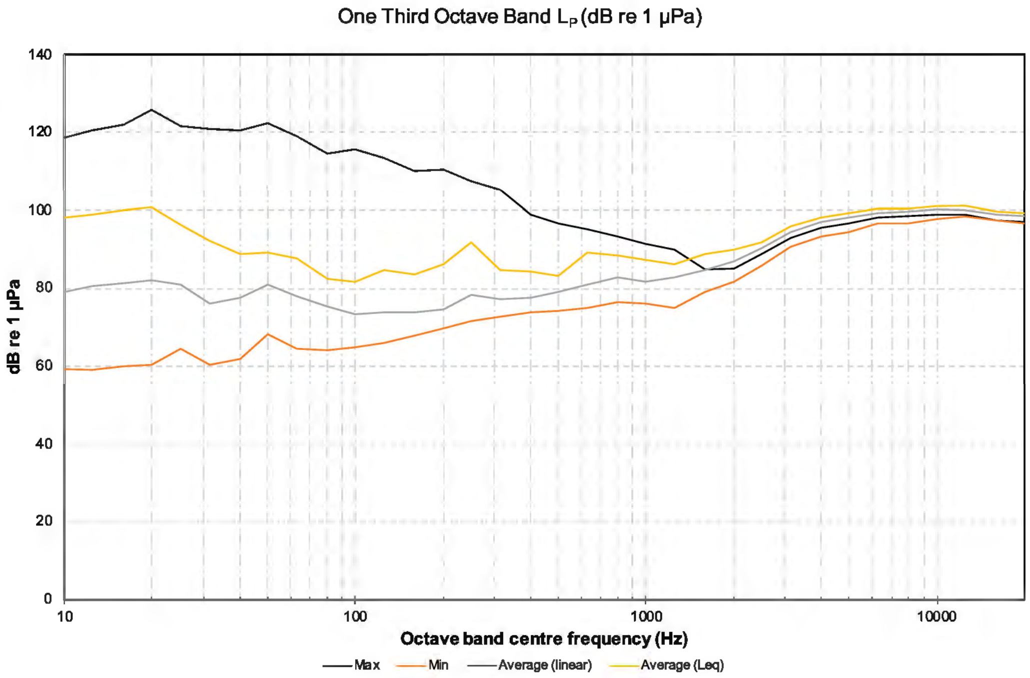

Figure 17: One third octave band sound pressure levels for selected periods.

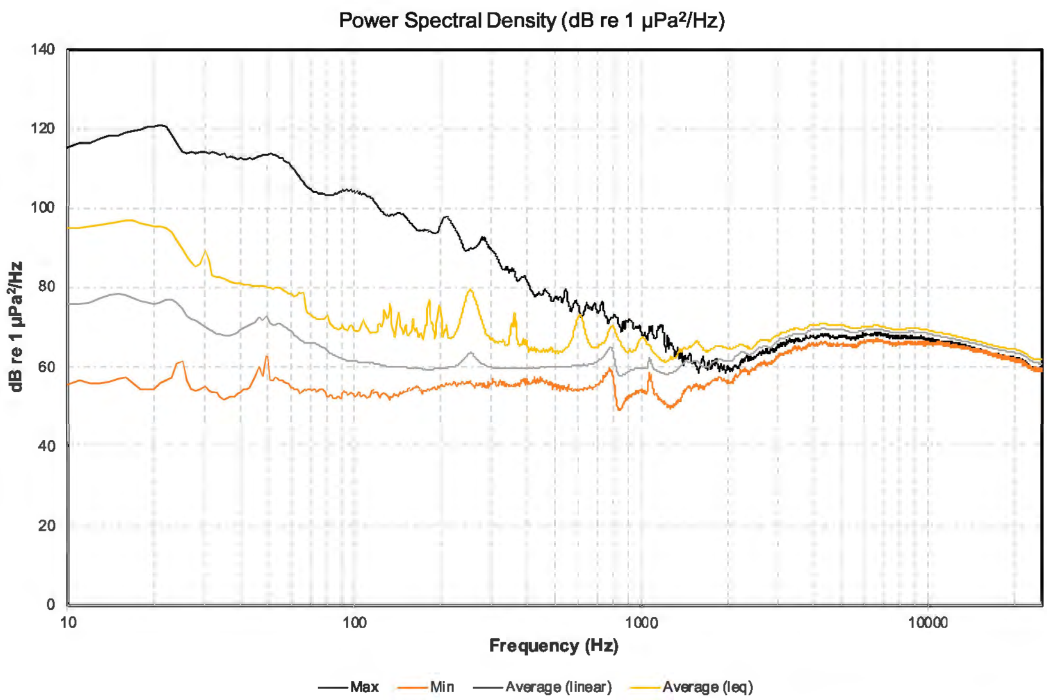

Figure 18: Power spectral density for selected periods.

12 Noise Source Characterisation

As described in Section 2, construction activities include dredging and piling. Operational activities include the movement of timber export and other vessels.

12.1 Dredging

A combination of grab dredging and cutter suction dredging may be employed, as described below. There would be no blasting during dredging works. If the substrate was found to be too hard for traditional dredging, a long-arm excavator/backhoe mounted on a jack-up barge may be employed.

12.1.1 Grab dredging

A grab dredge (GD), sometimes called a clamshell dredge, is typically a conventional wire crane mounted on a pontoon. The seabed materials are excavated by the mechanical bucket of the crane and raised by the hoisting movement of the wire. The materials are dumped onto a separate material transport barge. Once loaded to capacity, this barge would be towed by tug boats to the on-shore discharge location, where it would be offloaded and transported to storage and/or disposal areas.

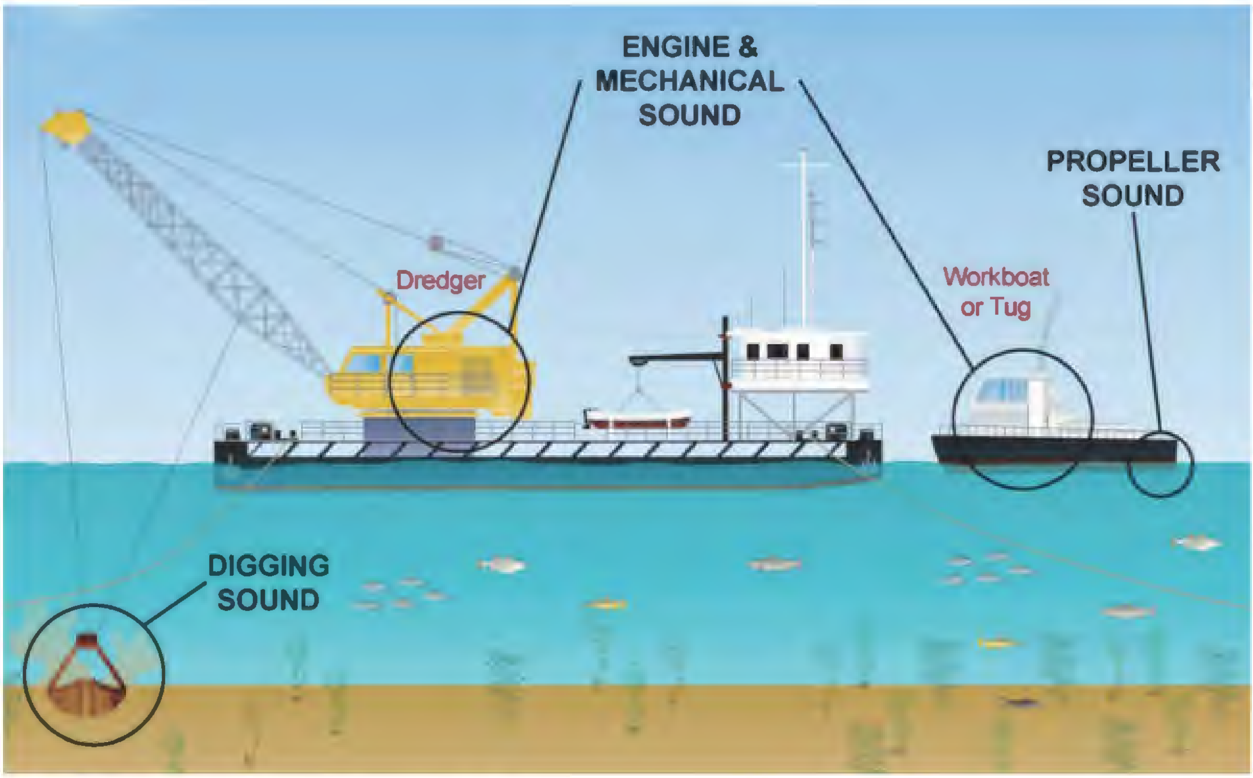

Figure 19: Grab dredging noise sources (CEDA, 2011)

There is limited noise data in the literature relating to GD noise levels. One study (Dickerson et al., 2001), measured noise from various GD activities at a distance of 150m. A level of 124 dB re 1μPa was measured due to bottom contact of the bucket, and 113 dB re 1μPa during digging of sediment. Assuming a propagation loss of 15 Log(r), these equate to source levels of 157 and 146 dB re 1μPa @ 1m, respectively.

12.1.2 Cutter suction dredging

A cutter suction dredger (CSD) dislodges the seabed materials with a rotating device equipped with cutting teeth. The loosened material is sucked into the cutter head's suction mouth located by a centrifugal pump installed on the pontoon or the ladder of the dredger. The dredged material is then transported hydraulically to the relocation or discharge site through a discharge pipeline (partly floating, partly land-based). CSDs are used mainly for capital dredging (dredging in harder soils) where the excavated material is transported no further than 5–10 km.

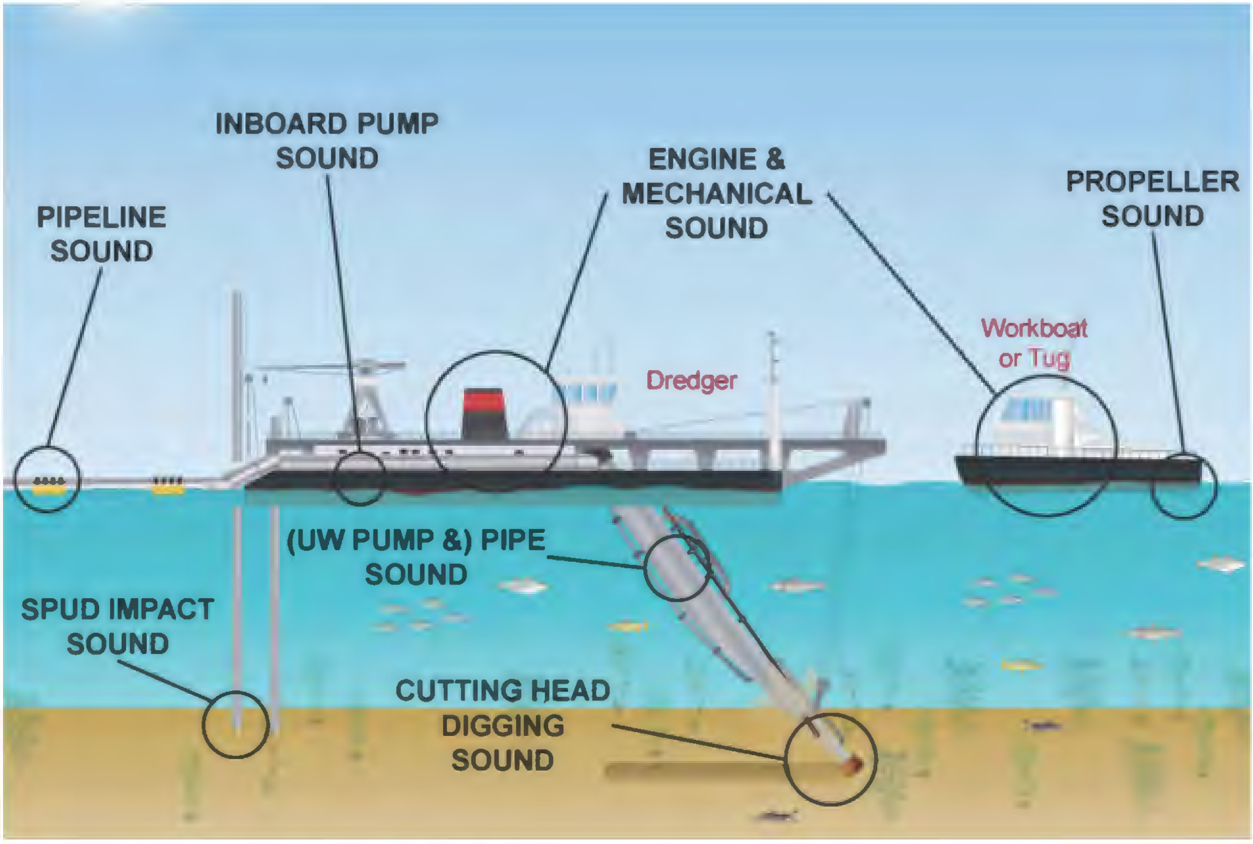

Figure 20: CSD dredging noise sources (CEDA, 2011)

Based on previous measurements in the literature, source levels for CSDs range from 158 to 187 dB re 1µPa @ 1m depending on the vessel size, activity being undertaken and the environmental conditions at the time of monitoring. A source level of 187 dB re 1µPa @ 1m has been adopted for this assessment, representing worst-case noise levels.

12.1.3 Backhoe dredging

Noise sources associated with dredging by means of an excavator on a jack-up barge are essentially the same as backhoe dredging, with the exception of spud anchoring and "walking" associated with backhoe dredge pontoons. Source levels are therefore expected to range between 154 and 179 dB re 1µPa @ 1m.

12.1.4 Summary

Of the types of dredging which may be employed, CSD is expected to generate the highest noise levels, by a significant margin. A conservative approach has been adopted for this assessment, whereby modelled dredging noise levels are based on CSD methodology.

12.2 Piling

Pile driving techniques include impact pile driving, where a pile is hammered into the ground by a hydraulic ram, and vibro-driving, where rotating eccentric weights create an alternating force on the pile, vibrating it into the ground.

- Impact piling – Impulsive in character with multiple pulses occurring at blow rates in the order of 30 to 60 impacts per minute. Typical source levels range from SEL 170–225 dB re 1 µPa^2·s for a single pulse, and peak level 190–245 dB re 1 µPa. Most of the sound energy usually occurs at lower frequencies between 100 Hz and

1 kHz. Factors that influence the source level include the size, shape, length and material of the pile, the weight and drop height of the hammer, and the seabed material and depth.
- Vibro-driving – Continuous in character and usually of a much lower level than impact piling. Typical source levels range from SPL 160–200 dB re 1 µPa, with most of the sound energy occurring between 100 Hz and 2 kHz. Strong tones at the driving frequency and associated harmonics may occur with the driving frequency typically ranging between 10 and 60 Hz. Sound propagation at such low frequencies is often poor in shallow water environments, such that the tones may not be noticeable at greater distances from the source.

For the purposes of this assessment it is assumed that the primary piling methodology is impact piling. On average around one pile will be installed per day, with a total of approximately 140 piles to be installed. Up to 1,800 impacts per day may be expected during piling.

Based on a steel pile diameter of approximately 0.9m, a source level of SEL 198 dB re 1 $\mu Pa^2 \cdot s$ per impact and a peak level of 225 dB re 1 µPa @ 1m have been determined from (Rodkin et. al.).

12.3 Vessels

The underwater noise associated with both construction and operational activity will vary significantly depending on the type of vessels used and how they are operated. The range of noise from boats is generally SEL 110–195 dB re 1 $\mu Pa^2 \cdot s$. A source level of 170 dB re 1 $\mu Pa^2 \cdot s$ has been assumed for this assessment, and is considered to represent the upper range of expected vessels. Up to 10 vessel movements per day may be expected during peak times during construction or operation, with the majority of these being smaller boats.

13 Ocean Acoustic Modelling

13.1 Basic principles

The spreading of source noise throughout the ocean environment is generally modelled using the *source-path-receiver* model illustrated in Figure 21. This model recognises that an underwater noise assessment involves a noise source with particular characteristics, changes in noise characteristics as the noise propagates away from the source, and a receiver with specific hearing or detection capabilities.

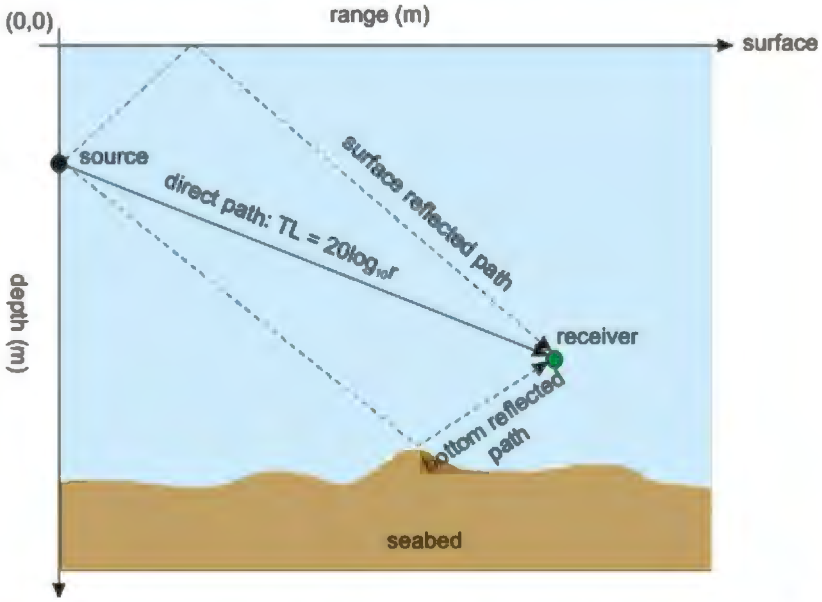

Figure 21: Source-path-receiver model used for predicting sound transmission from source to receiver (DPTI 2012)

As illustrated in Figure 21, the transmission path is often not only the straight line between the source and receiver. Multiple transmission paths can occur due to reflections from the surface and seafloor. Furthermore, a rough surface or seafloor causes scattering of the source noise, and some of the noise impacting on the seafloor is absorbed. As a result, the total sound transmission loss between a source and receiver is typically a combination of various transmission loss mechanisms such as geometrical spreading, absorption, scattering, refraction, etc.

Along the direct path between the source and the receiver, the noise level drops off at 20 $\log_{10}(r)$ with r the distance from the source, i.e. the range. This effect is referred to as spherical spreading or the geometric spreading of the sound energy emitted by the noise source. Additional transmission losses (on top of the spherical transmission loss) typically occur due to, for instance, absorption of sound and scattering of sound waves at the surface and seafloor. These transmission loss mechanisms are generally frequency dependent and depend on the seafloor geo-acoustic properties and the surface and seafloor roughness.

The total transmission loss between a source and a receiver can also be smaller than the transmission loss due to spherical spreading alone. This, for example, occurs when surface and seafloor reflected sound waves interfere at the receiver location such that the noise level is increased, i.e. the transmission loss is reduced. For the frequencies of importance to this assessment, the transmission loss is expected to be less than spherical spreading because the sea surface and seabed of the study area are highly reflective at the small grazing angles that are important for long range propagation.

13.2 Methodology

13.2.1 Parabolic equation (RAM) method

The US Naval Research Laboratory's Range-dependent Acoustic Model (RAM) has been used to compute acoustic propagation via a parabolic equation solution to the acoustic wave equation (Collins, 1993, 1999). The model inputs are bathymetry, sediment properties, and sound speed profile. RAM has been extensively benchmarked and is widely employed in the underwater acoustics community. The RAM model is most applicable to low frequencies and shallow water.

Noise levels have been modelled at third octave band frequencies between 12.5 Hz and 2 kHz. The modelled frequency range is considered representative of the noise source and hearing sensitivity of relevant species, and is within the accepted range of accuracy of the model.

Noise levels were predicted in 5 degree intervals around a 180 degree arc with a radius of 10 km from the source location. The nominal source location is a point approximately 400 m from the shoreline (at the position of the proposed wharf). Both the source and receivers were modelled at 5 m depth.

13.2.2 Bathymetry

Bathymetry data obtained from Geoscience Australia was used to determine the seabed depth within the area of interest, as shown in Figure 22.

Figure 22: Bathymetry within the area of interest

13.2.3 Seabed acoustic properties

The seabed structure assumed in the RAM model is based on the *Assessment of Marine Sediments* report (draft V4 dated 14 September 2018, and the *Geotechnical Investigation Report*, dated 30 November 2017.

We understand that the seabed consists of sediment (silty sand) to a depth of up to 1.4 m, overlying a substrate of clay, cobbles, gravel, sandstone, mudstone, and conglomerate of unknown depth. To simplify the calculation steps required within the sound transmission model, a bedrock layer was included below the substrate at a depth of 500m.

The geo-acoustic properties of the sand, substrate (assumed to be equivalent to sandstone for the purpose of the model) and bedrock layers that were included in the RAM model are given in Table 18.

Table 18: Geo-acoustic properties of seabed included in the RAM model.

Geo-acoustic property	Seabed layer		
	Sand	Semi Consolidated Sand	Bedrock
Compressional wave speed (m/s)	1650	2400	2800
Compressional wave absorption (dB/λ)	0.8	1.5	0.05
Density (kg/m³)	1900	2300	2700

13.2.4 Sound speed profile

Based on the expected range of water temperature and salinity, the sound speed is not expected to vary significantly with water depth. A constant sound speed of 1506 m/s in water has been adopted for this assessment.

13.3 Predicted noise levels

13.3.1 CSD Dredging

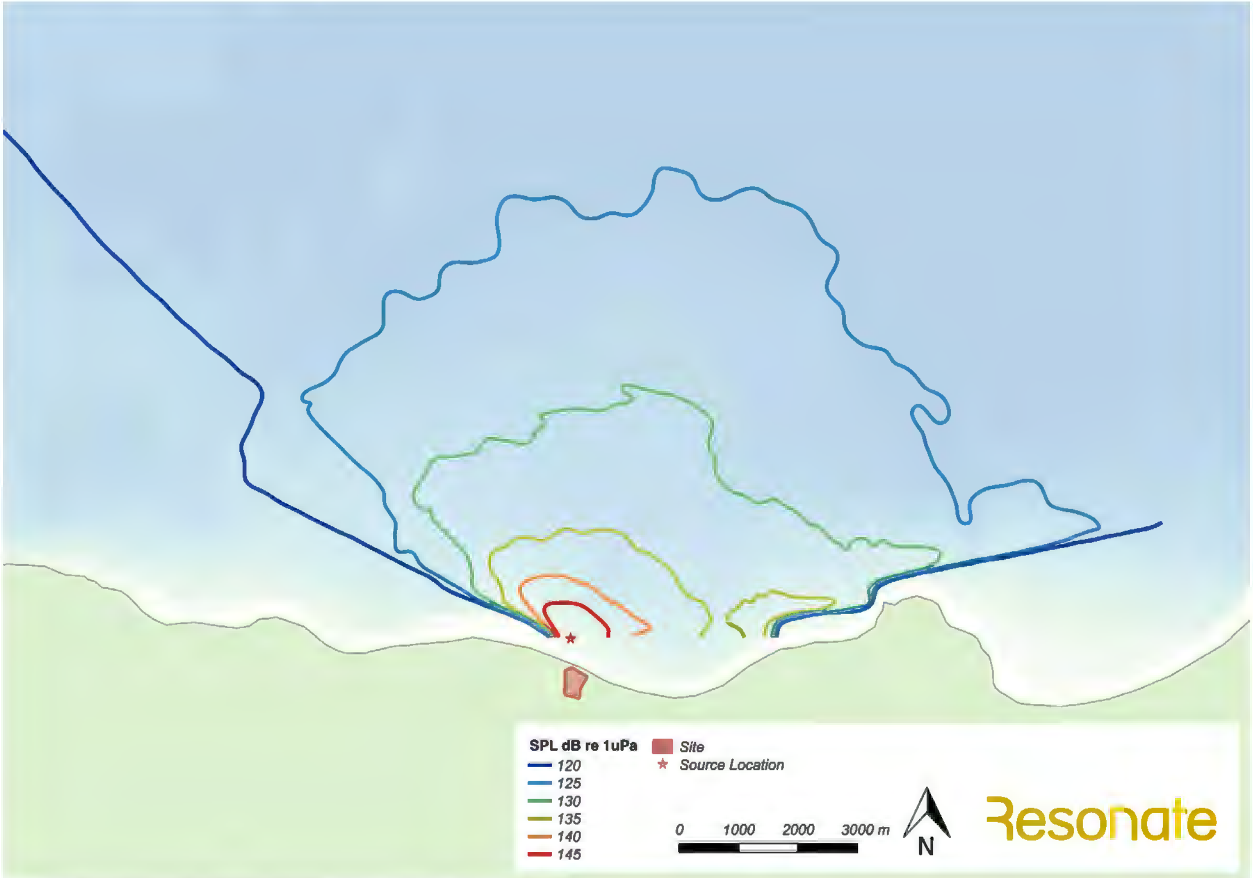

Figure 23: Predicted CSD noise levels (SPL dB re 1 µPa)

Figure 23 shows predicted levels for CSD in SPL dB re 1 µPa. For comparison with adopted SEL_C criteria for TTS and PTS, an assumption regarding the duration of exposure must be made. Note that the predicted noise levels for CSD are based on a source level of 187 dB re 1 µPa, which represents the worst-case level, which is unlikely to be generated for significant periods. Furthermore, the species considered in this assessment are mobile and have the ability to move away from the noise source if experiencing discomfort.

Table 19 below shows the effect of duration on predicted SEL_C noise levels, based on an SPL of 145 dB re 1 µPa (predicted approximately 500m from the noise source).

Table 19: Effect of exposure duration on predicted SEL_C.

Exposure duration	SEL_C
1 minute	163
5 minutes	170
10 minutes	173
30 minutes	178
1 hour	181

At this distance, noise levels are expected to be less than TTS threshold for the most sensitive category of species (low frequency cetaceans) for an exposure duration of 30 mins or less to worst-case CSD noise.

13.3.2 Piling

Figure 24 shows predicted peak piling noise levels. The peak levels are expected to be below TTS and PTS thresholds for all mammals, with the exception of very close (less than 5m) to the source, where levels may exceed the TTS threshold for low frequency cetaceans.

Figure 25 shows predicted piling noise levels in SEL_C dB(Mlf) re 1 µPa^2·s, along with TTS and PTS contours for low frequency cetaceans.

Figure 26 shows predicted piling noise levels in SEL_C dB(Mow) re 1 µPa^2·s, along with the TTS contour for Otariid Pinnipeds (Australian sea-lions). The PTS threshold is not expected to be exceeded for this species.

Figure 27 shows predicted piling noise levels in SEL_C dB re 1 µPa^2·s, along with the TTS contour for Great White Sharks. The PTS threshold is not expected to be exceeded for this species.

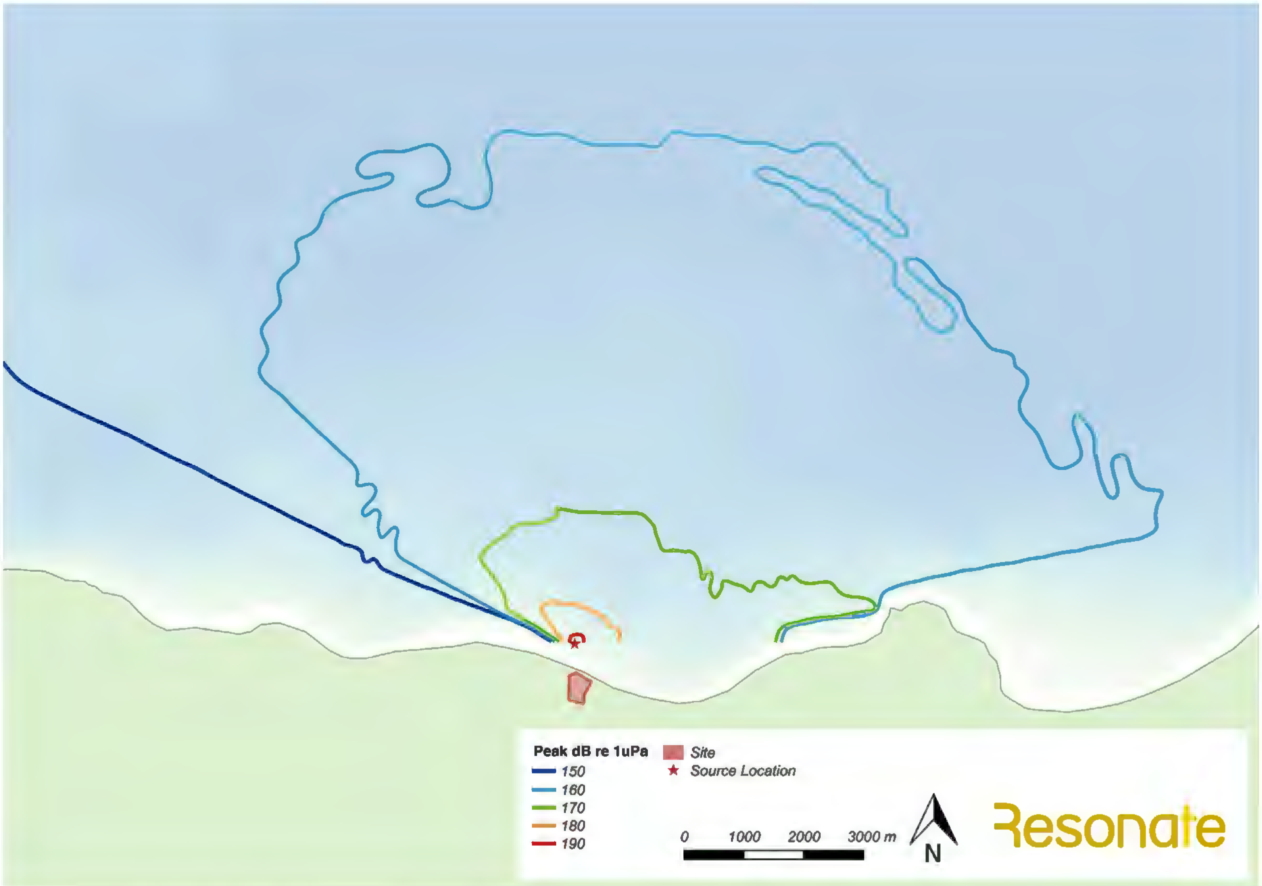

Figure 24: Predicted piling noise levels (peak dB re 1 μPa)

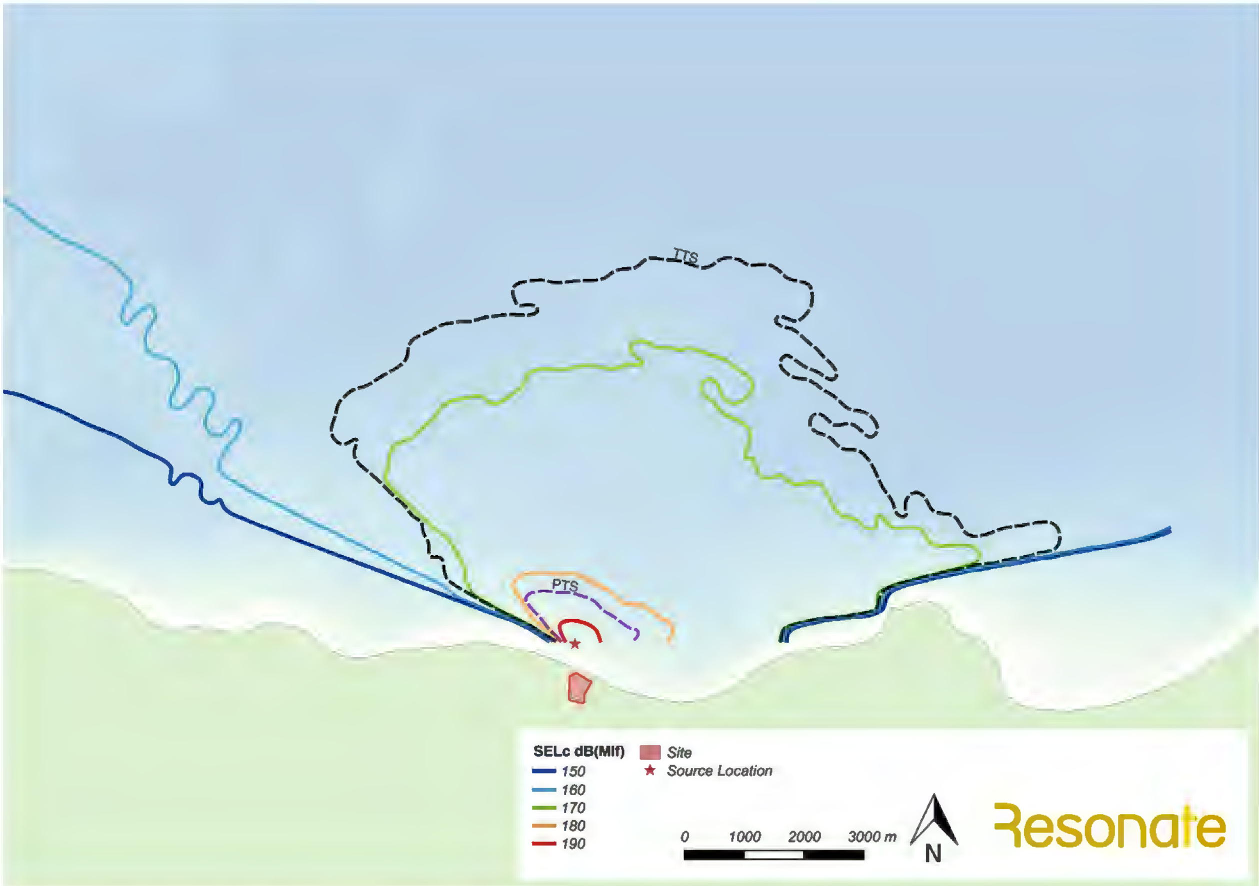

Figure 25: Predicted piling noise levels (SEL_C dB(Mlf) re 1 μPa²·s)

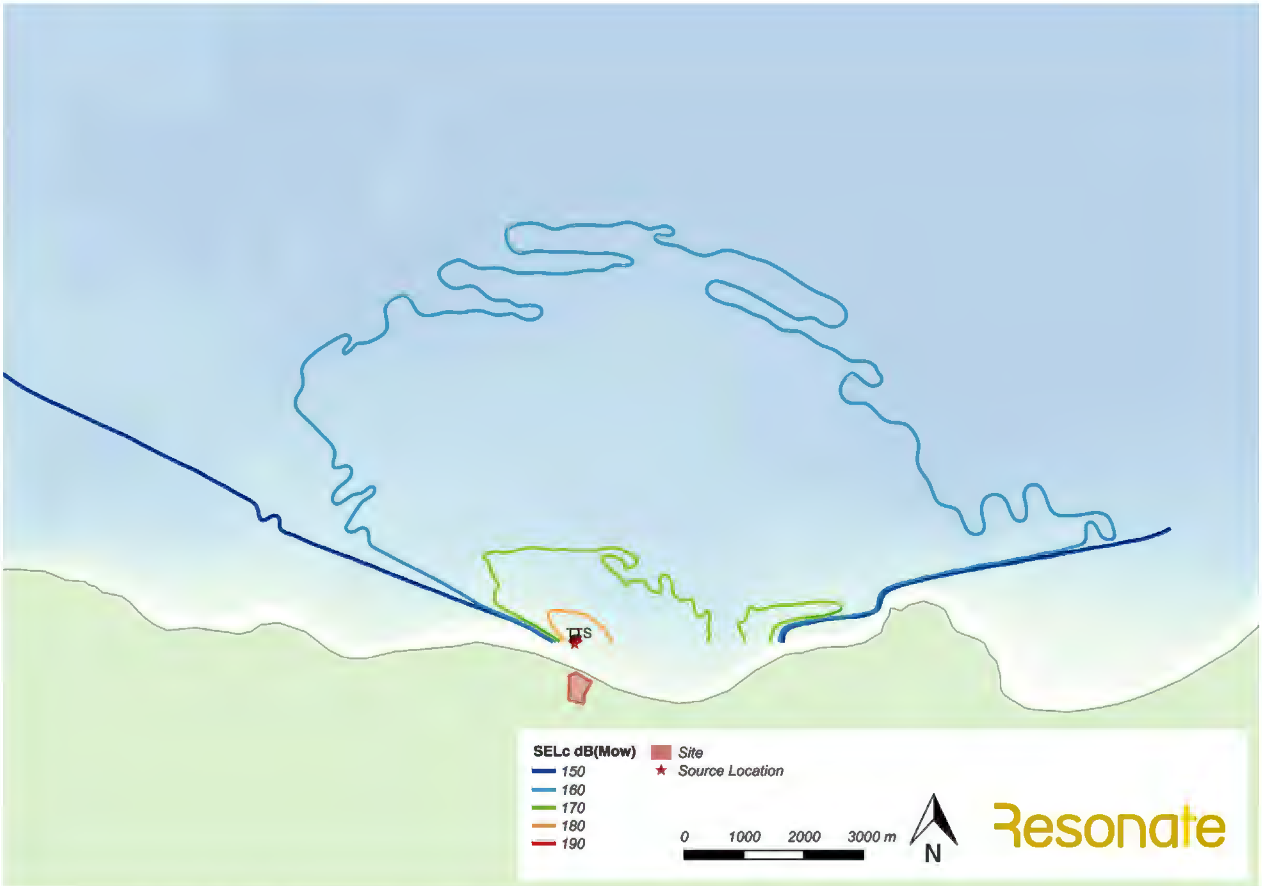

Figure 26: Predicted piling noise levels (SEL$_C$ dB(Mow) re 1 μPa^2·s)

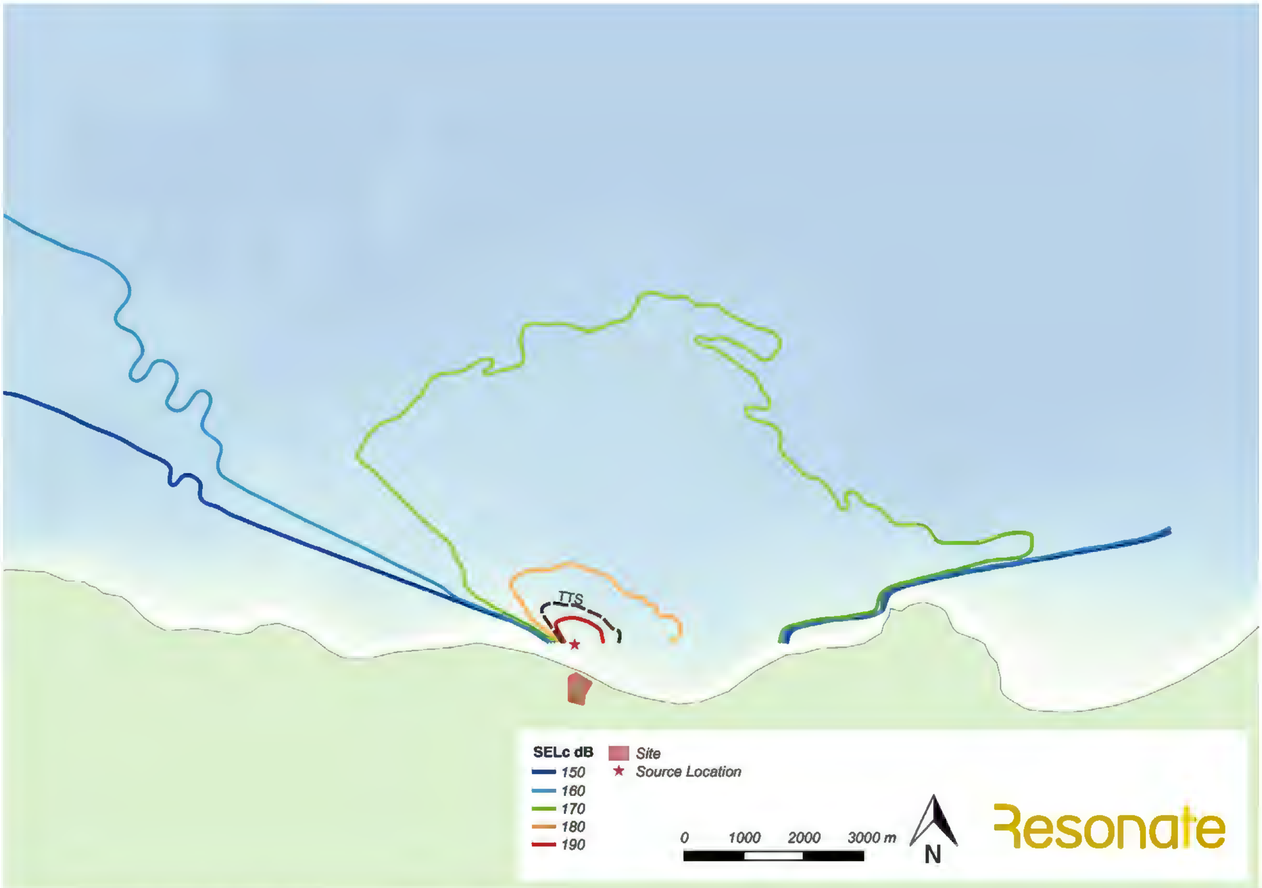

Figure 27: Predicted piling noise levels (SEL$_C$ dB re 1 μPa^2·s)

13.3.3 Vessels

Predicted vessel noise levels are based on a worst-case scenario of 10 vessel movements in a day. We note that vessels are mobile and in practice will not remain in one location for any significant duration. The RAM model does not allow for noise predictions from moving sources. However the noise level at distance from a single vessel pass-by can be estimated using the relationship $SEL_{receiver} = SEL_{Source} - 15 \log(r)$, where r is the distance to the vessel.

Predicted noise levels using this approach are shown in Table 20. It can be seen that predicted noise levels, even at minimal distances, are significantly below TTS thresholds for the relevant species. At large distances (greater than 5000m), predicted noise levels are in the same order of magnitude as existing ambient noise levels.

Table 20: Predicted noise levels with distance from a vessel

Distance (m)	Predicted noise level, SEL dB re 1 μPa^2 ·s
10	155
50	145
100	140
200	135
500	130
1000	125
2000	120
5000	115

Distance (m)	Predicted noise level, SEL dB re 1 $\mu Pa^2 \cdot s$
10000	110

13.4 Summary

Based on the adopted noise criteria, the size of the zone of influence was predicted for each of the construction and operational noise sources using the noise propagation modelling results. The results of these predictions are summarised in Table 21.

Table 21: Summary of underwater noise predictions showing threshold distances

Species	Noise source	Threshold distances (m)			
		Organ damage	PTS	TTS	Behavioural Response
Low Frequency (LF) Cetaceans • Blue whale • Southern Right Whale • Humpback Whale	Dredging	-	-	500(1)	6,000
	Piling	-	900	6,500	1,600(2)
	Vessels	-	-	10	2,000
Otariid Pinnipeds • Australian Sea-lion	Dredging	-	-	25(1)	6,000
	Piling	-	-	110	1,600
	Vessels	-	-	-	2,000
Fish (no swim bladder) • Great White Shark	Dredging	-	-	< 100	< 1,000
	Piling	6	6	680	< 1,000
	Vessels	-	-	< 100	< 1,000
Turtles • Loggerhead Turtle • Green Sea Turtle • Leatherback Turtle	Dredging	-	-	< 100	< 1,000
	Piling	20	< 100	< 100	< 1,000
	Vessels	-	-	< 100	< 1,000

(1) Based on an exposure time of 30 mins, to worst-case dredging noise

(2) TTS and PTS thresholds for low frequency cetaceans are expressed in SEL_C, while behavioural response criteria are expressed as RMS noise levels. The SEL_C descriptor takes into account the assumed duration of exposure and results in a significantly more stringent threshold than RMS criteria which only consider noise from a single impact. This results in a larger TTS threshold distance than predicted for Behavioural Response.

Resonate

14 Risk analysis

The risk analysis is based upon framework adopted from Resonate's previous experience in undertaking risk analyses on similar projects. Risk is assessed for major underwater noise generating activities identified in Section 12 impacting on each of the species identified in Section 9.

14.1 Risk analysis framework

The risk level is determined by first selecting the appropriate consequence and likelihood descriptors from the definitions included in Table 22 and Table 23.

Consequence levels reflect the impact that exposure to noise from the project would have on a species. We note that population density information and general biodiversity information for the project area has not been made available at this stage of the project, and so our assessment of consequence has been based upon the impact that high underwater noise levels will have on functional hearing groups generally, as opposed to specific impacts to local populations of individual species. In determining the consequence level we have also considered the existing noise environment levels and character, as discussed in Section 11.

Table 22: Risk analysis framework consequence descriptors

Consequence level				
Negligible Minimal impact in a localised area within natural variability	**Minor** Low impact in a localised or regional area with a functional recovery within less than 1 year	**Moderate** Medium impact in a localised or regional area with a functional recovery of 1 to 5 years	**Major** High impact in a localised or regional area with a functional recovery within 5 to 10 years	**Extreme** Very high impact in a regional area with functional recovery in greater than 10 years if at all
Consequences likely to be no greater than the normal population experiences and remains within natural annual and seasonal variability	Consequences likely to be low and no greater than population experiences within natural annual and seasonal variability.	Medium impact with a potential loss of individuals leading to reduction in viability of population in a localised or regional area. Functional recovery within 1 to 5 years.	Loss of large number of individuals leads to a high impact on populations in the localised area or regional area. Functional recovery within 5 to 10 years.	Long-term impact on populations in the regional area that may not be recoverable. Functional recovery in greater than 10 years if at all.

Likelihood levels consider how probable it is for exposure of members of a functional hearing group or species to noise from an activity associated with the Project to occur.

Table 23: Risk analysis framework likelihood levels

Likelihood level				
Rare	**Unlikely**	**Likely**	**Almost certain**	**Certain**
Highly unlikely to occur but theoretically possible.	May occur within the life of the project or activity.	Likely to occur more than once during the life of the Project or activity.	Very likely to occur during the life of the Project or activity.	Will occur as a result of the Project or activity.

Risk is then determined by identifying the matching risk row and consequence column of the risk matrix in Table 24, with the risk level given by the matrix cell which the risk row and consequence column intersect at.

Table 24: Risk assessment matrix

Likelihood	Consequence				
	Negligible	Minor	Moderate	Major	Extreme
Rare	Low	Low	Low	Medium	High
Unlikely	Low	Low	Medium	Medium	High
Likely	Low	Medium	Medium	High	High
Almost certain	Medium	Medium	High	High	Critical
Certain	Medium	Medium	High	Critical	Critical

14.2 Risk analysis

The overall level of risk to nationally threatened marine species has been determined using the framework described above, based on predicted noise levels and information regarding fauna and habitats from the *Smith Bay Marine Ecological Assessment* and the Project EPBC Referral.

Note that all relevant species are highly mobile and able to move out of noise exposure zones during operation of significant noise sources. There is extensive alternative habitat in the area for all relevant species.

14.2.1 Low frequency cetaceans

TTS is considered to be of Minor consequence to cetaceans, whilst PTS is considered to be of Moderate consequence. Cetaceans suffering from hearing threshold shifts as a result of the project could potentially have difficulty avoiding predators and locating prey after noise exposure, and losses of individuals could occur for those suffering PTS. TTS would have the same impact; however, TTS is considered of less consequence due to the temporary nature of the injury.

Of the three listed species of low frequency cetaceans, two (Blue Whales and Humpback Whales) have been rarely sighted in or near the study area. Southern Right Whales are known to migrate to Victor Harbour and the Great Australian Bight in winter for calving, and are infrequently seen in or near the project area.

The PTS threshold may be exceeded within 900m of piling, while the TTS level may be exceeded within 6.5km (for a piling duration of 30 minutes @ 60 blows/minute or 15minutes @ 120 blows/minute). The likelihood of exposure to construction noise levels exceeding TTS or PTS thresholds for Blue and Humpback Whales is therefore Rare, while for Southern Wright Whales exposure is Unlikely.

Operational noise levels are not expected to exceed the PTS threshold level and only exceed the TTS level within 10m of vessels. The likelihood of operational noise exposure is therefore rare for all species.

The overall risk level to low frequency cetaceans is Moderate for PTS and Low for TTS occurrence.

14.2.2 Otariid Pinnipeds

TTS is considered to be of Minor consequence to pinnipeds, whilst PTS is considered to be of Moderate consequence. PTS threshold levels for Otariid Pinnipeds are not expected to be exceeded for any construction or operational activity. TTS levels may be exceeded within 25m of dredging, and within 110m of piling.

Australian Sea Lions are seasonal visitors to the South Australian gulfs and are regularly observed near the project area (particularly during winter or spring). Considering the duration of construction activities and the small areas encompassing TTS zones for these activities, the likelihood is categorised as Unlikely.
The overall risk level to otariid pinnipeds is Low for PTS and TTS occurrence.

14.2.3 Fish (no swim bladder)

Elevated underwater noise levels are anticipated have a Minor consequence where the TTS criterion is exceeded and a Moderate consequence on Fish species where the PTS or Organ Damage criterion is exceeded. Fish exposed to high levels of underwater noise could experience tissue damage or other physical injury, potentially leading to mortality.

Great white sharks visit the area for feeding are have been recorded in or near the project area. PTS or organ damage may occur within 6m, and TTS may occur within 680m of piling activities. TTS may also occur within 100m of dredging or vessel activity. It is unlikely that individual Great White Sharks would come within 6m of piling activity, or occupy the TTS zone for a duration likely to cause TTS during dredging or vessel movements.

The overall risk level to sharks is Low for organ damage, PTS and TTS occurrence.

14.2.4 Turtles

Elevated underwater noise levels are anticipated to have a Minor consequence where the TTS criterion is exceeded and a Moderate consequence on Turtle species where the PTS or Organ Damage criterion is exceeded. Turtles exposed to high levels of underwater noise could experience tissue damage or other physical injury, potentially leading to mortality.

Loggerhead, Green and Leatherback Turtles have been recorded in or near the Project area on rare occasions.

Organ damage to turtles may occur within 20m, and PTS or TTS may occur within 100m of piling activities. TTS may also occur within 100m of dredging or vessel activity.

The overall risk level to turtles is Low for organ damage, PTS and TTS occurrence.

15 Management and Mitigation

The risk assessment has shown impact piling to be the highest risk activity associated the Project. Although the total duration of impact piling is limited, a medium level of risk has been identified for PTS occurring to low frequency cetaceans. The level of risk associated with PTS or TTS for all other species is low.

To mitigate this level of risk, an appropriate combination of the noise mitigation strategies outlined as follows could be adopted as part of a reasonable and practicable approach. We note that noise mitigation strategies should only be implemented such that they do not cause significant delay or expand the duration of piling activities, as doing so may increase the risk that marine fauna is exposed to high levels of noise from impact piling.

Table 25: Potential noise mitigation strategies for impact piling

Type of mitigation	Mitigation measure	Details
Operational modifications	Use of alternative piling methods	Use low noise impact techniques such as suction piling or vibro-piling in preference to impact piling where possible.
	Implement a soft start procedure at commencement of piling	Impact energy to be gradually increased over a 3-5 minute period such that noise levels gradually increase to their maximum values. Soft starts procedure should be implemented at the commencement of piling each day, if piling is stopped for a period longer than 3 hours, or if piling is stopped due to marine mammals or turtles entering the impact zone where the TTS criterion is exceeded.
	Control construction program to avoid noise exposure	Impact piling should be scheduled to occur for the minimum practical total duration, to reduce the likelihood that endangered species will be exposed to piling noise. Impact piling should not occur during the night when marine mammals will be difficult to observe with MMOs. Also this is the time of day when turtle movements are more likely to occur (Gitschlag and Herczeg, 1994). Piling should be scheduled to occur outside the months when cetaceans may be present in or near the project area.

Type of mitigation	Mitigation measure	Details
Observation	Safety zones	Safety zones typically include observation and shut-down zones. In the observation zone, the movement of marine species should be monitored to determine whether they are approaching or entering the shut-down zone. When a marine species is sighted within or appears to enter the shut-down zone, pile driving must be stopped as soon as reasonably possible. Safety zones dimensions are based upon the radial distance from the noise source. The safety zones should be sized based on the size of the predicted zones of noise impact, but also need to account for practicality of monitoring for the presence of marine fauna. For example a shutdown zone of greater than 1 km will be difficult to monitor. Implementing large safety zones are difficult due to their relative size to the shutdown zone making observations at sea very difficult.
	Marine Mammal Observers (MMOs)	Trained MMOs should be used to monitor safety zones during, and prior to, all pile driving activities.

15.1 Post-mitigation risk analysis

Each of the mitigation strategies included in Table 25 provides a means of reducing the likelihood of the occurrence of adverse effects from impact piling. Where species are likely to be present during piling, strategies which identify the presence of marine fauna will allow for operations to be modified or stopped reducing the likelihood of exposure to noise levels which lead to harm.

With an appropriate combination of these mitigation strategies in place, the risk of impact piling causing adverse effects to cetaceans and all other relevant species is Low.

Dredging and vessel operation (during both construction and operation) are predicted to have a low level of risk to all marine fauna.

16 Conclusion

A risk assessment of the environmental impacts has been conducted based on the existing conditions (e.g. ambient noise environment, local bathymetry, wave and wind climate), the marine species of significance present in the study area, the significance of the area as a habitat for marine species, the sensitivity to sound of marine species, the characteristics of the identified noise sources in terms of duration, source level and frequency content, and the sound propagation characteristics of the marine study area. Significant underwater noise sources associated with construction and operation of the port are dredging, piling and marine vessels.

The potential impacts that have been considered in the risk assessment are, in increasing order of severity, behavioural change, temporary threshold shift in hearing, permanent threshold shift in hearing, and organ damage (possibly leading to death). To assess the impacts of the construction and operational sources, noise criteria have been established for each of the considered impact levels.

The adopted underwater noise criteria are based on NOAA *Marine Mammal Acoustic Technical Guidance* (2018), and the *Sound Exposure Guidelines for Fishes and Sea Turtles* (Popper et al., 2014). These represent the most up to date research and approach for the species considered in this assessment, and are generally more stringent than the DPTI *Underwater Piling Noise Guidelines* (2012).

Without mitigation, the overall risk of adverse noise effects on the relevant marine species is Low, with the exception of a Medium level of risk associated with impact piling potentially resulting in PTS in Southern Right Whales.

To minimise the environmental impacts of underwater noise, the following potential mitigation and management strategies are recommended:

- Use of alternative piling methods
- Implementing a soft start procedure at the commencement of piling
- Control of construction programme to avoid noise exposure, including scheduling piling to occur outside of the months when cetaceans may be present in the area
- Establishment of safety and shut-down zones, with marine mammal observers used to monitor the presence of relevant species.

With an appropriate combination of reasonable and practicable mitigation procedures implemented, the impacts from underwater noise associated with construction and are likely to be minimal.

Resonate

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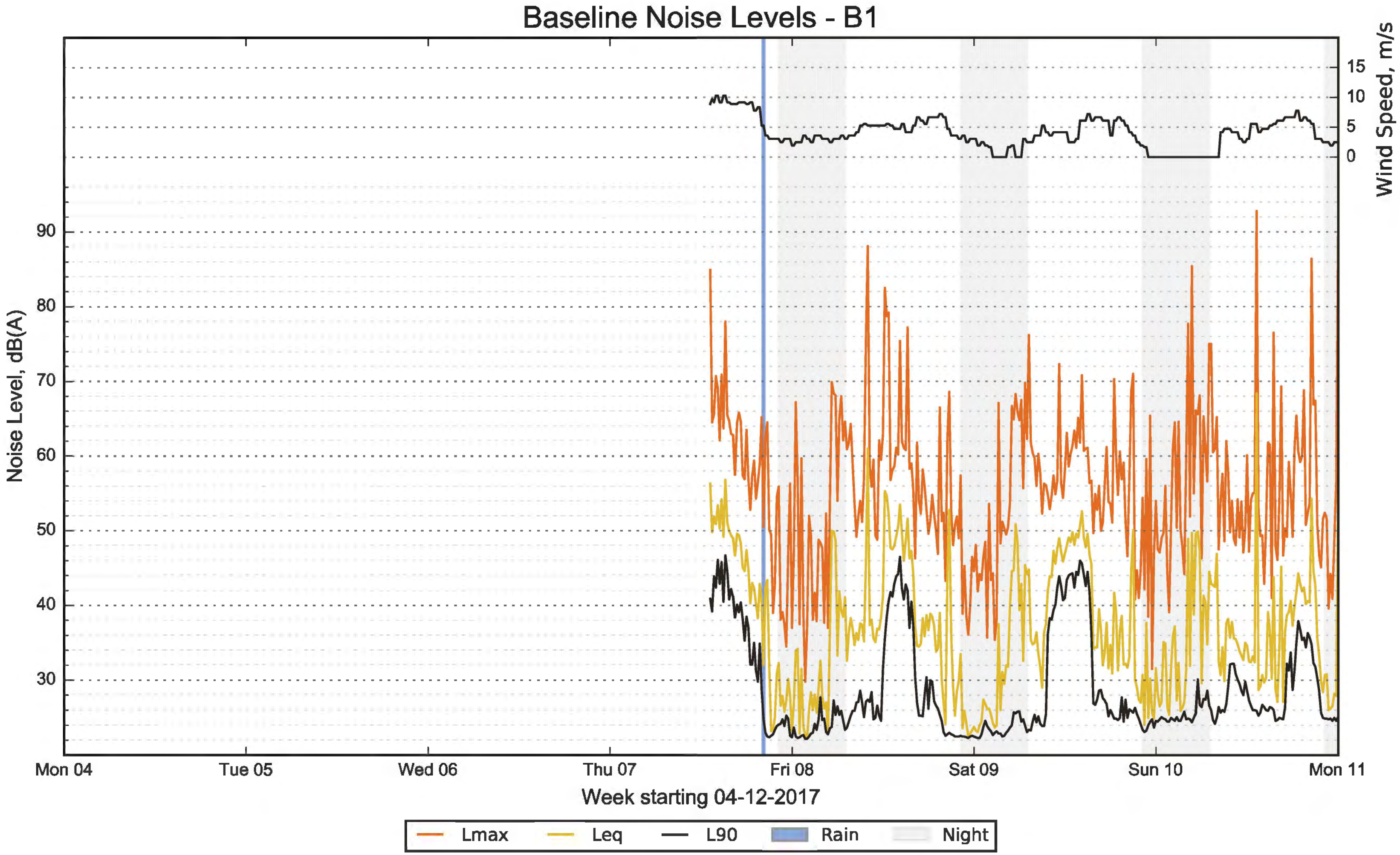
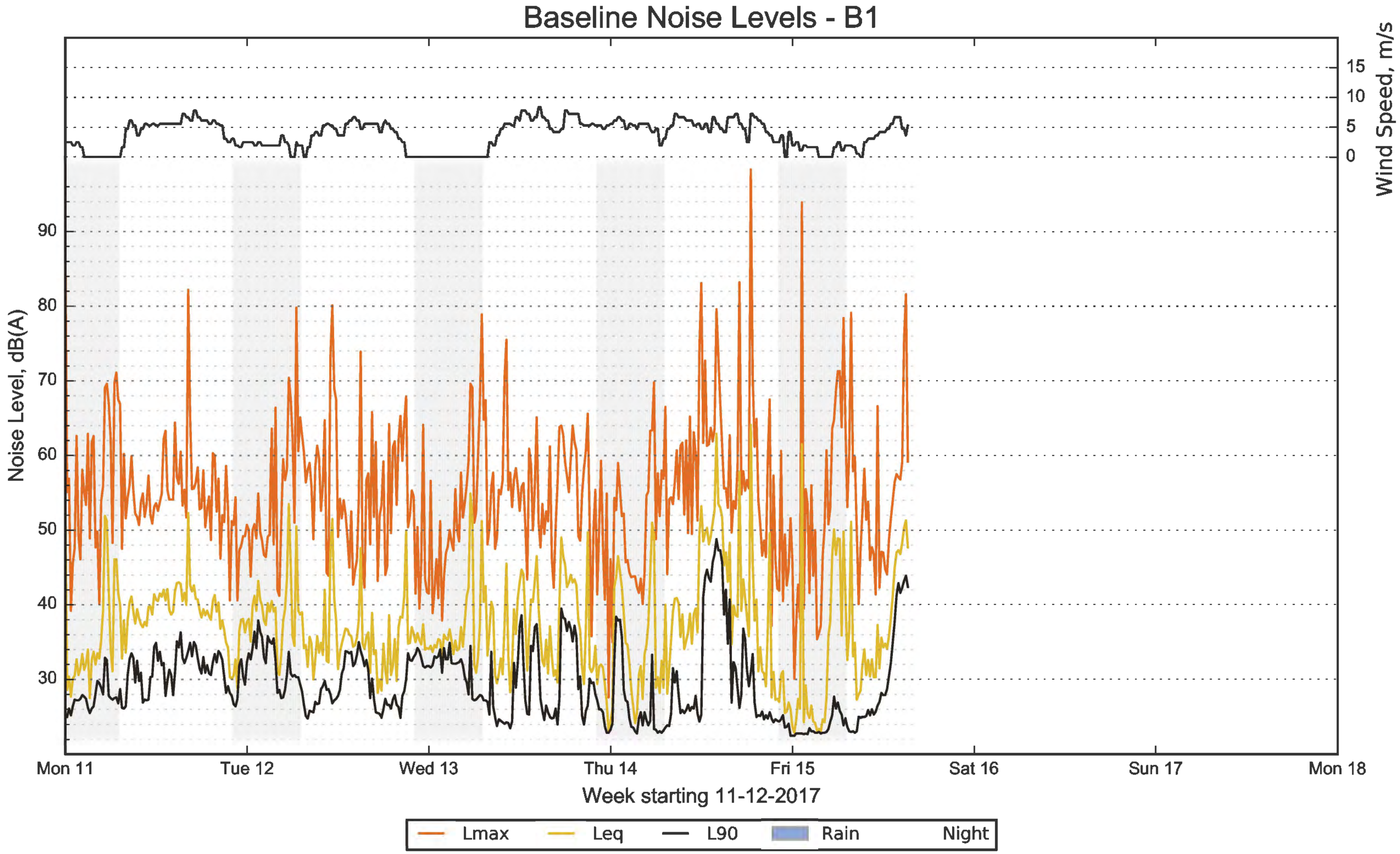
Appendix A: Baseline noise monitoring results

Resonate



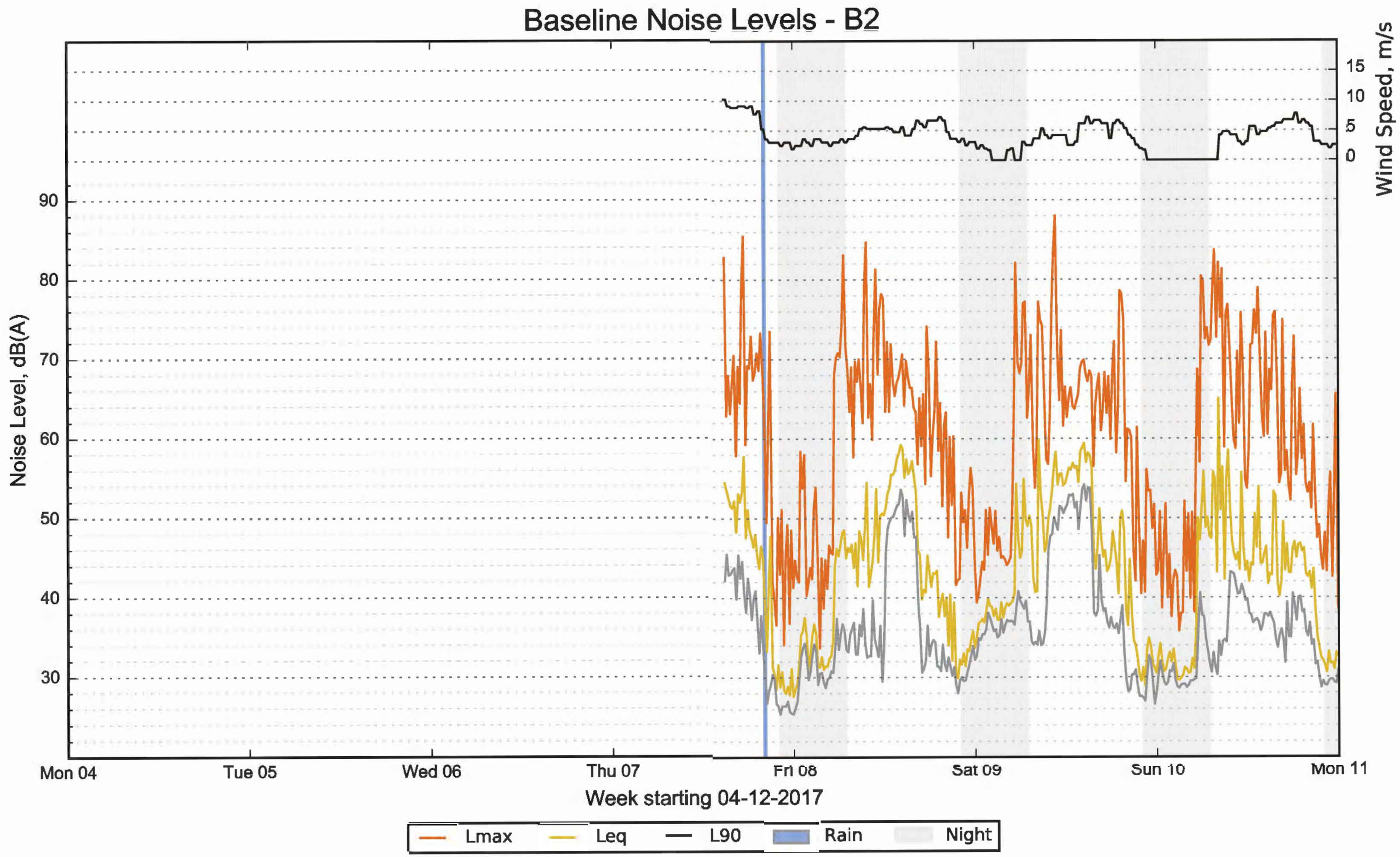
Baseline Noise Levels - B1
Noise Level, dB(A)
90
80
70
60
50
40
30
15
10
5
0
Wind Speed, m/s
Mon 04
Tue 05
Wed 06
Thu 07
Fri 08
Sat 09
Sun 10
Mon 11
Week starting 04-12-2017
Lmax
Leq
L90
Rain
Night

Resonate

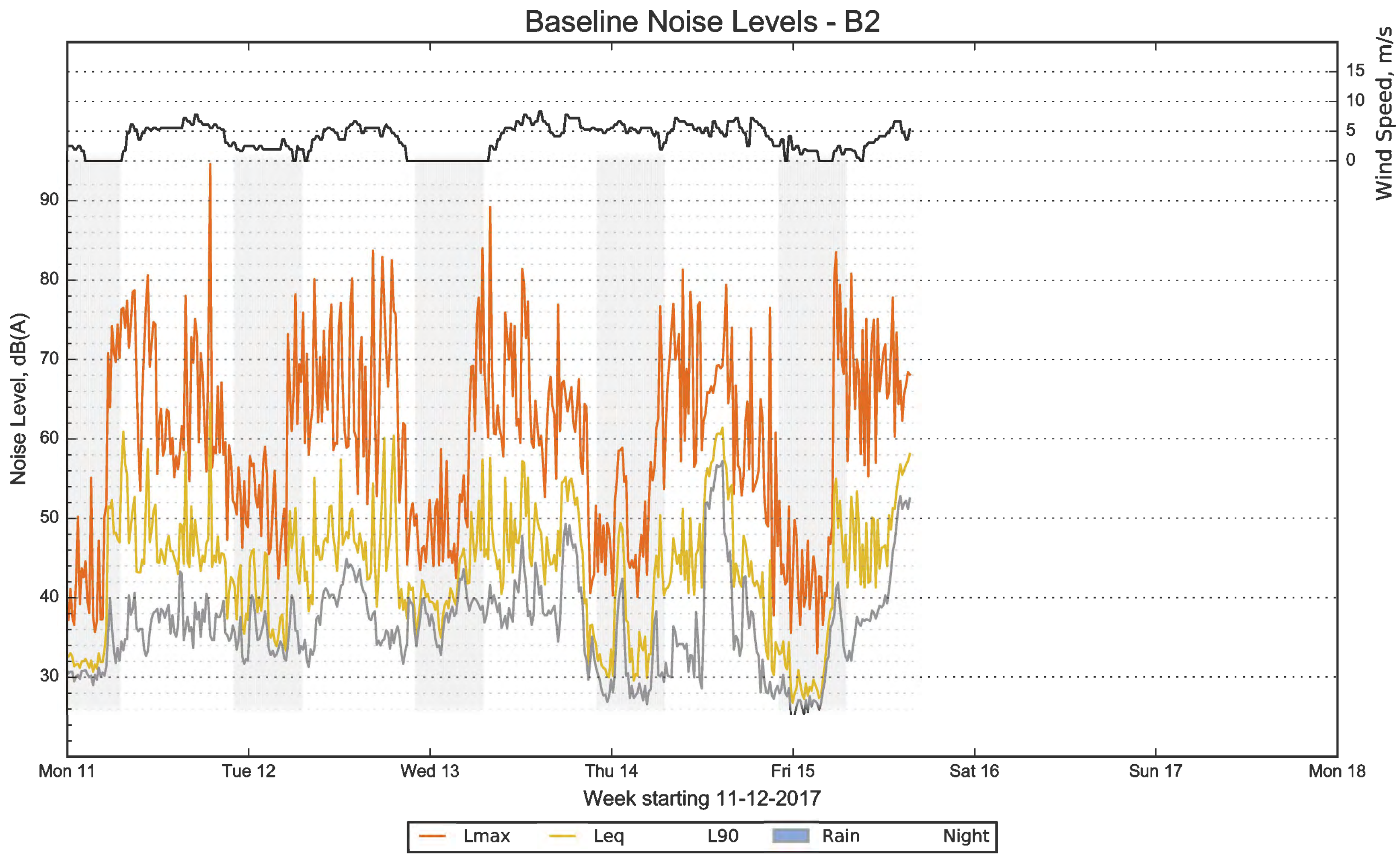


Baseline Noise Levels - B1
Noise Level, dB(A)
Wind Speed, m/s
15
10
5
0
90
80
70
60
50
40
30
Mon 11
Tue 12
Wed 13
Thu 14
Fri 15
Sat 16
Sun 17
Mon 18
Week starting 11-12-2017
Lmax
Leq
L90
Rain
Night

Resonate

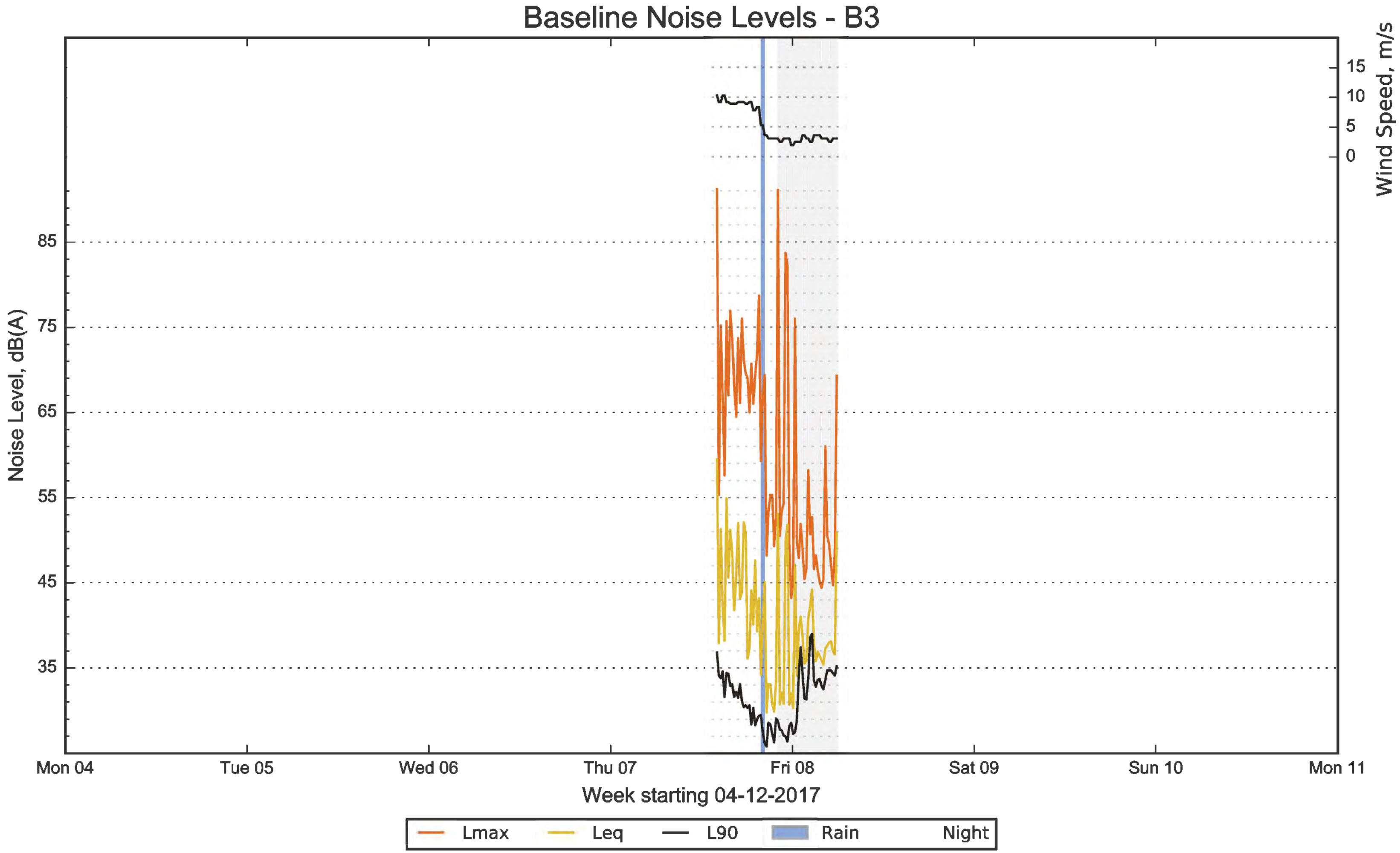

Baseline Noise Levels - B2
Noise Level, dB(A)
90
80
70
60
50
40
30
Wind Speed, m/s
15
10
5
0
Mon 04
Tue 05
Wed 06
Thu 07
Fri 08
Sat 09
Sun 10
Mon 11
Week starting 04-12-2017
Lmax
Leq
L90
Rain
Night

Resonate



Baseline Noise Levels - B2
Noise Level, dB(A)
90
80
70
60
50
40
30
Wind Speed, m/s
15
10
5
0
Mon 11
Tue 12
Wed 13
Thu 14
Fri 15
Sat 16
Sun 17
Mon 18
Week starting 11-12-2017
Lmax
Leq
L90
Rain
Night

Resonate


Baseline Noise Levels - B3
Noise Level, dB(A)
85
75
65
55
45
35
15
10
5
0
Wind Speed, m/s
Mon 04
Tue 05
Wed 06
Thu 07
Fri 08
Sat 09
Sun 10
Mon 11
Week starting 04-12-2017
Lmax
Leq
L90
Rain
Night