Noise and Vibration

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16.1 Introduction

The Lindeman Great Barrier Reef Resort has been planned and designed and will be constructed and operated to protect the environmental values of the acoustic environment. This chapter of the EIS provides an assessment of the current and proposed airborne noise and vibration impacts associated with the construction and operation of the development against the current relevant statutory criteria, in particular the *Environmental Protection Act 1994*, *Queensland Environmental Protection (Noise) Policy 2008* and *Department of Transport and Main Road's Construction Noise Guideline*. As the resort is currently not operational, noise from the existing noise sources was referenced but not separately assessed as a part of this assessment, as noise sources on site will be subject to change once the construction and operation of the development commences. The following sections provide a summary of the assumptions, modelling inputs, adopted criteria and predicted noise impacts expected on the development along with recommended mitigation measures where appropriate, while the full technical report prepared by Cardno is available in **Appendix N – Noise Impact Assessment**.

Addendum: *This EIS was initially prepared assuming that the safe harbour was to be part of the Lindeman Great Barrier Reef Resort Project. With the commencement of the Great Barrier Reef Marine Park Authority's (GBRMPA) Dredging Coral Reef Habitat Policy (2016), further impacts on Great Barrier Reef coral reef habitats from yet more bleaching, and the recent impacts from Tropical Cyclone Debbie, the proponent no longer seeks assessment and approval to construct a safe harbour at Lindeman Island. Instead the proponent seeks assessment and approval for upgrades to the existing jetty and additional moorings in sheltered locations around the island to enable the resort's marine craft to obtain safe shelter under a range of wind and wave conditions. Accordingly, remaining references to, and images of, a safe harbour on various figures and maps in the EIS are no longer current.*

16.2 Statutory Framework and Standards

16.2.1 Environmental Protection Act 1994

The Environmental Protection Act (EP Act) provides the legislative framework by which Queensland's environment is protected while allowing for development that improves the total quality of life, both now and in the future. Specifically, the EP Act seeks to maintain a range of environmental values including:

(a) *a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or*

(b) *another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.*

For the purposes of the environmental impact statement, reference is made to the environmental values provided in the *Environmental Protection (Noise) Policy 2008* (EPP Noise) established under the EP Act. The following sections provide an overview of the environmental values identified in this policy along with the objectives established achieve their protection.

16.2.2 Environmental Protection (Noise) Policy 2008

The EPP (Noise) provides that the environmental values (section 7) to be enhanced or protected under this policy are:

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following—

(i) sleep;

(ii) study or learn;

(iii) be involved in recreation, including relaxation and conversation; and

(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

16.2.3 Summary of Key Statutes and Standards

The following table provides a summary of the key statutes and standards applicable to the development. A full summary of the noise and vibration levels are available in **Appendix N – Noise Impact Assessment.**

Table 16-1. Construction and Operational Noise Sources and Applicable Noise and Vibration Standards.

Type	Legislative and Policy Guidance
Construction	
Noise arising from construction activities	Queensland Department of Transport and Main roads (TMR) provides guidance for assessing construction noise impacts from road construction projects in the *QLD Transport Noise Management Code of Practice (CoP) Volume 2 – Construction Noise & Vibration (TMR 2014)*
Vibration arising from construction activities	*British Standard BS 5228-2:2009* provides an alternative approach to those historically used to assess human comfort presented in the *British Standard BS 6472-1:2008*. Table B.1 provides guidance on measurements used to determine potential building damage.
Operation	
Mechanical Plant Noise	*Environmental Protection Act 1994* (Current as at 2 October 2015), Division 3, Default Noise Standards, Section 440U Air Conditioning and Section 440V Refrigeration Equipment
Aircraft Noise	*Australian Standard AS2021 Acoustics – Aircraft noise intrusion – Building sitting and construction:*
Truck Movement	*Environmental Protection (Noise) Policy (EPP) 2008*
Boat Docking	*Environmental Protection (Noise) Policy (EPP) 2008*

Type	Legislative and Policy Guidance
	Environmental Protection Act 1994 (Current as at 2 October 2015), Division 3, Default Noise Standards, Section 440ZA Operating Power Boat Engine at Premises
Water Treatment Pump	*Environmental Protection Act 1994* (Current as at 2 October 2015), Division 3, Default Noise Standards, Section 440T Pumps
Diesel Generator	*Environmental Protection Act 1994* (Current as at 2 October 2015), Division 3, Default Noise Standards, Section 440S Regulated Devices

16.3 Existing Acoustic Environment

An aerial photograph presented in **Figure 16-1** and **Figure 16-2** below shows the location of the existing resort and the services infrastructure. A summary of existing site description is listed below:

- The existing resort is focussed on the south-western corner of Lindeman Island. The existing accommodation is housed in 14 wings with large central facilities building that housed the main restaurant, bars and entertainment facilities. The reception is further up the hill with Nicholson's Restaurant, conference rooms and staff accommodation on the plateau above the resort.
- All the services areas including power plant, sewerage treatment works, water filtration and general maintenance, fuel stores and Back of House facilities are also on the plateau.
- A grassed unlicensed airstrip is also situated on the plateau used by charter aircraft from the mainland and nearby Hamilton Island.
- Sea access is gained from jetty adjacent to the resort. This jetty is a Queensland Government asset and White Horse Australia are currently exploring the possibility of acquiring and maintaining the jetty from the State.

The resort is currently closed with accommodation for the three Caretakers provided in the centre of existing resort in the former villas/staff accommodation located to the west of the Airstrip. Apart from three Caretakers that maintain the resort's key facilities and airstrips, there are no current residents or guests residing on the site.

16.3.1 Existing Noise Sources

Based on the site inspection conducted on 22nd October 2015, a list of identified existing noise sources is presented below:

- Noise from a boat docking;
- Water treatment pump noise; and
- Diesel generator located within the central energy plant site

As the resort is currently not operational, noise from the existing noise sources was referenced but not separately assessed as a part of this assessment, as noise sources on site will be subject to change once the construction and operation of the development commences. The location of the existing Beach Resort and services infrastructure is presented in **Figure 16-1** and **Figure 16-2**.

Figure 16-1. Existing Beach Resort.

Figure 16-2. Location of Services Infrastructure.

16.3.2 Ambient Noise Monitoring Methodology

Unattended noise monitors were installed at the following four locations (refer to **Figure 16-3**) to measure ambient (i.e. background) noise levels between 22 October and 29 October 2015. Noise monitors were configured to measure 15-minute statistics and noise was measured as per *Australian Standard 1055.1:1997 – Acoustics – Description & Measurement of Environmental Noise* (AS1055.1), and the Queensland Environmental Noise Measurement Manual. Noise monitoring locations and equipment details are described below in **Table 16-2** and **Figure 16-3**.

Table 16-2. Noise Monitoring Equipment.

Location	Logger Type	Monitoring Location	Serial Number	Monitoring Dates
1	Norsonic 131	Air Strip	2976654	22 October 2015
2	Rion NL-21	Lindeman Jetty	509345	22 – 29 October 2015
3	Rion NL-21	Outlook Cliff	509346	22 – 29 October 2015
4	Rion NL-21	Golf Course Park	509343	22 – 23 October 2015

Figure 16-3. Noise Logger Locations.

Calibration of the sound monitoring equipment was conducted before and after the measurement period, with a variance of less than + / - 0.3 dB(A) recorded. A summary of the environmental conditions noted during the measurement period were as follows (source weather station located on site):

Conditions: *Fine*

Wind: *0-9.7 m/s predominantly from E, ENE, N, NE, NNW direction*

Humidity: *61 - 92%*

Temperature: *21 – 27 °C.*

In the absence of any weather data from the actual monitoring location, weather information for the monitoring period from the nearest weather station (Hamilton Island) has been referenced. It should be noted that Hamilton Island Airport (Station Id 033106) is located at 58.66 m above sea level. At this height, higher wind speed will be recorded relative to the wind speed at the monitoring location (1.5m above ground). Based on the monitoring results, site inspection and weather data presented in **Appendix N – Noise Impact Assessment,** monitoring data has not been affected by adverse weather. Therefore, no measurement data has been excluded.

As environmental noise varies with time, the use of statistical descriptors is necessary to understand and describe these variations. For road traffic noise these descriptors are further classified for day time (7 am – 10 pm) and night time (10 pm – 7 am). For environmental noise, the assessment period for day time is further split into day (7 am – 6 pm) and evening (6 pm – 10 pm). A-weighted statistical levels are used to describe ambient noise levels. The common descriptors used to describe environmental noise are described as follows:

L_{Amax}: *the A-weighted maximum noise level measured during the measurement period.*

L_{A1}: *the A-weighted noise level exceeded for 1% of the measurement period.*

L_{A10}: *the A-weighted noise level exceeded for 10% of the measurement period, generally referred to as the average maximum sound pressure level.*

L_{A90}: *the A-weighted noise level exceeded for 90% of the measurement period, generally referred to as the background noise level (refer AS1055.1).*

L_{Aeq} : *the equivalent continuous noise level over the measurement period, generally referred to as the energetical average sound pressure level over the measurement period.*

16.3.3 Measured Noise Levels – Unattended Noise Measurements

Measured noise levels at each logger location were observed to be affected by the following:

Table 16-3. Observed Existing Noise Environment.

Logger	Location	Observed Noise Environment
1	Air Strip	No aircraft movements observed during the attended noise measurements. Primary sources of noise at this location were birds, insects and wind in nearby trees. Occasional noise from a quad bike and golf buggies noted. Occasional aircraft flyover.
2	Lindeman Jetty	Surf and boat noise audible at this location. Boat noise only audible when boats docking at the jetty which was occasional. Primary sources of noise at this location were surf and water lapping. Occasional noise from golf buggies noted. Occasional aircraft flyover.

Logger	Location	Observed Noise Environment
3	Outlook Cliff	Primary sources of noise at this location were birds, insects and quite high levels of wind. Occasional noise from quad bikes noted. Occasional aircraft flyover.
4	Golf Course Park	Primary sources of noise at this location were birds, insects. Occasional noise from quad bikes noted. Occasional aircraft flyover.

The measured background noise levels measured during the monitoring period (noting some shorter periods due to equipment failures) are presented below.

Table 16-4. Measured Average Background Noise Levels.

Logger	Descriptors	Measured Background Noise Levels		
		7 am to 6pm	6pm to 10pm	10pm to 7am
1	Average LA90	32.6	38.4	-
	LAeq	54.1	42.9	-
	RBL	28.7	35.4	-
2	Average LA90	41.5	41.5	31.9
	LAeq	47.8	45.0	41.5
	RBL	36.7	39.9	22.3(1)
3	Average LA90	32.2	33.2	36.3
	LAeq	43.4	38.6	43.9
	RBL	25.9(1)	31.0	32.6
4	Average LA90	37.6	39.4	34.8
	LAeq	45.2	45.5	41.3
	RBL	34.1	37.6	28.4(1)

(1) Where RBLs are calculated to be less than 30 dB(A), an RBL of 30 dB(A) has been adopted in accordance with general industry practice.

Measured ambient noise levels and monitoring graphs for these locations are presented in **Figure 16-4** to **Figure 16-7.** The measured background noise at location 3 (Outlook Cliff) is lower than the background noise levels measured at location 2. As such, monitoring results from location 3 have been used to determine the benchmark design limits for the development to provide a conservative assessment. Charts of each monitoring period are shown in **Appendix N – Noise Impact Assessment**.

Figure 16-4. Averaged Measured Noise Levels – Location 1 (Air Strip)

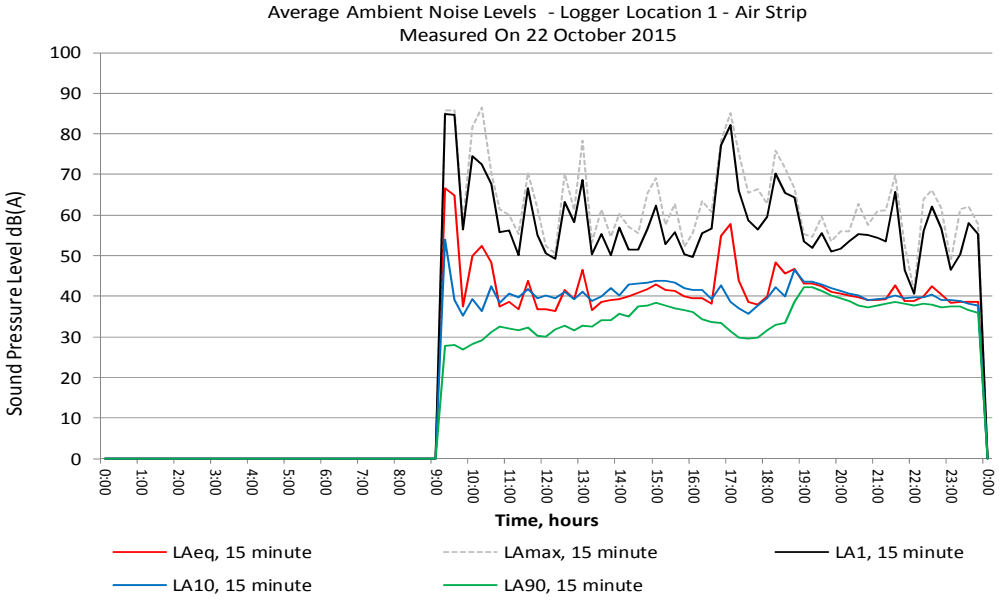


Figure 16-5. Averaged Measured Noise Levels – Location 2 (Lindeman Jetty).

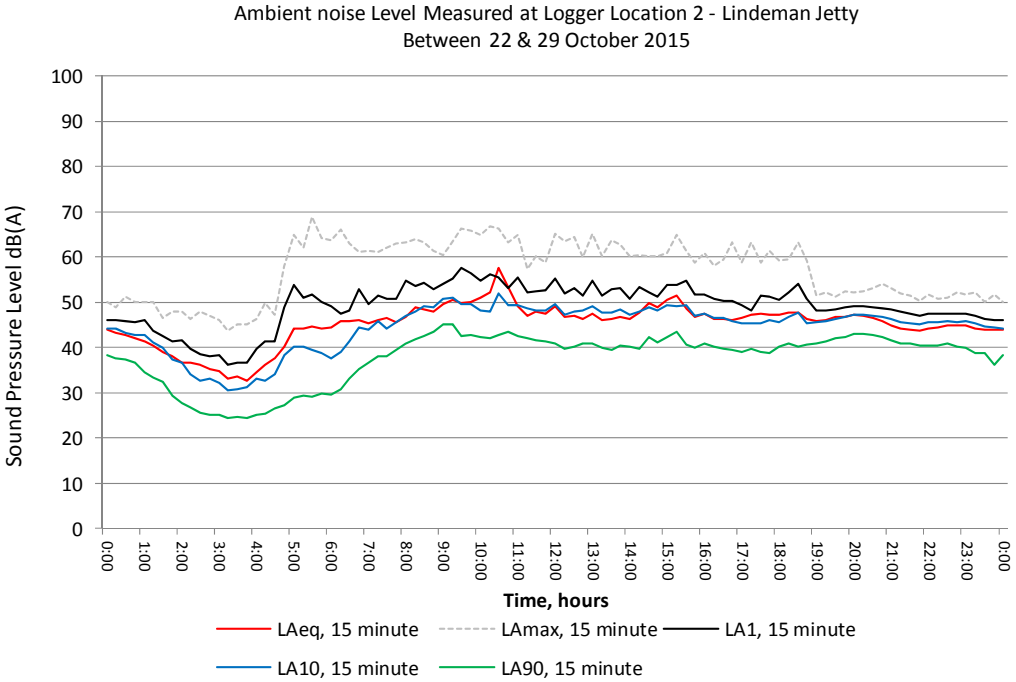


Figure 16-6. Averaged Measured Noise Levels – Location 3 (Outlook Cliff).

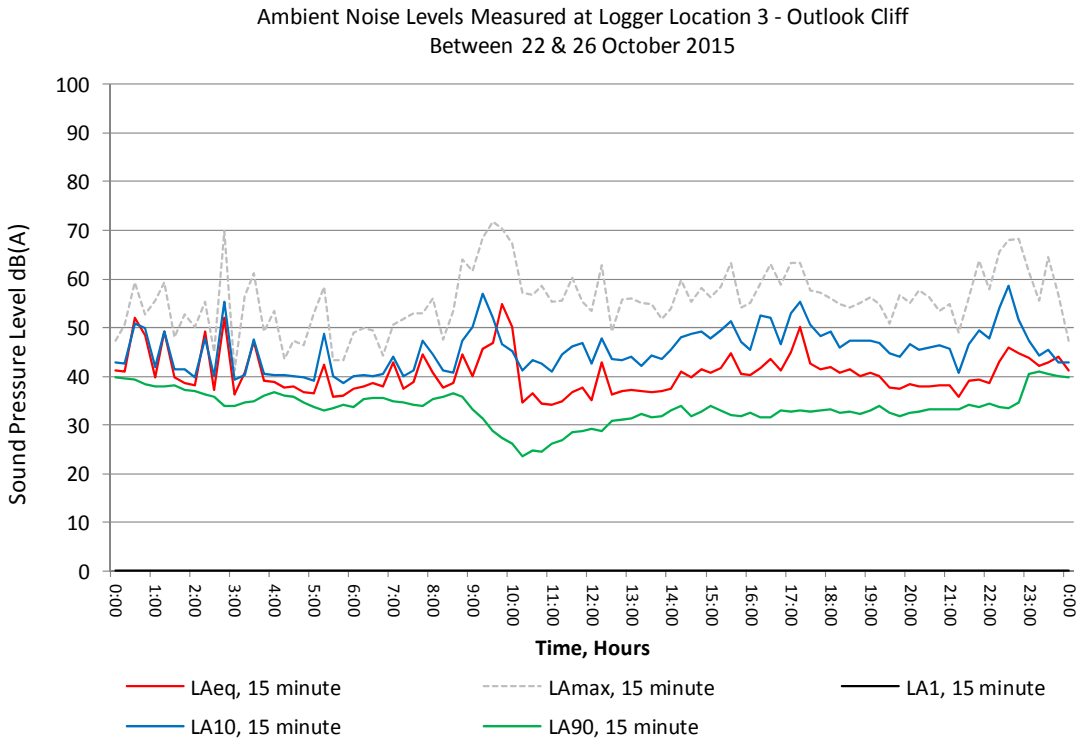
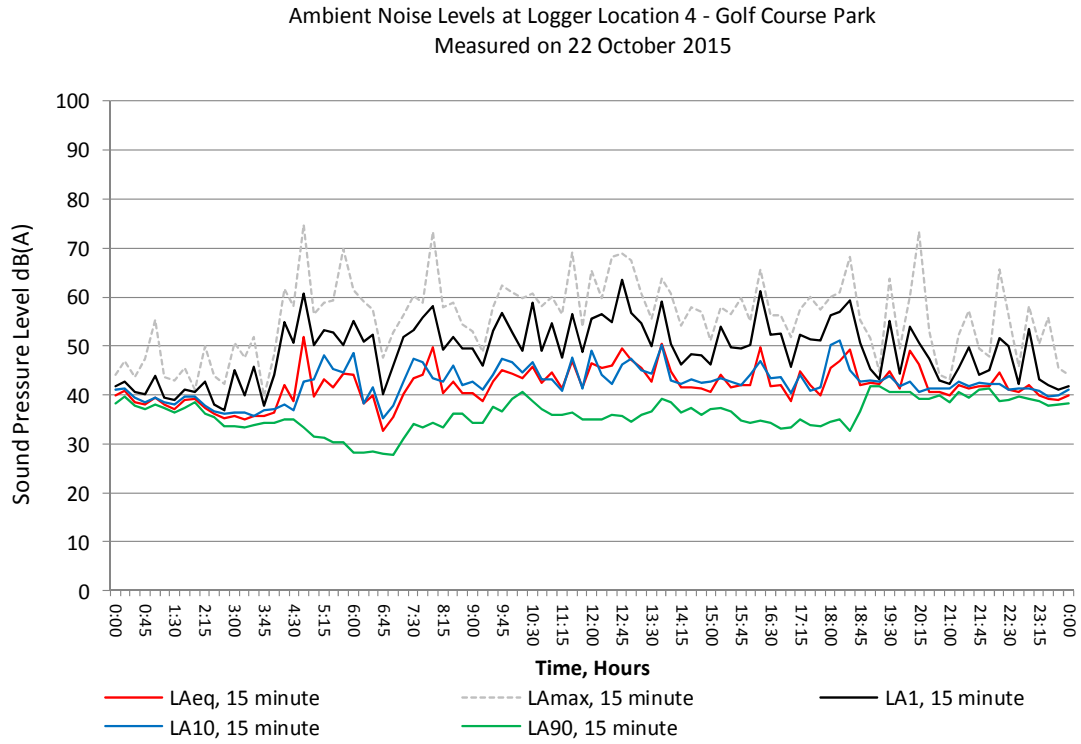


Figure 16-7. Averaged Measured Noise Levels – Location 4 (Golf Course Park).



16.3.4 Measured Noise Levels – Attended Noise Measurements

Minimal activities were observed during the site inspection and attended measurements on 22 October 2015 as the existing resort is currently not operational. Attended measured source noise levels for the observed existing noise sources on the island are presented below in **Table 16-5**.

Table 16-5. Measured Ambient Noise Levels at Location 2 (Lindeman Jetty).

Noise Source	Measurement Distance	Measured Noise Levels, L_{Aeq} dB(A)	
		Measured Sound Pressure Level	Sound Power Level
Diesel Generator @ Louvre 1	1 metre	76	95
Diesel Generator @ Louvre 2	1 metre	76	95
Water Treatment Pump	1 metre	64	79
Medium Boat Docking	5 metre	73	94

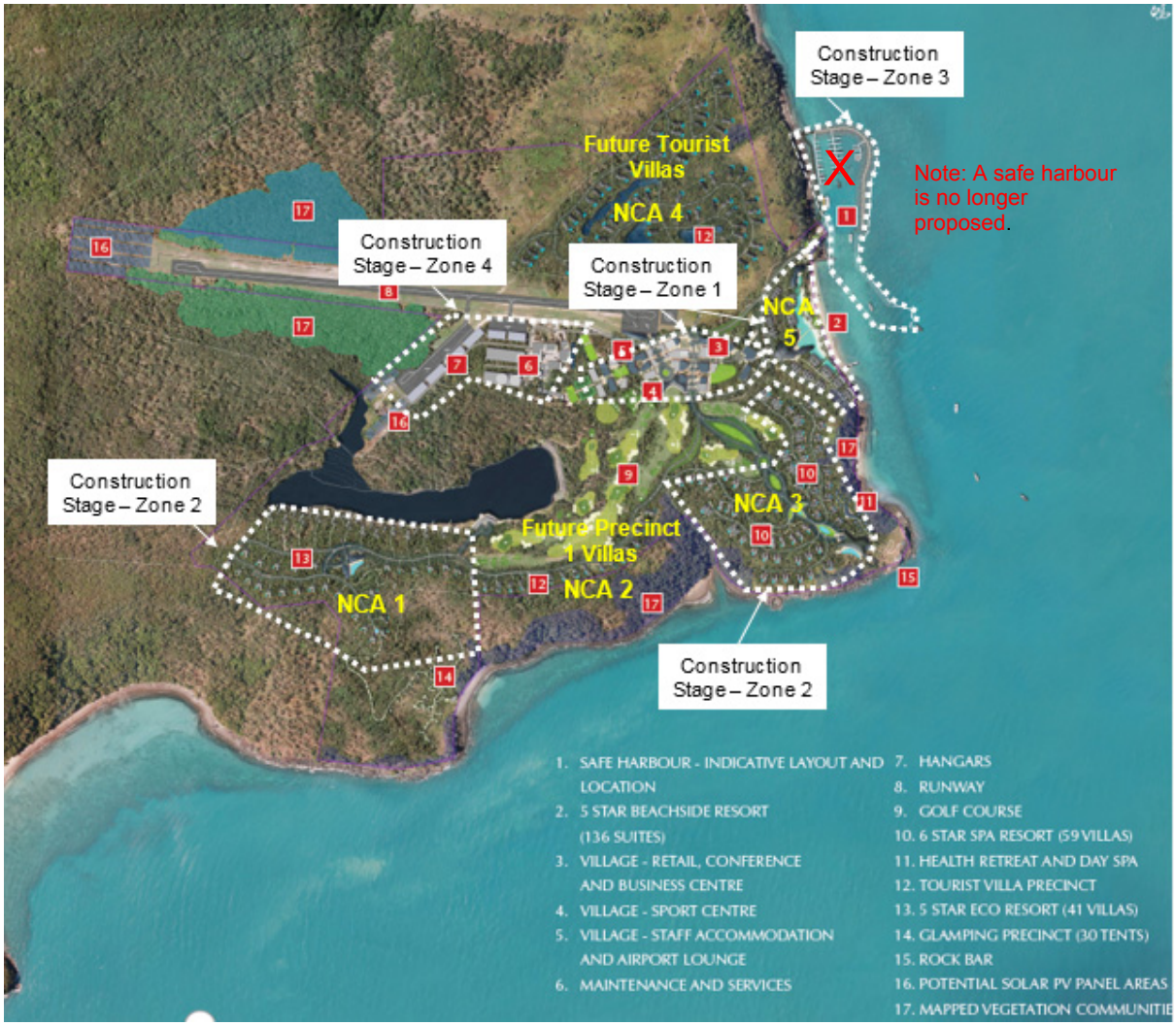
16.4 Construction Noise and Vibration Impacts

Construction noise modelling has been carried out for the worst case construction activities based on the staging and assuming that some completed stages of the resort will be operational during construction of other stages. This assessment provides a worst case scenario for construction operations based on the preliminary staging information available at the time of preparation of this assessment. It is assumed that construction works for the resorts, airstrip and the jetty upgrade will occur between 6.30am and 6.30pm, seven days per week as the resort will not be operational at this time, and the villa construction will occur during standard (daytime) hours. SoundPLAN 7.4 noise modelling software was used to predict construction noise impacting residential receivers. Construction equipment Sound Power Levels have been sourced from measurements conducted for previous assessments and supplemented with values referenced from Australian Standard *AS 2436:2010 – "Guide to noise and vibration control on construction, demolition and maintenance sites"*.

The results of the noise modelling are displayed as noise contour maps in Appendix N – Noise Impact Assessment. A noise map is provided for each model scenario. The noise contours represent the exceedance above the upper and lower external daytime noise limits ((41 dB(A) and 65 dB(A) respectively)), and non-standard hours criteria (40 dB(A)) which has been based on the evening time period as non-standard construction hours are not expected to exceed 6.30pm. Predicted construction noise levels were determined in accordance with the methodology, and modelled scenario numbers. Construction is proposed between 6.30am and 6.30pm seven days per week for the initial stages of the development when the resort is not operational, and then during standard daytime hours only, for construction of the villas. A summary of the predicted noise levels is provided in **Table 16-8.**

The following figure shows the location of the modelled construction zones:

Figure 16-8. Modelled Construction Zones & Noise Catchment Areas (for the purpose of the Noise assessment).



16.4.1 Construction Noise Catchment Areas

The site has been broken up into noise catchment areas (NCAs) to summarise the predicted construction noise impacts on groups of sensitive receivers located in similar areas on the island as follows (refer **Figure 16-8** for locations of these NCAs):

NCA 1: Residential Villas

NCA 2: Future Precinct 1 Villas

NCA 3: Residential Villas

NCA 4: Future Tourist Villas

NCA 5: Resort

Construction noise has not been assessed to commercial receivers or surrounding national parks as there are no formal assessment criteria available for these types of receivers. Recommended internal noise levels are provided below in **Table 16-7** as a guide and noise impact on the National Park should be minimised to the limits for residential receivers where possible, paying particular attention to highly impulsive noise sources that may affect nearby fauna, as a best practice measure.

16.4.2 Construction Noise Criteria

For construction noise impacts the following apply. Details of the derivation of these criteria can be found in **Appendix N – Noise Impact Assessment**.

Table 16-6. External Construction Noise Criteria for Residential Receivers (Source: TMR, 2013).

Time of Day	External Noise Level [4]$L_{Aeq\ (15\ min)}$, dB(A)	
	Lower Limit	Upper Limit
Standard Hours	41	65 Where RBL > 55
Non - Standard Hours	[1]40	Not Applicable

[1]Average Evening RBL + 5 dB(A) based on non-standard hours not exceeding 6.30pm.

Table 16-7. Internal Construction Noise Criteria for Non-Residential Receivers

Type of Occupancy/Activity	Internal Noise Level [1]$L_{Aeq\ (15\ min)}$, dB(A)
Medical/Health Buildings (wards, surgeries, operating theatres, consulting rooms)	40
Educational/Research Facilities (rooms designed for teaching/research purposes)	45
Court of Law (Court Room)	35
Court of Law (Court Reporting and Transcript Areas, Judge's Chambers)	40
Community Buildings (Libraries, Places of Worship)	45

Note:

(1) Noise contribution from construction activity.

Table 16-8. Construction Noise Impact Summary.

Scenario No.	Results Summary
1 - Earthworks & Demolition – Zone 1	Construction noise impacts are expected to comply with the upper limit criteria of 65 dB(A) at all other occupied zones within the development. There is some predicted exceedance of the lower daytime and evening limit across all NCAs, but these areas will not be operational during this construction stage.
2 - Structural Works Zone 1, Earthworks Zone 2	Exceedances of all noise limits are predicted within the development. Exceedances of the upper daytime limit are predicted at NCA3 in particular. This is not likely to be an issue as development will not be operation during this construction phase.
3 - Finishing Zone 1, Structural Works Zone 2	Exceedances of all noise limits are predicted across the development but as none of the areas where the limits are likely to be exceeded are operational at this time, this is likely to be acceptable. Exceedances of the daytime upper limit are expected in NCAs 1, 2 and 3.
4 - Finishing Zone 2	Exceedances of the daytime upper limit are not predicted but some exceedances of the lower and evening limits are predicted across NCA 1 and 3 but as none of the areas where the upper limit is likely to be exceeded are operational at this time, this is likely to be acceptable.
5a - Construction works Zone 3 (Safe Harbour)	The safe harbour is no longer proposed.
5b - Driven Piling Zone 3 (Safe Harbour)	The safe harbour is no longer proposed.
6 - Construction works Zone 4 (airstrip / airport)	Exceedances of the lower limits for both daytime and evening and predicted across all NCAs. However, exceedances of the upper limit daytime noise limits are predicted around the airstrip but not in any occupied zones. Therefore additional mitigation measures are not likely to be required other than best practice management.
7a - Construction works – Future Tourist Villas - Structure	Exceedances of the upper noise limits are predicted in the Future tourist Villa area (NCA 4). There are predicted exceedances of the lower noise and evening limits, across all NCAs. As the resorts are likely to be operational during this period, construction is recommended for daytime hours only, and management controls may be required.
7b - Construction works – Future Tourist Villas - Earthworks	
7c - Construction works – Future Tourist Villas - Finishing	
8a - Construction works – Future Precinct 1 Villas - Structure	Exceedances of the upper noise limits are predicted within the future Precinct 1 Villa area but not in other zones. Exceedances of the lower limits are predicted across the site, and therefore similar measures to those described above for Scenario 7 are recommended.
8b - Construction works – Future Precinct 1 Villas - Earthworks	
8c - Construction works – Future Precinct 1 Villas - Finishing	

16.4.3 Construction Vibration Impact

In general, plant with the potential to generate significant vibration includes:

- Vibratory rollers;
- Rock hammers; and
- Bored and Driven Piling.

Vibration levels vary depending on the distance from the equipment in use, the energy level imparted to the ground by the construction process, and the bedrock type. A range of construction equipment proposed for the project may cause ground borne vibration, with driven piling likely to have the most significant impact. On this basis, the following section provides an assessment of potential for vibration impact at the nearest sensitive receivers, as this is considered the worst case based on the proposed programming information available. The assessment has been carried out in two parts on the basis that driven piling would generate the highest vibration levels, with general construction plant such as excavators, vibratory rollers and rock hammers generating lower levels of vibration. Construction activities are considered to be sources of 'intermittent' vibration and have been assessed as such in terms of maximum peak particle velocity (PPV).

The potentially worst affected receivers were identified based on their location in relation to the proposed piling works, which would be expected to be carried out at the jetty as follows:

- 5 Star SPA Resort, accommodation – at 150 metres from the jetty; and
- 5 Star SPA Resort commercial building – at 75 metres from the jetty.

Table 16-9. Vibration Source Levels for Construction Equipment (ref: TNVIA 2006).

Equipment	PPV at 7.62m (25ft) in mm/s
Pile Driver (Impact) (Upper)	38.56
Pile Driver (Impact) (Typical)	16.36
Vibratory Roller	5.33
Large Bulldozer	2.29
Rock breaker	2.26
Bored Piling	2.24
Loaded Trucks	1.93
Jackhammer	0.89

Based on the above, the predicted piling vibration levels for the assessed receivers are shown below in **Table 16-10**.

Table 16-10. Predicted Construction Vibration Levels at Nominated Receivers.

Receiver	Equipment	Distance, m	Predicted Receiver PPV, mm/s	Human Comfort Vibration Criteria mm/s
5 Star SPA Resort Commercial	Pile Driver (Impact) (Upper)	75	1.2 mm/s	1 – 2 mm/s
	General Construction Equipment		0.03 – 0.5 mm/s	
5 Star SPA Resort Accommodation	Pile Drive	150	0.4 mm/s	1 - 2 mm/s
	Construction Equipment		0.01 – 0.2 mm/s	

The above table indicates that construction works are likely to provide vibration levels that are below 1.0 mm/s for most types of construction at the nearest commercial receiver (75 metres from the jetty). The above figure indicates that the majority of construction works are likely to provide vibration levels that are just above 1 mm/s for piling at the nearest commercial premises but less than 2 mm/s so compliance with the criteria is expected. Based on these results, the estimated vibration level at all sensitive receivers near to the proposed site is likely to comply with both the human comfort and building damage criteria adopted for this project. Therefore vibration mitigation measures are not likely to be required where the separation distance between the works and receivers is 75 metres or greater.

16.5 Operational Noise and Vibration Impacts

Operational noise has been assessed in the following sub-sections, and predicted noise contour maps associated with each noise source are contained in **Appendix N – Noise Impact Assessment**. Based on the proposed development project description included in **Chapter 4**, the noise sources presented below have been assessed for this noise impact assessment:

- Aircraft noise landing and take-off;
- Truck Noise (e.g. trucks delivering goods/produce and collecting refuse);
- Diesel generator noise;
- Water treatment pump; and
- Boat docking noise.

There is some potential for operational noise impact from bar/restaurant facilities on the site to impact the nearby residential areas if the separation distances between the two uses is inadequate. However, this noise source has not been assessed as the locations of these facilities are subject to detailed design and it is expected that appropriate noise controls and building constructions would be adopted in the design and location of these facilities during future stages of the project.

A low frequency noise assessment has not been carried out for the proposed operational noise sources within the resort. Low frequency noise data for the proposed sources is not available and this assessment methodology is generally only applied to wind farms during the planning stage, or in response to low frequency noise complaints in our experience. It is expected however, that any plant noise controls would be designed

based on the available octave band data for the selected plant, which would include octave band data for frequencies from 63 Hz as a minimum.

16.5.1 Aircraft Noise

The existing airstrip consists of two runways. The main runway is aligned 18 / 36 and is a grass strip nominally 1097 metres long. The proposal is to upgrade the main runway to a sealed surface with upgraded storm water drainage to allow for operations during rainy periods. The main sealed runway will be extended within the existing leased areas to approximately 966 metres which will open up the airfield to a wider variety of aircraft including twin propeller aircraft with a capacity of 19 seats. At this stage, a 9 seater ALA B350 has been proposed to operate 10 flights per day. To determine the noise impact from the aircraft overpasses associated with the proposed runway, reference is made to the aircraft noise level data in *Australian Standard AS2021-2000 Acoustics – Aircraft noise intrusion – Building siting and construction* (AS2021). AS2021 does not contain source noise level data for ALA B350 aircraft and therefore, noise data from the following similar aircraft from AS2021 presented below, has been adopted for this assessment:

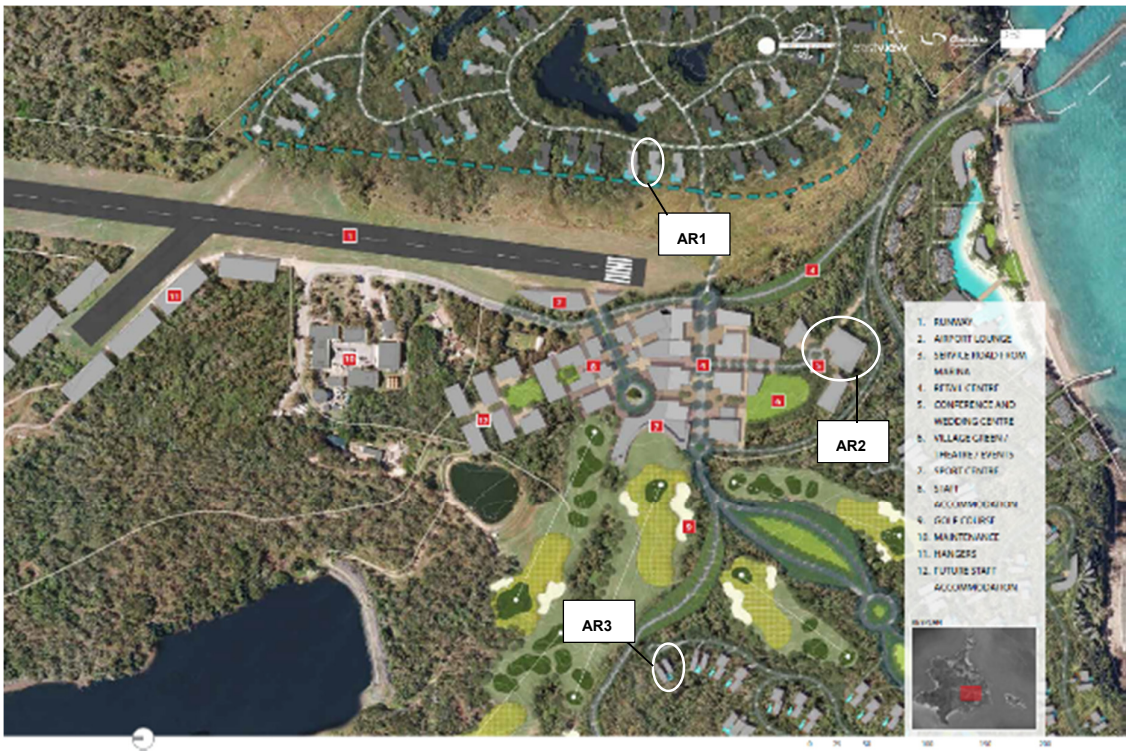
- SAAB 340, Boeing Dash 8, Fokker F50;
- Corporate Jet; and
- Light general aviation aircraft.

Noise levels for the above mentioned aircraft type at various distance have been referenced from Table 3.19 to Table 3.24 of AS2021.

The locations of the most affected receiver in each identified sensitive receiver area (AR) are presented below in **Figure 16-9** and defined as follows:

- AR1: Future Tourist Villas;
- AR2: Conference and Wedding Centre; and
- AR3: 6 Star SPA Resort.

Figure 16-9. Location of Most Exposed Receivers – Potential Aircraft Noise Impacts.



16.5.1.1 Predicted Aircraft Noise Levels

Noise from the nearest runway was considered in the assessment, with the distance between the runways/flight paths and the site determined in accordance with AS2021. **Table 16-11** provides the adopted aircraft source L_{AMax} noise levels used in this assessment.

Table 16-11. AS2021 Aircraft Noise Levels L_{Amax} dB(A).

Aircraft Type	Aircraft Noise Levels, L_{Amax}		Distance Coordinates
	Arrivals	Take-Offs	
Corporate Jet	92	93	DS[1] – 0m DT[2] – 2500m DL[3] – 500m
Light General Aviation Aircraft	88	92	DS[1] – 0m DT[2] – 1500m DL[3] – 500m

Notes:

1 DS – distance from the runway centre-line to the site

2 DT – distance along the runway centre-line to the receiver building site, starting from the furthest end of the runway

3 DL – distance along the runway centre-line to the receiver building site, starting from the closer end of the runway

Based on **Table 16-11** L_{Amax}, 93 dB(A) has been adopted to determine the minimum building facade noise reduction likely to be required for buildings in each receiver area within the proposed development. Required noise reduction for various building types associated with the proposed development are presented below in **Table 16-12.** These indicative noise reductions should be used to determine the external facades construction requirements for different building types of the proposed development.

Table 16-12. Required Aircraft Noise Reduction Levels.

Zone	Receiver Description	Indoor Design Sound Level, L_{Amax} dB(A)	Aircraft Noise Reduction (ANR) Required, dB(A)
Jetty Precinct	Retail/Beach	75	18
5 Star Beach Resort	Visitor Centre	75	18
	Central Facilities	75	18
	Hilltop and Pool Suites	55	38
6 Star Spa Resort	Central Facilities	75	18
	Courtyard, Hilltop, Cliffside and Exclusive Villas	55	38
5 Star Eco Resort	Central Facilities	75	18
	Eco Butterfly and Eco Treetop Villa	55	38
	Glamping Facilities	75	18
Village & Maintenance	Airstrip Lounge	75	18
	Conference Centre	55	38
	Retail	75	18
	Sports Centre	75	18
	Staff Accommodation	55	38
	Maintenance	75	18
Lakeside Restaurant		75	18
Day Spa	Reception & Amenities	75	18
	Treatment Rooms	55	38

Building design for the proposed development has not been finalised at this stage. As such, recommended detailed building design advice has not been included in this assessment. In the absence of any detailed building design, Queensland Development Code Mandatory Part 4.4 (QDC) MP4.4 has been adopted to provide indicative building construction recommendations. This document contains minimum building construction required to achieve certain noise reductions and is normally referenced where buildings are required to provide a reasonable level of noise reduction of traffic noise from state controlled roads. Schedule 1 of QDC MP4.4 provides generic building construction requirements for minimum transport noise reduction (transport noise reduction in dB(A)) required for habitable rooms ranging from 40 dB(A) (Category 4) to 25 dB(A) (Category 1)).

Further detail on building construction requirements is included in **Appendix N – Noise Impact Assessment.**

16.5.2 Truck Movement Noise

Based on the Technical Memorandum – *'Lindeman Island EIS Initial Traffic Assessment',* dated December 2015, assumptions regarding proposed vehicle movement on the island are presented below:

- Daily trips for operations workforce (500 people) – 64 light vehicle trips and six bus trips;
- No information on operations deliveries has been provided at this time. A maximum of three trucks per day is assumed to operate to deliver goods and services for the purpose of this assessment.

It is understood that access to the island is proposed by the new upgraded air strip and boats accessing the island through the proposed upgrades to the jetty. Movement around the resort will be undertaken by golf carts. Based on our previous experience, golf carts are not likely to have any major noise impact on to the proposed development. On this basis, noise impact from the light vehicle trips has not been assessed in this report. With regard to deliveries during the operation of the development, the assumptions provided only refer to barge deliveries. **Table 16-13** below shows operation delivery assumptions in relation to barge deliveries.

Table 16-13. Proposed Barge Movements.

Component	Assumptions
Water	1 barge per week
Food	1 barge per week
Waste	1 barge per week
Fuel	1 barge per week

Based on the barge movement assumptions presented in the above table our assumption of truck movements (three trucks per day) on the island is considered to be conservative. For this reason, our predicted results from the truck movements should also be considered conservative to be updated once more information becomes available. On this basis, further review and assessment may be required at the detailed design stage once building design and information regarding operation vehicle movement/locations are finalised. SoundPLAN 7.4 3D noise modelling software was used to predict the noise impact from the above mentioned mobile vehicle sources. The following modelling inputs and assumptions were adopted for the modelling:

Table 16-14. Noise Modelling Inputs – Operational Transport Vehicle Noise.

Modelling Element	Input/Assumption
Ground Elevation Geometry	Provided by Cardno
Ground Absorption	50% over soft ground
Methodology	Industrial Noise Impact: *ISO 9613.2_1996 – Acoustics – Attenuation of Sound During Propagation Outdoors*
Weather Condition	Calm conditions
Façade Reflection	+2.5 dB(A) applied to traffic models, as all receivers are located at facades of receivers
Receiver Height	Assumed to be 1.8m and 4.6m above ground for ground and first floors respectively
Source Sound Power Levels	Revving sound power level of 110 dB(A) and idling sound power level of 102 dB(A) was assumed to calculate the sound power levels of truck movement along the different sections of the proposed road network on the island. Based on the distance travelled and 20km/h speed, calculated sound power levels were entered as a line source 1.5m above ground level.

It has been assumed that goods and services will be delivered and refuse will be collected from the 5 star resort central facilities, 6 star spa resort central facilities and eco resort central facilities. Therefore, three situations listed below were modelled to predict the truck movement noise associated with the development:

Table 16-15. Truck Movement Modelled Scenario.

Situation	Distance Travelled at 20km/h	Calculated LAeq Sound Power Levels, dB(A)
Truck travelling to 5 star resort central facilities	285 meters	86
Truck travelling to 6 star spa resort central facilities	1012 meters	91
Truck travelling to eco resort central facilities	1436 meters	93

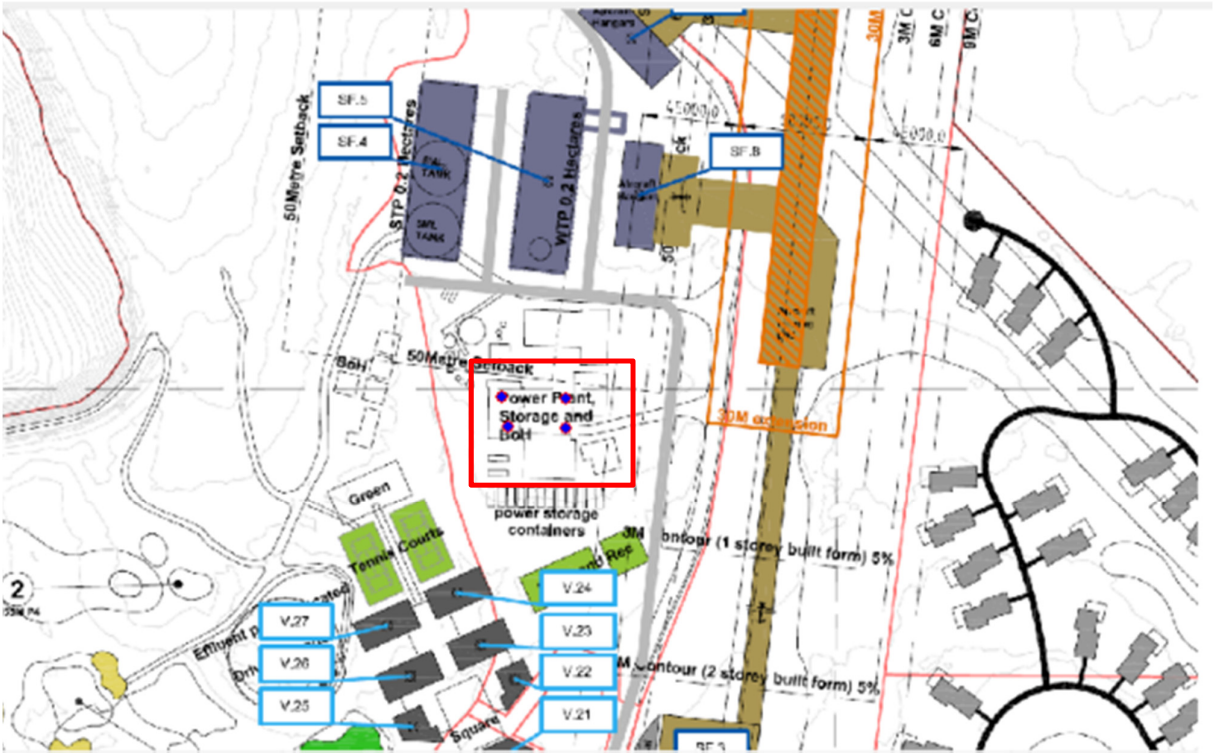
Predicted noise levels from the truck movement along mapped pathways for the 5 star resort, 6 star spa resort and eco resort did not identify any exceedances above the proposed noise limit of 50 dB(A).

For further information refer to **Appendix N – Noise Impact Assessment.**

16.5.3 Diesel Generator Noise

SoundPLAN 7.4 3D noise modelling software was used to predict the noise impact associated with the power plant of the proposed development. In the absence of any detailed information, four diesel generators were entered in the computer model as point sources to predict the noise impact of the proposed power plant. Operation of all four generators simultaneously is expected to the worst case scenario when no solar energy is being utilised. We understand that this scenario is unlikely to occur on a regular basis. Based on the attended measurement near the existing diesel generator, a calculated sound power level of 95 dB(A) was entered at each source location. The location of the modelled generator sources are presented below in **Figure 16-10.**

Figure 16-10. Location of Power Plant Diesel Generator.



The following modelling inputs and assumptions were made for the modelling:

Table 16-16. Noise Modelling Inputs.

Modelling Element	Input/Assumption
Ground Elevation Geometry	Provided by Cardno
Ground Absorption	50% over soft ground
Methodology	Industrial Noise Impact: *ISO 9613.2_1996 – Acoustics – Attenuation of Sound During Propagation Outdoors*
Weather Condition	Calm conditions
Receiver Height	Assumed to be 1.8m and 4.6m above ground for ground and first floors respectively
Source Sound Power Levels	Based on the attended measurements performed onsite, a sound power level of 95 dB(A) was entered as a point source located at 1m above ground level

Predicted noise levels from the power plant (four diesel generators) at the worst affected receivers are presented below in **Table 16-17**.

Table 16-17. Predicted Power Plant, Noise , LAeq.

Receiver	Obj No	Floor	Façade	Proposed Noise Limits, Night / Day, dB(A)	Predicted Noise Levels with No Mitigation	Exceedance of Proposed Noise Limits, dB(A)
V24	350	F2	E	35 / 37	54	19 / 17
V23	347	F2	E	35 / 37	51	16 / 14
V22	341	F2	NE	35 / 37	49	14 / 12
V27	353	F2	N	35 / 37	49	14 / 12

As shown in **Table 16-17**, predicted noise from diesel generators will exceed the *Environmental Protection Act 1994* (EP Act) criteria. As such, an enclosure or noise barriers around all four diesel generators will be required. An enclosure will need to be designed in such a way that the maximum measured sound power level emitted from the enclosure is 83 dB (A) to comply with the daytime noise limits. In order to comply with the evening and night-time noise limits, measured sound power levels outside the enclosure should be less than 81 dB(A) during the evening and night time operation. This assessment has assumed that all four generators will be running concurrently which would only be the case when the entire island is being powered by the generators. Should a percentage of the energy be generated by solar panels, the noise levels will reduce accordingly.

16.5.4 Water Treatment Pump

SoundPLAN 7.4 3D noise modelling software was used to predict the noise impact associated with the water treatment plant proposed for the development. In the absence of any detailed information, one point source was entered in the computer model to predict the noise impact from the water treatment pump. Based on the attended measurement carried out near to the existing water treatment pump, a sound power level of 79 dB(A) was modelled at the location shown in **Figure 16-11**.

Figure 16-11. Location of the Water Treatment Pump.

The following modelling inputs and assumptions were made for the modelling:

Table 16-18. Noise Modelling Inputs – Water Treatment Plant Pump.

Modelling Element	Input/Assumption
Ground Elevation Geometry	Provided by Cardno
Ground Absorption	50% Over soft ground
Methodology	Industrial Noise Impact: *ISO 9613.2_1996 – Acoustics – Attenuation of Sound During Propagation Outdoors*
Weather Condition	Calm conditions
Receiver Height	Assumed to be 1.8 and 4.6 meters above ground for ground and first floors respectively
Source Sound Power Levels	Based on the attended measurements performed onsite, a sound power level of 79 dB(A) was entered as a point source above 1m above ground level

Predicted noise levels from the water treatment plant at the worst affected receivers are presented below in **Table 16-19.** Predicted noise levels from the water treatment pump comply with the adopted EP Act noise criteria. Information regarding whether the number of pumps will increase or any other treatment plant is to be added as a result of the development was not available at the time of preparation of this report. However, given that the predicted noise levels are generally 10 dB(A) below the most stringent night-time criteria, exceedances are not likely to occur unless a significant increase in the number and size of plant occurs. If this is the case, then a more detailed, updated assessment of noise impacts from the WTP will be required.

Table 16-19. Predicted Water Treatment Plant (WTP) Noise – Daytime, LAeq

Receiver	Obj No	Flr.	Façade	Proposed Noise Limits, dB(A)			Predicted Noise Levels	Exceedance of Proposed Noise Limits, dB(A)
				Daytime	Evening	Night		
Village 24	350	F2	E	37	36	32	22	-
Village 23	347	F2	E	37	36	32	21	-
Village 27	353	F2	N	37	36	32	21	-
Village 21	335	F1	N	37	36	32	21	-

16.5.5 Boat Docking Noise

SoundPLAN 7.4 3D noise modelling software was used to predict the noise impact associated with the boats docking at the jetty of the proposed development. Based on attended measurements at the existing facility, a point source with a sound power level of 94 dB(A) was modelled at the location near the existing jetty to predict the boat docking noise. The following modelling inputs and assumptions were adopted for the modelling:

Table 16-20. Noise Modelling Inputs – Boats Docking.

Modelling Element	Input/Assumption
Ground Elevation Geometry	Provided by Cardno
Ground Absorption	50% over soft
Methodology	Industrial Noise Impact: *ISO 9613.2_1996 – Acoustics – Attenuation of Sound During Propagation Outdoors*
Weather Condition	Calm conditions
Receiver Height	Assumed to be 1.8m and 4.6m above ground for ground and first floors respectively
Source Sound Power Levels	Based on the attended measurements performed onsite, sound power level of 94 dB(A) was entered as a point source at 1m above ground level

Predicted noise levels from the medium boat docking at the worst affected receivers are presented below in **Table 16-19**. As shown in the table, predicted noise from a medium sized boat docking at the jetty is predicted to comply with the adopted noise limits. Conceivably, larger boats may dock at the jetty or the barge landing point once the development is complete. A larger boat may have a source noise level of up to 10 dB(A) higher when docking. If this were the case, the noise criterion is likely to be exceeded. However these noise levels are likely to be short–term and occur infrequently so predicted noise emissions from boats are likely to be acceptable and not subject to noise mitigation requirements.

Table 16-21. Predicted Boat Docking Noise – Daytime, LAeq.

Receiver	Obj No	Floor	Façade	Proposed Noise Limits, dB(A)	Predicted Noise Levels	Exceedance of Proposed Noise Limits, dB(A)
Beach Resort	1	GF	S	50	43	-
Tourist Villas	180	F1	S	50	42	-
Tourist Villas	181	F1	S	50	41	-
Tourist Villas	179	F1	S	50	41	-

16.6 Assessment of Cumulative Noise Impacts

The closest habitable island from the development is Hamilton Island and is located approximately 13 kilometres away from the proposed development. Based on the distance of Hamilton Island from the proposed development, assessments have identified that there should be no adverse noise impact from the proposed development onto the nearest receivers. Therefore, as no external noise sensitive receivers are located within the close proximity of the development, a detailed assessment of cumulative noise impacts from proposed noise sources within the development has not been included in this report.

16.7 Potential Impacts and Mitigation Measures

Potential noise impacts for both the operational and construction phases of the proposal have been identified by this assessment. This risk evaluation process affords a score ranging from Low (1) to Extreme (25). The resulting risk assessment is presented in **Table 16-22**. Detailed site specific measures are included in **Appendix N – Noise Impact Assessment,** while marine based noise sources are addressed in **Chapter 9 – Marine Ecology.**

Table 16-22. Risk Assessment - noise.

Potential Impact	Significance of Impact: Unmitigated	Mitigation Measure			Significance of Impact: Mitigated
		Design	Construction	Operation	
Aircraft Noise					
Aircraft noise causing sleep disturbance at night	High (16)	• Provide adequate building construction to accommodation in accordance with AS2021	-	• Do not operate aircraft at night except for emergencies.	Low (1)
High levels of aircraft noise during the day	High (16)	• Provide adequate building construction to sensitive areas in accordance with AS2021	-	• Manage timing and number of aircraft movements	Low (4)
Operational Truck Noise					
Excessive truck noise from deliveries and refuse collection	Low (3)	-	-	• Manage hours of deliveries / refuse collection • Truck movement operations should operate during the daytime (7am to 6pm) and evening (6pm to 10pm) periods only.	Low (1)
Diesel Generator noise					
Excessive noise at sensitive receivers from diesel generators	High (16)	• Design barriers or enclosures around the generators • Adopt a percentage of solar power energy production	-	• Manage maintenance operation during daytime hours only • Maintenance of an enclosure or noise barriers around all four diesel	Low (1)

Potential Impact	Significance of Impact: Unmitigated	Mitigation Measure			Significance of Impact: Mitigated
		Design	Construction	Operation	
				generators to achieve 83 dB(A) day and 81 dB(A) night.	
Boat Docking Noise					
Noise from boats using jetty and moorings at nearby sensitive receivers	Low (4)	• Provide adequate noise screening / enclosure	-	• Boats with sound power levels over 101 dB(A) may cause excessive noise impacts. The number of larger boats using the jetty/moorings will be limited due to the limited number of moorings available. • Boat docking only permitted to occur within daylight hours.	Low (1)
Water Pump Noise					
Excessive plant noise at nearby sensitive receivers	Low (4)	• Provide adequate noise screening / enclosure	-	Maintenance of enclosure or screening	Low (1)
Construction Noise					
Excessive construction noise at existing external receivers	Low (1)	-	• Not required – nearest external sensitive receivers are located at least 13 km away.	-	Low (1)
Excessive evening construction noise at operational sensitive areas	High (16)	• Provide local barriers screening and plant controls	• Prepare and implement a Noise and Vibration Management Strategy based on Australian Standard AS2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites; • All equipment and machinery to be maintained in good operating condition and be fitted with appropriate noise attenuation devices. Wherever practicable machines will be switched off when not in use; • All generators, compressors and welders to be	-	Low (1)

Potential Impact	Significance of Impact: Unmitigated	Mitigation Measure			Significance of Impact: Mitigated
		Design	Construction	Operation	
			checked during daily prestart to ensure they produce minimal noise; • Maintain awareness of construction workers in relation to minimising noise and vibration impacts from equipment operation; • Manage staging to locate construction as far from operational areas as possible • Do not carry out construction outside of standard hours while adjacent resorts are operational; and • Maintain buffer distances between plant equipment and sensitive receptors.		
Excessive construction noise impacts at sensitive areas during the day	Medium (12)	-	• Manage staging to locate construction as far from operational areas as possible • Maintain buffer distances	-	Medium (8)

For the construction phase the following mitigation measures are proposed to mitigate the impacts associated with noise:

- Prepare and implement a Noise and Vibration Management Strategy based on *Australian Standard AS2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites*;
- Provide adequate building construction to accommodation (resort hotels and staff accommodation) in accordance with AS2021 and building construction requirements contained in QDC MP4.4. Schedule 1 of QDC MP4.4 provides generic building construction requirements for minimum transport noise reduction (transport noise reduction in dB (A)) required for habitable rooms ranging from 40 dB(A) (Category 4) to 25 dB(A) (Category 1));
- All equipment and machinery to be maintained in good operating condition and be fitted with appropriate noise attenuation devices. Wherever practicable machines will be switched off when not in use;
- All generators, compressors and welders to be checked during daily prestart to ensure they produce minimal noise;

- Maintain awareness of construction workers in relation to minimising noise and vibration impacts from equipment operation;
- Manage staging to locate construction as far from operational areas as possible;
- Do not carry out construction outside of standard hours while adjacent resorts are operational;
- Maintain buffer distances between plant equipment and sensitive receptors;
- All equipment and machinery to be maintained in good operating condition and be fitted with appropriate noise attenuation devices. Wherever practicable machines will be switched off when not in use;
- All generators, compressors and welders to be checked during daily prestart to ensure they produce minimal noise; and
- Maintain awareness of staff in relation to minimising noise and vibration impacts from equipment.

For the operational phase the following mitigation measures are proposed to mitigate the impacts associated with noise:

- Provide adequate building construction to accommodation (resort hotels and staff accommodation) in accordance with AS2021 and building construction requirements contained in QDC MP4.4. Schedule 1 of QDC MP4.4 provides generic building construction requirements for minimum transport noise reduction (transport noise reduction in dB (A)) required for habitable rooms ranging from 40 dB(A) (Category 4) to 25 dB(A) (Category 1));
- No night flights allowed accept for emergencies;
- Install and maintain a barrier or enclosures around the diesel generators and ensure the total emitted plant sound power level does not exceed 83 dB(A) during the day and 81 dB(A) at night;
- Noise emissions from use of boats should not exceed a sound pressure level of 78 dB(A) @ 5 metres and operation be limited to the daytime (7am to 6pm) and evening (6pm to 10pm) period only;
- Install and maintain adequate noise screening/enclosure for water pump;
- Truck movement operations are limited to three trucks per day operate during the daytime (7am to 6pm) and evening (6pm to 10pm) periods only;
- All equipment and machinery to be maintained in good operating condition and be fitted with appropriate noise attenuation devices. Wherever practicable machines will be switched off when not in use;
- All generators, compressors and welders to be checked during daily prestart to ensure they produce minimal noise; and
- Maintain awareness of staff in relation to minimising noise and vibration impacts from equipment operation.

It is proposed that monthly noise monitoring reports will be prepared detailing all of the monitoring results and any exceedances of project criteria. This information should then be used to inform the construction team on whether compliance is being achieved and whether the proposed noise mitigation strategies need to be altered to accommodate exceedances. In addition, it is proposed that additional noise monitoring may be carried out as part of a complaint management strategy if required.

16.8 Summary

The noise and vibration assessment has identified that construction of the project will result in predicted exceedances of the *Department of Transport and Main Roads Transport Noise Management Code of Practice - Construction noise criteria* for a number of the proposed construction scenarios. General noise mitigation measures to minimise construction noise impacts have been identified in the above sections. As the resorts are not proposed to be operational during this construction phase adverse impacts on human sensitive receivers are not expected. The predicted exceedances are generally a result of very quiet ambient noise levels, and therefore stringent criteria, combined with large numbers of plant that have been adopted for each modelled scenario. This modelling has been carried out to provide a worst case scenario and it may be possible to reduce the number of plant on site and still provide the same level of operations by making processes more efficient. Ground vibration levels at 75 metres from driven piling, and general construction activities are expected to range between approximately 0.01 and 1.2 mm/second at the nearest receiver. Based on this, the estimated vibration level at all sensitive receivers near to the proposed Zone 3 site is likely to comply with both the human comfort and building damage criteria adopted for this project.

Operationally, predicted aircraft noise levels from the proposed airstrip upgrade are likely to impact the proposed development and as such indicative building construction requirements based on Queensland Development Code MP4.4 have been identified in this report. Predicted noise levels from truck movements are expected with thein daytime and evening noise limits. Operational truck movement operations should be limited to 3 trucks per day and should operate during daytime only. Based on the worst case scenario of 4 diesel generators running simultaneously, the predicted noise levels from the proposed energy plant is expected to exceed both daytime and night-time EPA noise limits. Therefore, an enclosure or noise barriers located around all 4 diesel generators has been recommended. Predicted noise levels from the proposed water treatment pump and from a medium boat docking is expected to comply with the adopted assessment noise limits. Exceedances are predicted for docking boats with a maximum sound power level of 100 dB(A) or a sound pressure level of 78 dB(A) @ 5 metres. Boat docking activities at the barge landing point and jetty are recommended to be limited to the daytime (7am to 6pm) and evening (6pm to 10pm) period only.

The closest habitable island from the development is Hamilton Island and is located approximately 13 kilometres away from the proposed development. Based on the distance of Hamilton Island from the proposed development, assessments have identified that there should be no short or long term adverse noise impacts from the proposed development on the nearest receivers.