8.10 Noise and Vibration

8.10.1 Terrestrial Noise

8.10.1.1 Introduction

A detailed noise and vibration impact assessment for the proposed LNG facility (see Figure 3.4.6) has been undertaken. The following chapter provides a summary of the assessment findings, including a description of the existing environmental values, assessment of potential noise impacts and recommended mitigation measures in accordance with the ToR requirements of the EIS. The detailed technical assessment report can be referred to in Appendix U1.

8.10.1.2 Methodology

The assessment considered the potential noise and vibration impacts associated with the construction and operational phases of the LNG facility and included:

- A description of the existing acoustic and vibration environment surrounding the proposed LNG facility;
- An overview of applicable construction and operational noise and vibration goals based on relevant legislation and EPA guidelines;
- Conduct of noise and vibration modelling to predict the potential impacts at sensitive receivers during the construction and operational phases of the LNG facility:
  - Noise modelling was carried out using the SoundPLAN (Version 6.4) utilising the CONCAWE prediction methodology. The computer model calculated noise emission levels and considers source SWL, location, distance attenuation, ground absorption, air absorption, shielding attenuation, and meteorological conditions including wind effects. Further details on the methodology and equipment SWL are provided in Appendix U.
  - Vibration impacts were determined by comparing the measured vibration levels for construction equipment/activities detailed above (refer Appendix U1) with the applicable vibration guidelines (refer Section 8.10.2.3). The “safe working distance” for both ‘cosmetic’ damage and human comfort was then able to be derived for pile driving and boring activities.
  - Traffic noise predictions associated with the new road were modelled using the Calculation of Road Traffic Noise (CoRTN) prediction technique recommended by the Department of Main Roads (DMR) Code of Practice. The model accounts for traffic volumes, composition, vehicle speed and road surface.
- Cumulative road noise was assessed based on anticipated traffic movements associated with LNG facility workers as a percentage of existing road traffic. Further assessment of cumulative noise impacts associated with project related transport is considered in Section 4; and
- An overview of possible mitigation measures which could be incorporated into the LNG facility to minimise the potential for impacts.

The noise and vibration assessment has been performed for two alternative liquefaction processes:

- Optimized Cascade Process (OCP); and
- Propane Pre-cooled Mixed Refrigerant (C3MR) process.

The noise impact results from both processes are presented in Appendix U1.

The OCP liquefaction process is the preferred process chosen by Santos. Two scenarios were modelled for both neutral and “worst case” weather conditions for the OCP scenario. The scenarios related to the processing capacity (3 Mtpa and 10 Mtpa) for each cryogenic liquefaction process under consideration for the LNG facility:

- OCP- 3 Mtpa; and
- OCP- 10 Mtpa.

8.10.1.3 Regulatory Framework

Noise

Refer to Section 6.10.3 for relevant legislation and guidelines.

Marine Noise

The construction of the PLF, MOF, access channels and the potential bridge (including the marine section of the gas transmission pipeline that will be trenched from Friend Point to Laird Point) all have the potential to produce underwater noise. The ongoing operations of the GLNG Project will produce underwater noise from the movement of LNG carriers exporting the LNG product.

Legislation and guidelines relevant to construction and operational marine noise levels includes:

- *Environmental Protection and Biodiversity Conservation Act 1999* (Cth);
- *Environmental Protection Act;*
- *Environmental Protection Policy (Noise)* 2008;
- *Nature Conservation Act 1992* (Qld);
- *Marine Parks Act 2004* (Qld); and
- *Great Barrier Reef Marine Park Act 1975* (Qld).

Environmental Protection and Biodiversity Conservation Act 1999

The *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the key piece of legislation for the Commonwealth Government to provide for the protection of the environment and heritage, especially matters of national environmental significance and areas that have values (whether natural, indigenous, historic or other) of significant heritage value to Australia (Protected matters). Among other things, the Act promotes biodiversity conservation, heritage protection and recognises the role of indigenous people in the conservation of Australia's biodiversity. It is designed to provide for the conservation of biodiversity through the protection of threatened species and ecological communities, migratory, marine and other protected species listed under the Act.

The Terms of Reference issued in August 2008 under Part (4) of the *State Development and Public Works Organisation Act 1971*(Qld) for the GLNG Project lists species and communities that must be considered within the requirements of the EPBC Act.

A search of the dataset identified eight species listed as vulnerable or endangered that may occur (or have suitable habitat) in the study area. Potential species included Humpback Whale, Water Mouse/False Water Rat and six species of turtle. Further details of the EPBC search results for threatened species in the Project area are provided in the Nature Conservation technical reports in Appendix N.

EP Act

The EP Act aims to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (being ecologically sustainable development). The regulation of underwater noise in Queensland is governed by the EP Act.

Environmental nuisance is an unreasonable interference or likely interference with an environmental value, such as amenity. The *Environmental Protection Regulation 2008* outlines the scope for application of applying noise criteria. A "noise sensitive place" is classed as a "protected area" which includes areas protected area under the *Nature Conservation Act 1992*.

EPP (Noise) 2008

Refer to Section 6.10.3 for relevant EPP (Noise) 2008 legislation.

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NC Act) is the principal legislation for the conservation and management of the State's native flora and fauna which includes the preservation of protected areas, protected plants and protected wildlife as listed under relevant regulations and plans, including the *Nature Conservation (Protected Areas) Regulation 1994* and the *Nature Conservation (Whales and Dolphins) Conservation Plan 1997*.

The regulation of underwater noise in Queensland is governed by the NC Act and the *Nature Conservation (Protected Areas) Regulation 1994* in which reference is made to conservation management plans and noise impact.

The *Nature Conservation (Whales and Dolphins) Conservation Plan 1997* provides for further protection of whales and dolphins, including a restriction on making noise without a reasonable excuse that is likely to disturb a whale or dolphin. The issue considered in this impact assessment is whether sounds from construction (pile driving and/or dredging) and future operations at the potential bridge spanning Port Curtis between Friend Point and Laird Point and new berths are likely to disturb whales, dugong, dolphins, turtle or fish.

All six species of turtle found in Queensland are listed as either 'Endangered' or 'Vulnerable' under the *Nature Conservation (Wildlife) Regulations 1994.*

Marine Parks Act 2004

The *Marine Parks Act 2004* provides for the conservation of the marine environment through establishing an integrated strategy of management including (amongst other things) the establishment of marine park zones (such as the *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004* (MPGBRC Zoning Plan)), designated areas and highly protected areas within marine parks. The *Marine Parks Act 2004* also sets out various permitting and licensing requirements to carryout activities within a declared marine park zone. The MPGBRC Zoning Plan regulates the area from the low water mark of the Great Barrier Reef Marine park to either the high water mark or the seaward edge of significant mangrove forests.

The *Marine Parks Act 1982* also provides for the protection of marine turtles through zoning and the issuing of permits, similar to the *Great Barrier Reef Marine Park Act 1975*.

Great Barrier Reef Marine Park Act 1975

The *Great Barrier Reef Marine Park Act 1975* aims to provide for the long term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region, including the ecologically sustainable use of the Great Barrier Reef for recreational, economic and cultural activities. The Act provides for zoning plans and plans of management. The Act also establishes the *Great Barrier Reef Marine Park Zoning Plan 2003* which provides for the establishment, control, care and development of the Great Barrier Reef Marine Park and is the primary planning instrument for the conservation and management of the Marine park.

Construction Criteria

The EPP (Noise) does not include construction noise limits, with noise impacts minimised by limiting the hours of operation to:

- Monday- Saturday: 6:30 am to 6:30 pm.

The adopted project noise and vibration criteria for the construction phase are described in Table 8.10.1.

Table 8.10.1 Summary of Construction Criteria

Construction Noise		Vibration		
Monday to Saturday (6:30 am to 6:30 pm)	Monday to Saturday (6:30 pm to 6:30 am); Sundays and Public Holidays	Structural Damage (mm/s)	Human Comfort (mm/s)	
			Day	Night
No limit	50 dBA LAmax	12.5	0.3 – 0.6	0.2

Operational Noise Criteria

All operational noise emissions were assessed in accordance with the EPA *EcoAccess Guideline: Planning for Noise Control* guideline (EcoAccess) which considers:

- Background noise creep criteria;
- Planning noise levels criteria;
- Short term intrusive criteria;
- Sleep disturbance noise criteria; and
- Low frequency noise criteria.

Background Noise Creep Criteria

The background noise creep criteria aim to prevent an incremental increase in background noise from all noise sources. Where existing noise levels approach the recommended RBL, criteria must be adjusted to prevent background creep. The RBL's for each sensitive receiver were determined from ambient noise monitoring (refer Table 8.10.10) conducted at each sensitive receiver. The background creep criteria were then developed from the RBL in accordance with the EcoAccess and are presented in Table 8.10.2.

A full description of the methodology used to derive the adopted criteria for the LNG facility is provided in Appendix U.

Table 8.10.2 Project Background Noise Creep Criteria

Noise Assessment Location	Background Noise Creep Criteria LA90(1hour) (dBA)		
	Day	Evening	Night
Plant 1	31	31	31
Plant 2	25	32	25
Plant 3	27	32	27
Plant 4	27	30	27
Plant 5	25	25	25
Plant 6	28	32	28
Plant 7	30	35	30

Note 1: Design criterion is the most stringent of the Planning Noise Level (PNL) and Specific Noise Level (SNL) (as defined in EcoAccess).

2: Sleep disturbance and low frequency criteria have been adjusted to represent outdoor levels.

3: Noise criteria are based on typical background noise levels for an "Industrial Area' as shown in Queensland's *EcoAccess* 'Recommended Outdoor Planning Noise Levels' table.

The most significant continuous noise sources associated with the LNG facility were assessed against the applicable background noise creep criteria with the exception of noise from ship movements and flare events which were assessed against the short term intrusive noise criteria (transient noise sources). Refer Appendix U for further details.

Planning Noise Level Criteria

Maximum Planning Noise Levels (PNL) for various noise area categories are also recommended within EcoAccess. Where existing noise levels in an area approach the maximum PNL, the noise level from any new source must be controlled to preserve the amenity of the area. To achieve this, the EcoAccess recommends modifications be made to the maximum PNL depending on the existing noise levels (based on measured maximum LAeq(1 hour) noise levels (see Table 8.10.11).

Short Term Intrusive Noise Criteria

The short term intrusive noise criteria (SNL) were based on the existing measured RBL with the addition of 3 dBA as per EcoAccess. The SNL noise criteria is in terms of the LAeq(1hr) noise level.

In very rural areas (where minimum LA90 is lower than 25 dBA) it may be possible for the (LAeq) SNL to be calculated to a lower noise level than the recommended background creep level (LA90) due to the 25 dBA threshold nominated for background creep in the Guideline. It is considered to be appropriate to set the SNL (LAeq level) higher than the background creep level (min LA90), therefore background creep + 3 dBA has been adopted for the SNL in these instances.

Sleep Disturbance Noise Criteria

The guideline recommends that in order to achieve good night of sleep, internal noise levels should not exceed:

- L_{Amax} of 45 dBA > 10 - 15 times per night.

The project adopted the sleep disturbance noise criteria of 50 dBA assumes a conservative 5 dBA attenuation from the building facade (refer Section 6 of Appendix U1 for further detail). The sleep disturbance noise criteria are shown in Table 8.10.3.

Low Frequency Noise Criteria

The potential for low frequency noise in the range of 20 Hz to 200 Hz was assessed in accordance with *EcoAccess Guideline: Assessment of Low Frequency Noise*. The adopted project criteria for low frequency noise are provided in Table 8.10.3 and are based on the guideline limit of 20 $L_{pA,LF}$ (dBA) internal low frequency noise level and a conservative estimate of 3 dBA attenuation from building façades(for low frequency noise) resulting in 23 $L_{pA,LF}$ (dBA) external low frequency noise level.

Table 8.10.3 Summary of Most Stringent Noise Criteria

Noise Assessment Location	Background Noise Creep Criteria	Design Criteria[1]	Sleep disturbance[2]	Low Frequency Criteria[2]
	LA90(1hour) (dBA)	LAeq(1hour) (dBA)	LAmax (dBA)	LpA,LF (dBA)
Plant 1	31	44	50	23
Plant 2	25	34	50	23
Plant 3	27	40	50	23

Noise Assessment Location	Background Noise Creep Criteria	Design Criteria[1]	Sleep disturbance[2]	Low Frequency Criteria[2]
	LA90(1hour) (dBA)	LAeq(1hour) (dBA)	LAmax (dBA)	LpA,LF (dBA)
Plant 4	27	40	50	23
Plant 5	25	34	50	23
Plant 6	28	41	50	23
Plant 7 [3]	30	43	50	23

Note 1: Design criterion is the most stringent of the PNL and Specific Noise Level (SNL) (as defined in EcoAccess).

2: Sleep disturbance and low frequency criteria have been adjusted to represent outdoor levels.

3: Noise criteria for Plant 7 are based on typical background noise levels for an "Industrial Area' as shown in EcoAccess 'Recommended Outdoor Planning Noise Levels' table.

Table 8.10.4 Acoustic Quality Objective EPP (Noise) 2008

Sensitive Receptor	Time of Day	Acoustic Quality Objectives (measured at receptor) dB(A)			Environmental Value
		LAeq,adj,1hr	LA10,adj,1hr	LA1,adj,1hr	
Dwelling (for outdoors)	Daytime and evening	50	55	65	Health and wellbeing
Dwelling (for indoors)	Daytime and evening	35	40	45	Health and wellbeing
	Night time	30	35	40	Health and wellbeing

In general, the acoustic quality objectives in the EPP (Noise) 2008 are lower than (or equal to in some instances) the 55 dBA objective in the EPP (Noise).

The acoustic quality objects in the EPP (Noise) 2008 do not apply for transport activities (road, rail, aircraft and ports). Transport activities associated with a specific facility would be assessed via other limits relevant to the transport mode (e.g. Main Roads' Road Traffic Noise Management Code of Practice).

Vibration

Activities associated with the construction and operational phase of the LNG facility were assessed for each of the following impacts:

- Human comfort;
- Structural damage;
- Safe vibration levels for common services; and
- Effects of vibration on building contents.

Human Comfort

Guidelines for the assessment of potential human disturbance inside buildings and structures are provided by the British Standard BS 6472 *"Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)"* (1992).

The relevant peak vibration levels (below which probability of 'adverse comment' is low) for different building occupancy types are shown in Table 8.10.5.

Table 8.10.5 Building Occupancy Vibration Guidelines (BS 6472)

Type of Space Occupancy	Time of Day	Satisfactory Peak Vibration Levels in mm/s Over the Frequency Range 8 Hz to 80 Hz			
		Continuous Vibration		Impulsive Vibration with up to 3 Occurrences per Day	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (e.g. some hospital operating theatres, some precision laboratories, etc)	Day Night	0.14 0.14	0.4 0.4	0.14 0.14	0.4 0.4
Residential	Day Night	0.3 to 0.6 0.2	0.8 to 1.6 0.6	8.4 to 12.6 2.8	24 to 36 8
Offices	Day Night	0.6 0.6	1.6 1.6	18 18	51 51
Workshops	Day Night	1.2 1.2	3.2 3.2	18 18	51 51

Note: The vibration guideline levels in Table 8.10.5 may need to be reduced by up to 50 % for continuous vibration sources

Structural Damage

Guidelines for the assessment of potential for building damage caused by ground vibration damage are contained in the *British Standard 7385* (1993). The guideline vibration values below which there is a minimal risk of cosmetic damage to residential buildings and industrial buildings for transient vibration are shown in Table 8.10.6.

Further information on vibration guidelines is provided in Appendix U.

Table 8.10.6 Vibration Guide Values for Cosmetic Damage (BS 7385)

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Non-reinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Road Traffic Noise Criteria

Traffic noise criteria applicable to the project are established in the EPP (Noise) and the Road Traffic Noise Management: Code of Practice (Queensland Main Roads, January 2000).

Different criteria apply depending on whether the road is new or existing. For this project, the proposed road connecting the bridge to Landing Road is regarded as a new road.

The road traffic noise criteria applicable for the assessment of noise from vehicle movements associated with the project are summarised below in Table 8.10.7.

Table 8.10.7 Road Traffic Noise Criteria

Road Type		Criteria
State	Existing Road	68 dBA $L_{A10(18\ hour)}$ and ≤ 2 dBA change in existing $L_{A10(18\ hour)}$
	New Road	63 dBA $L_{A10(18\ hour)}$
Other public road	Existing Road	63 dBA $L_{A10(18\ hour)}$ and ≤ 2 dBA change in existing $L_{A10(18\ hour)}$
	New Road	63 dBA $L_{A10(18\ hour)}$

8.10.1.4 Existing Environmental Values

Sensitive Noise Receptors

The proposed LNG facility located on Curtis Island is situated approximately 5 km north-east of the City of Gladstone in Queensland. The island is essentially rural with undeveloped land parcels used for cattle grazing. A residential development lies at the south-eastern end of the island known as South End, approximately 10 km from the proposed LNG facility. There are approximately 50 dwellings, including 20 permanent and 90 seasonal residents.

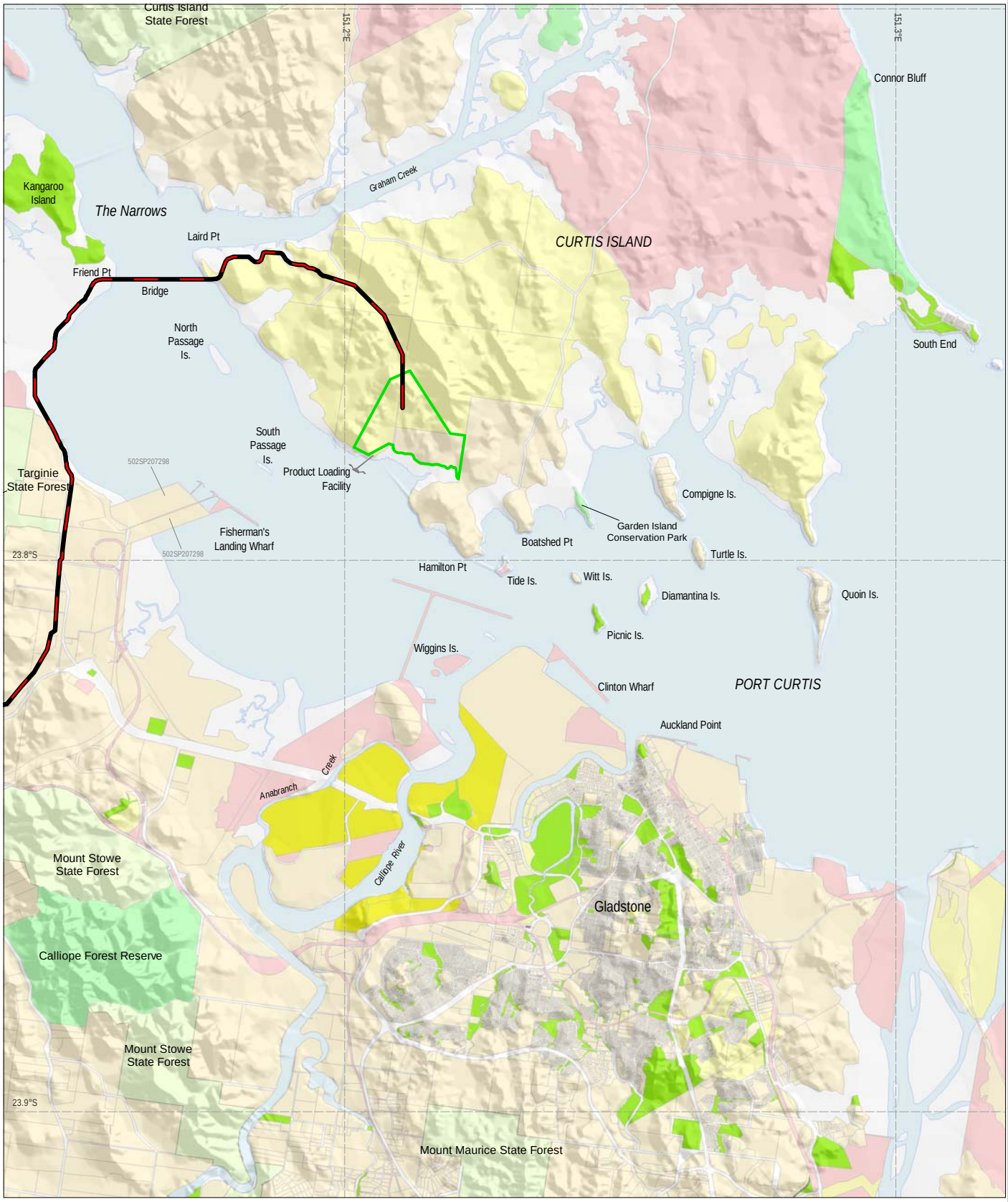
Other small islands in Port Curtis with permanent or seasonal residents include Facing Island, She Oak Island, Tide Island and Compigne Island. Figure 8.10.1 shows the location of the proposed LNG facility in relation to South End and other inhabited islands.

Existing noise sources in the surrounding environment are typical of rural areas with the nearest residential area located approximately 3.4 km to the south of the proposed LNG facility.

Sensitive receivers defined by the EPA (2006) Noise Guidelines include:

- Dwellings;
- Library, childcare centre, kindergarten, school, college, university or other educational institution;
- Hospital, surgery or other medical institution;
- Protected area, or an area identified under a conservation plan as a critical habitat or an area of major interest, under the *Nature Conservation Act 1992*;
- Marine park under the *Marine Parks Act 1982*; and
- Park or garden that is open to the public (whether or not on payment of money) for use other than for sport or organised entertainment.

Seven assessment locations were identified within the vicinity of the proposed LNG facility. The assessment locations were grouped based on their proximity to ambient noise monitoring locations. Prediction locations within each ambient noise monitoring group are assessed against the same construction/operational criteria based on the results of the monitoring. Only the prediction location within each ambient noise monitoring group with the highest predicted noise level is reported. All receivers have been positioned 1.5 m above ground and a minimum of 4 m from the nearest building facade (ie free field). The nearest receptor is located on Tide Island, 3.4 km south of the proposed LNG facility (refer Figure 8.10.2)



Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright

Client: LNG	Project: GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	Title: **LNG FACILITY LOCALITY NOISE SENSITIVE RECEPTORS**	
URS	Drawn: CA / Approved: JB / Date: 26-02-2009 Job No: **4262 6220** / File No: 42626220-g-871b.wor	Figure: **8.10.1**	Rev:B **A4**

Client

URS

Project

GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Drawn: CA | Approved: JB | Date: 26-02-2009

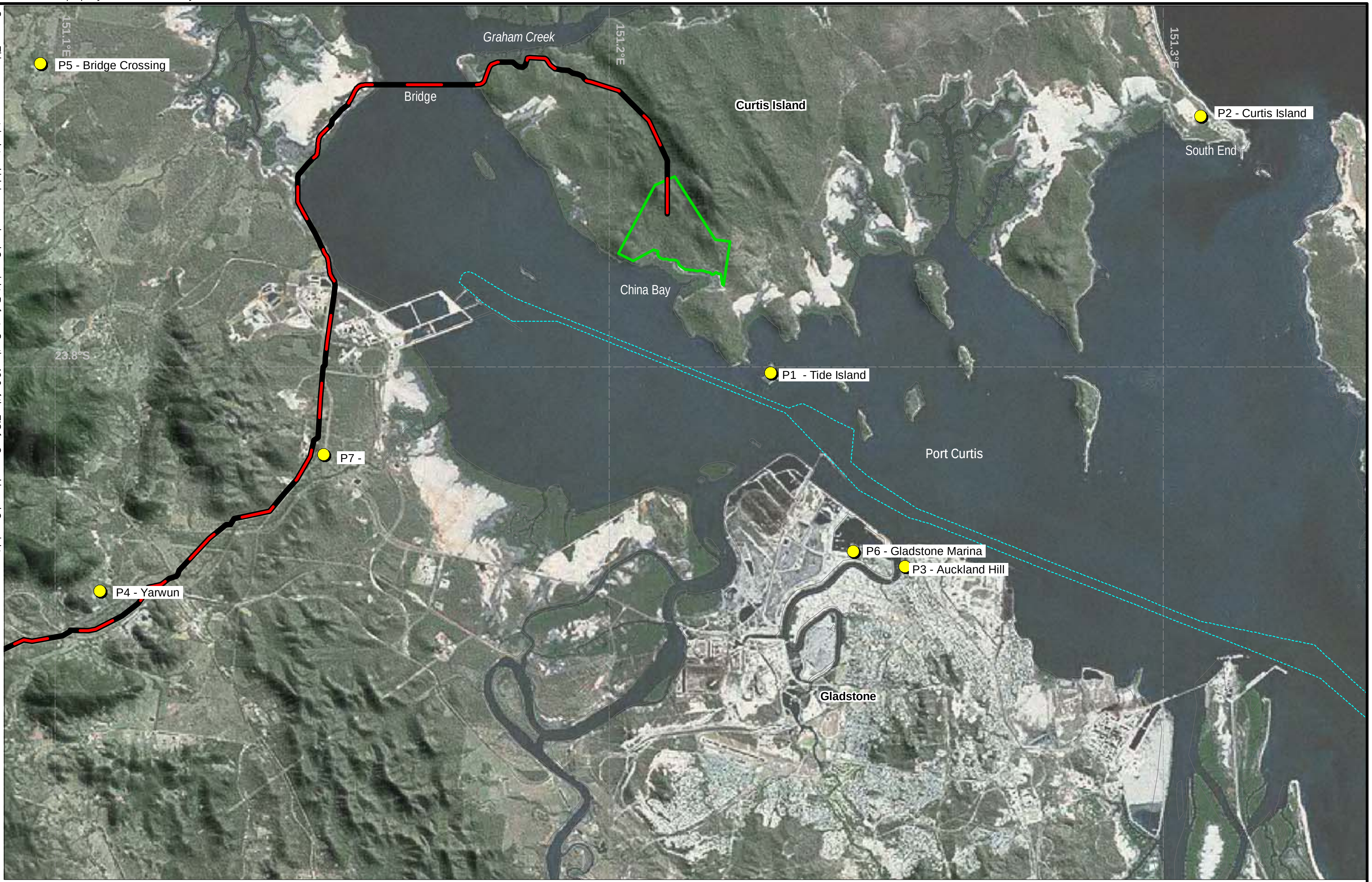
Job No: 4262 6220 | File No: 42626220-g-872b.wor

Title

AMBIENT NOISE MONITORING LOCATIONS FOR THE LNG FACILITY

Figure: 8.10.2 | Rev: B | A4

Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.



N W E S

0 1.25 2.5km

Scale 1:100 000 (A4)
Datum: GDA94

Ambient Noise Monitoring Locations
Gas Transmission Pipeline
LNG Facility Site Boundary
Existing Shipping Channel

Existing Ambient Noise

To determine the existing ambient noise environment in the vicinity of the LNG facility, attended and long term unattended ambient noise monitoring was conducted at six sensitive receiver locations. A full description of the monitoring sites is provided in Table 8.10.8 and their location in relation to the LNG facility is illustrated in Figure 8.10.2.

Unattended monitoring

Unattended monitoring was conducted continuously at each of the 6 monitoring sites using ARL EL-316 and ARL EL-215 Noise Loggers (NATA certified). Unattended monitoring was used to determine the Rating Background Level (RBL) which is the median of the 90th percentile background (L_{A90}) noise levels during an assessment period (day evening and night) for the duration of monitoring. The RBL was developed in accordance with the *Queensland Environmental Protection Agency's EcoAccess Guideline, Planning for Noise Control*. Unattended monitoring was conducted between the following dates:

- 20 February to 6 March 2008 (Plant 1, 3-6); and
- 16 June 2008 to 30 June 2008 (Plant 2).

Attended monitoring

Attended monitoring was also conducted at each of the 6 monitoring sites using a Rion NA-27 Precision Sound Level Meter. Attended monitoring was undertaken to confirm noise levels with an operator present. It also enabled the identification of nearby noise sources during the recording period to enable interpretation of results. Attended monitoring was conducted for one (1) 15 minute period during the day (7 am-6 pm), evening (6 pm-10 pm) and night (10 pm-7 am) recording periods. Attended monitoring was conducted between the following dates:

- 21 to 22 February 2008 (Plant 3, Plant 6);
- 5 to 6 March 2008 (Plant, 1, Plant 4, Plant 5); and
- 25 to 26 June 2008 (Plant 2).

Table 8.10.8 Ambient Noise Monitoring Locations

Monitoring Location	Distance from proposed LNG Facility	Description of Monitoring Site	
		Location	Logger Position
Plant 1	3.4 km	Tide Island (Gladstone Harbour).	5 – 6 m from shed facing proposed LNG facility.
Plant 2	10 km	South End (Curtis Island): 22 Poinciana Avenue.	Garden in front yard along fence.
Plant 3	7.9 km	Auckland Hill: A Auckland Street Gladstone.	Positioned 3 - 4 m from north corner of house; 3.5 m above ground level (abl).
Plant 4	12.4 km	Yarwun: Mt Larcom Gladstone Road (near Flynn Road).	Positioned in front yard garden.
Plant 5	10.5 km	Near bridge crossing: Northern end of Flinders Road.	Positioned 7 - 8 m from home facing south-east to Gladstone.
Plant 6	7.2 km	Gladstone Marina: Bryan Jordan Drive.	Positioned on top of shelter in from of Gladstone Water Police.

Ambient Noise Sources

Ambient noise sources include general industrial noises, coal loading activities and traffic noise from Gladstone Road on Mount Larcom. Intermittent noise sources were associated with birdlife and jet boating. Seasonal noise sources include insects (usually most prevalent during the summer months) and prevailing weather conditions.

A summary of noise sources identified during attended monitoring and results is provided in Table 8.10.9.

Table 8.10.9 Attended Monitoring Results and Noise Sources

Monitoring Location	Date	Time (end of 15 min period)	Measured Noise Level (dBA)			Comments
			LA90	LAeq	LA10	
Plant 1	21/02/08	8:30 am	41	45	46	Industry from Gladstone audible, Insect and bird noise; occasional passing power boat.
	-	-	-	-	-	No evening attended measurement due to site access restrictions.
	-	-	-	-	-	No night time attended measurement due to site access restrictions.
Plant 2	19/06/08	4:30 pm	31	46	50	Birds and insects dominant noise source; distant ocean movement audible; domestic noise occasionally audible (talking, TV, movement etc).
	26/06/08	6:45 pm	36	39	39	Insects and bats (squawking and movement in trees) dominant noise source; ocean movement audible; distant industry noise just audible (spiking 315 Hz band); domestic noise occasionally audible (cooking dinner, TV, movement etc).
	27/06/08	2:45 am	32	33	34	Bat squawking and movement in trees; insects; 'ocean' movement within harbour (SW breeze), ocean side not audible; industry audible in SW breeze.
Plant 3	05/03/08	5:15 pm	44	51	53	Bird noise dominant; low traffic on Flinders Parade; minimal domestic noise.
	21/02/08	7:00 pm	46	58	61	Insects, birds and coal loading industrial noise dominant; insects loud in the last 2 - 3 minutes on measurement; low traffic on Flinders Parade.
	22/02/08	2:00 am	45	47	51	Coal loading industrial noise dominant; insects and low traffic on Flinders Parade.
Plant 4	06/03/08	4:45 pm	51	55	58	Industrial noise audible; occasional traffic on Mt Larcom – Gladstone Road; insects dominant at times; occasional birds; tree movement.
	05/03/08	8:30 pm	41	47	50	Insects dominant noise; distant industrial noise audible; occasional traffic on Mt Larcom – Gladstone Road; low tree movement.
	05/03/08	11:45 pm	40	49	54	Insects and distant industrial noise dominant noise sources.
Plant 5	06/03/08	3:15 pm	45	49	52	Insect and birds noise audible; tree movement.

Monitoring Location	Date	Time (end of 15 min period)	Measured Noise Level (dBA)			Comments
			LA90	LAeq	LA10	
	05/03/08	7:15 pm	50	51	52	Insects dominant noise source; tree movement.
	06/03/08	10:45 pm	41	44	46	Insects dominant noise source; distant industry noise just audible; tree movement.
Plant 6	06/03/08	11:15 am	44	48	50	Bird noise; tree movement; audible industrial noise; occasional power boat audible.

Noise Monitoring Results

Rating Background Level

The rating background levels were derived from the monitoring program following adjustment to take into consideration the extraneous noise such as insects and wind. The adjusted ambient noise monitoring results are presented in Table 8.10.10.

Table 8.10.10 Ambient Noise Monitoring Results

Monitoring Location	Rating Background Level (dBA)		
	Day	Evening	Night
Plant 1	41 [3]	41 [3]	41 [3]
Plant 2	33	32	31
Plant 3	42	42	37
Plant 4	41	40	37
Plant 5	31 [2]	31 [1, 2]	33 [1]
Plant 6	45	42	38

Note 1: Adjusted to correct for enhanced noise levels as a result of insect noise.
2: Adjusted to correct for elevated wind levels and increased noise levels due to movement of trees.
3: Adjusted to correct for elevated wind levels and increased noise levels due to lapping of harbour waves.

The maximum $L_{Aeq(1\ hour)}$ noise level representative of the ambient noise environment was noted for the daytime, evening and night-time periods. The representative maximum $L_{Aeq(1\ hour)}$ noise levels at each location are shown in Table 8.10.11.

Table 8.10.11 Maximum LAeq(1hour) Noise Levels

Monitoring Location	Maximum $L_{Aeq(1hour)}$ (dBA)		
	Day	Evening	Night
Plant 1	61	58	54
Plant 2	56	42	52
Plant 3	56	57	50
Plant 4	53	50	51
Plant 5	57	51	52
Plant 6	54	50	53

8.10.1.5 Potential Impacts and Mitigation Measures

Noise Impact Assessment

The assessment included the identification of potential noise sources associated with the LNG facility and development of a noise model which includes the sound power levels (SWL) of the identified noise sources to calculate the predicted noise level associated with the construction and operation of the LNG facility. Predicted noise levels were compared against the construction and operation criteria detailed in Section 8.10.2. The assessment included predictions for both sensitive receivers (refer Section 8.10.3) and LNG facility boundaries where no noise criteria apply (refer Section 8 Appendix U1).

Potential Noise Sources

Construction

Potential noise sources associated with the LNG facility development include:

LNG facility:

- Clearing and grading;
- Mobile equipment (air compressors, cranes and service trucks);
- Rock breaking;
- Erection of process trains and decking;
- Building of storage tank;
- Pile driving and PLF construction; and
- Barge and ferry movements.

Dredging:

- Dredging.

Bridge Construction:

- Clearing and grading;
- Mobile equipment (air compressors, cranes and service trucks);
- Rock breaking; and
- Pile driving.

Gas Transmission Pipeline:

- Gas transmission pipeline crossing Port Curtis between Friend Point and Laird Point; and
- High pressure testing of pipelines.

Sound power levels for individual construction equipment are provided in Appendix U1.

Operation

Operational noise sources primarily relate to the operation of the LNG facility and the process train which will initially comprise a single train increasing to three process trains as production capacity increases to 10 Mtpa. Other noise sources associated with the plant include the high pressure flare operation and LNG carrier (LNGC) movements.

Noise sources associated with the LNG facility cryogenic liquefaction process include:

LNG facility:

- Coolers;
- Combustion turbines;
- Compressors;
- Piping; and
- Gas turbine generators.

Flare Noise:

- High pressure flares operation.

Shipping Noise (max 2 LNGCs per week):

- Barge and ferry movements;
- Water pumps; and
- LNGC loading.

SWL for LNG plant facilities are provided in full in Appendix U1.

Predicted Noise Impacts and Mitigation Measures

Construction Phase

LNG facility

While noise from diesel-powered mobile plant (ie dozers and excavators etc) will generally form a major part of the emission over the construction phase of the project, the highest noise levels are expected to occur where construction requires the use of pile driving, rock drilling or rock breaking equipment. Also in the finishing stages of the LNG facility, there will be high pressure testing of the pipelines that will cause blow-out noise similar to that of flare noise. These processes are associated with the highest construction noise impacts.

Construction noise is predicted to meet the noise criteria during the evening and night time periods at all assessment locations. There are no construction noise criteria applicable to daytime construction works.

Dredging

Based on the proposed use of a Trailer Suction Hopper Dredge (TSHD) for the dredging of the main channel and a Cutter Suction Dredge (CSD) for the dredging of the swing basin (both include a dredge pump), the highest predicted noise levels at the assessment locations surrounding the LNG facility was 47 dBA (sound pressure level).

Dredging construction noise is predicted to meet noise criteria of 50 dBA (sound pressure level) at all sensitive receivers.

Proposed Bridge Construction

The construction scenario for the proposed bridge from Friend point to Laird Point are expected to be typical of bridge construction which includes; plant equipment, pile driving equipment, cement trucks, haul trucks ,cranes, generators and barge. The highest predicted noise level at the assessment locations was 30 dBA (sound pressure level).

Proposed bridge construction noise is predicted to meet noise criteria of 50 dBA (sound pressure level) at all sensitive receivers.

Pipeline Crossing Friend Point to Laird Point

It has been proposed that the gas transmission pipeline will cross Friend Point to Laird Point via a dredged trench. The gas transmission pipeline will then be lowered into the trench and held in place via rocks and other material. The construction scenarios and plant items expected for these activities are a CSD or TSHD, crane and barge, and welders. The highest predicted noise level at the assessment locations was 22 dBA (sound pressure level).

Proposed pipeline crossing noise is predicted to meet noise criteria of 50 dBA (sound pressure level) at all sensitive receivers.

Barge and Ferry Noise

Transportation of materials and equipment to the LNG facility at Curtis Island for the construction of Train 1 is estimated to require 2500 barge/vessel round trip movements across Gladstone Harbour from the mainland to Curtis Island and back (5000 ship calls).

It is further estimated that approximately 1200 barge/vessel round trips will be required for Train 2 and 1200 barge/vessel round trips for Train 3. This is based on approximately 8400 truck loads for Train 1 and approximately 4400 for Train 2, and 4400 for Train 3. This includes aggregate, cement, piping, structural steel, electrical and instrument bulks and the like based on 4 trucks per barge trip. Some of these trips will include the ferry designed to carry labour.

The movements for Train 1 will be spread over 24 months but are likely to be in clumps for the purpose of moving aggregate and cement. The tonnage of material is subject to change depending on the type of barge and the method to move aggregate. There may be some option of reducing the aggregate trucks by barging in aggregate if there is quarry material adjacent to a suitable load out location along the coast.

Construction of the LNG facility will require a workforce of approximately 3000 people. Accommodation for the workforce will be located on Curtis Island, therefore a ferry service is required to move the workforce on and off Curtis Island. The construction workforce will work on a 10 days on 4 days off rotation. A Marine Transport Strategy developed by Cardno Eppell Olsen (CEO) (2008) provided four options, but the preferred option is a ferry service from Auckland Point on the Mainland to the MOF on Curtis Island. This option requires 21 ferry trips to transport the construction personnel during each shift change and the total number of ferry trips for a 14-day work cycle.

During the operational phase of the LNG facility it is estimated that there will be 2 (includes return) ferry trips per day from Auckland Point on the mainland to the MOF on Curtis Island. Ferry capacities are expected to be approximately 150 passengers and will accommodate the estimated 80 staff required for operation of Train 1, which will increase up to approximately 130 staff for Train 3.

Due to the high volume of marine traffic already present on the waters of Gladstone Harbour, the addition of barges/ferries is expected to have negligible noise impacts on surrounding sensitive receptors (eg. Tide Island).

Construction Mitigation

The adoption of off-set buffer distances will limit the likelihood of construction noise and vibration impact for construction activities. Limiting intrusive construction work during evening and night-time periods (6.30pm to 6.30am) and on Sundays/Public Holidays should be undertaken in accordance with “best practice” noise management. AS 2436-1981 “*Guide to Noise Control on Construction, Maintenance and Demolition Sites”* sets out numerous practical recommendations to assist in mitigating construction noise emissions. Noise control strategies that should be considered for construction activities carried out on the LNG facility are listed below.

Source Noise Control Strategies:

- Quietest plant and equipment that can economically undertake the work should be selected, wherever possible; and
- Regular maintenance of equipment in order to keep it in good working order.

Work Practice Control Strategies:

- Construction work to occur, wherever possible, within the daytime period;
- Where practicable, avoid the coincidence of plant and equipment working simultaneously close together; and
- Operators of construction equipment to be made aware of the potential noise problems and of techniques to minimise noise emission through a continuous process of operator education.

Community Liaison Strategies:

- Utilise existing community consultation framework to provide access to information for the community and maintain positive relations with residents.

For short term LNG facility construction noise alternative arrangements may be considered (e.g. temporarily relocating people).

Operational Phase

LNG facility

The predicted noise impacts on sensitive receivers from the two cryogenic liquefaction options are presented in Table 8.10.12. The predictions are based on no mitigation measures incorporated into the LNG facility with the difference between the noise criteria and the predicted noise level indicated in brackets. The results indicate that mitigation measures are required to meet the overall A-weighted noise criteria for most sensitive receivers (refer Appendix U1).

Table 8.10.12 Summary of Predicted Impact by Liquefaction Option

Plant Scenario	Processing Capacity	
	3 mtpa (1 train)	10 mtpa (3 trains)
OCP	Neutral weather conditions - the noise criteria is exceeded at one (1) receiver by 2 dBA *(Plant 1)*. "Worst case" weather conditions - the noise criteria are exceeded at three (3) receivers *(Plant 1,3,7)* by 3 dBA to 7 dBA.	Neutral weather conditions - the noise criteria is exceeded at three (3) receivers *(Plant 1,3,7* by 4 dBA to 8 dBA). "Worst case" weather conditions, the noise criteria is exceeded at six (6) receivers *(Plant 1,2,3,5,6,7)* by 1 dBA to 13 dBA.

Noise predictions indicate that there will be significant low frequency noise components to the overall noise levels. The predictions indicate that mitigation measures are required to meet noise criteria for the low frequency assessment.

Flare Noise

The flare noise is intermittent and a short term event. Flaring only occurs when there is an upset within the facility, which is rare or during scheduled maintenance. Predictions for noise levels indicate that noise criteria will be met at all sensitive receiver locations without the inclusion of noise mitigation measures with the exception of the sensitive receiver on Tide Island (Plant 1).

Shipping Noise

Shipping noise is an intermittent and short term event. Train 1 will average approximately 50 ships per year and three trains will average approximately 160 ships per year. The LNGCs will travel into the Port and berth for approximately 24 hours before returning to sea. Predictions for noise levels indicate that noise criteria will be met at all sensitive receiver locations without the inclusion of noise mitigation measures with the exception of the sensitive receiver on Tide Island.

Operation Mitigation

Mitigation measures will be required to ensure background noise creep criteria are met at all sensitive receptors. A summary of the mitigation options identified include:

- Mitigation Scenario 1 – reduce the noise emission from piping located close to the compressors by 20 dBA by silencers on both the intake and outlet pipes for the compressors as well as applying appropriate acoustic lagging on the piping.
- Mitigation Scenario 2 – reduce the predicted noise levels to meet the background creep criteria at all assessment locations except Tide Island (P1). Reductions in noise emissions are required on the combustions turbines and air-cooled exchangers. These additional mitigation measures (to those proposed for Mitigation Scenario 1) are only required for the OCP design.
- Mitigation Scenario 3 - reduce the predicted noise levels to meet the background noise creep criteria at all assessment locations, including Tide Island (P1). Reductions in noise emissions are required on the following plant items:
  - Combustion turbines;
  - Air-cooled exchangers;
  - Generators;
  - Compressors;
  - Pumps (lean solvent charge pump); and
  - Boil off gas compressor.

The above mitigation measures are all examples only. Mitigation measures should be assessed in more detail during the detailed design phase for the LNG facility when more accurate noise emission data for the various part items is available.

Many assumptions were made regarding the frequency spectra (octave band data) for many of the major plant items due to a lack of data at the time of reporting. It is therefore recommended that the low frequency noise assessment component of this report be more closely assessed during the detailed design phase of this project when more accurate octave data would be available.

However, based on the initial assessment of low frequency noise, it is expected that compliance with the applicable noise criteria is able to be achieved with the incorporation of appropriate noise mitigation measures to the LNG facility. The details of such noise mitigation measures would be determined during the detailed design phase, when more detailed information relating to plant items is available.

Flare Noise

To achieve the applicable short-term intrusive noise criteria at all assessment locations, mitigation measures to reduce noise by 4 dBA include lagging of piping, muffling the gas stream jets (or via water injection) and use of appropriate diameter flare ports.

8.10.1.6 Vibration Impact Assessment

Potential Vibration Sources

Construction Phase

Based on the current proposed construction methodology, it is anticipated that the primary source of potential ground vibration is likely to be from pile driving associated with construction of the product loading facility (PLF) and the bridge construction.

Another potential source of vibration is heavy truck movements. The intensity of vibration is determined by the condition of the haul road.

Operational Phase

There is no major vibration sources that can induce ground vibration over long distances (outside LNG facility property boundary) associated with the operation of the LNG facility, gas transmission pipeline or CSG fields. Vibration emission from the operational phase of the LNG facility, gas transmission pipeline and CSG fields is not considered further.

8.10.1.7 Predicted Vibration Impacts and Mitigation

Construction Phase

The typical levels of ground vibration from pile driving range from 1 mm/s to 3 mm/s at distances of 25 m to 50 m, depending on the ground conditions and the energy of the driving hammer. Recent measured vibration levels (September 2006) from pile driving at the RG Tanna Coal Terminal Berth 4 expansion for a 14 tonne hammer driving a 1200 mm pile of 600 mm wall thickness showed that vibration levels at a distance of 380 m from the piling site were not measurable (only ambient vibration levels were measured, at less than 0.1 mm/s Peak Particle Velocity).

“Safe Working Distances” for the pile driving activities have been determined In Appendix U2. Worst case safe working distances for pile driving equipment “impact driver” is 20 - 40 m for cosmetic damage and 80 - 120 m for human comfort.

The safe working distances are indicative and will vary depending upon the particular item of plant and local geotechnical conditions (eg presence of elevated water table). Furthermore, it is noted that the safe working distances for “cosmetic” damage apply to damage of typical buildings and do not address heavy industrial buildings.

Based on the significant separation distances between the bridge and PLF structures and the nearest buildings, vibration emissions from pile driving would be in compliance with the relevant vibration criteria. The recommended safe working distances should be adhered to for all pile driving activities carried out on the project.

Truck Traffic

Heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels, typically ranging from 0.01 mm/s to 0.2 mm/s at the footings of buildings located 10 m to 20 m from a roadway. Very large surface irregularities can cause levels up to 5 to 10 times higher.

Based on the data above, vibration levels from truck traffic utilising the roads on site are expected to be significantly below both “building damage” and “human comfort” criteria. In fact it is expected that any vibration from truck movements would be imperceptible (ie less than 0.15 mm/s).

8.10.1.8 Transport Noise Impact Assessment

Potential Traffic Sources

Transport noise generated by the new road and potential bridge was considered during the construction and operational phases. Worker access to the LNG facility will be the primary traffic noise source. As worker accommodation will be provided on Curtis Island during the construction phase, transport traffic is assumed to be nil. During the operational phase, daily traffic flow was estimated to be approximately 300 traffic movements. Further information on traffic numbers/movements are provided in Appendix U1.

Predicted Transport Noise Impacts and Mitigation

New Roads

LNG facility

In order to assess the likely compliance with the road traffic noise criterion it is necessary to estimate the overall $L_{A10(18\ hour)}$ road traffic noise level from vehicles (associated with the LNG Project) travelling on new roads.

The Assessment competed in Appendix U shows that a new road with a speed limit of 80 km/hr could therefore carry up to 2,500 vehicles per day and meet the $L_{A10(18\ hour)}$ road traffic noise criterion of 63 dBA at a distance of 25 m from the road edge.

A new road including a bridge has been proposed to join the LNG facility to Gladstone. It is expected that there will be approximately 300 vehicle movements (associated with this project) per day on this road when the LNG facility is at full capacity (i.e. 3 process trains). This figure is based on 120 employees travelling to and from the LNG facility each day as well as delivery vehicles and other contractors and visitors travelling to and from the facility. As stated above, the assumed percentage of heavy vehicles travelling to and from the LNG facility is 10 %.

It is also assumed that the likely traffic speed along this road would be 70 – 80 km/hr with a dense graded asphalt (DGA) road surface, with the majority of vehicles travelling between 6 am and 12 midnight.

Based on the expected traffic composition for the proposed new road linking the LNG facility to Gladstone, the predicted LA10(18hour) noise level at a distance of 25m from the pavement edge is 57 dBA. This predicted level is significantly lower than the applicable 63 dBA $L_{A10(18\ hour)}$ road traffic noise criterion for new roads.

Existing Road Noise

Data relating to the existing roads to be used for road transportation associated with the LNG Project and the associated traffic volumes on those roads was not available. Therefore it is appropriate to consider the resultant change in $L_{A10(18hour)}$ road traffic noise levels as a function of the percentage increase in traffic volume (as a result of the project) on the subject road.

Assuming that the proportion of heavy vehicles, traffic speed and road surface remain constant, the relationship between increases in traffic volume on a roadway and the resulting increase in $L_{A10(18\ hour)}$ traffic noise emission can be developed and is summarised in Table 8.10.13.

Table 8.10.13 Relationship between Traffic Volumes Changes and LA10(18hour) Noise Emissions

% Increase/Decrease in Traffic	Resultant Change in $L_{A10(18hour)}$ Noise Emission
10 %	0.4 dBA
25 %	1.0 dBA
50 %	1.8 dBA
75 %	2.4 dBA
100 %	3.0 dBA

It can be seen from Table 8.10.13 that a doubling of traffic on a given roadway will result in a 3 dBA increase in the $L_{A10(18\ hour)}$ emission from the roadway.

Based on the workforce-generated traffic volumes used in Appendix U, an increase of greater than 2 dBA from road traffic associated with the LNG facility may occur for roads with existing traffic volumes less than 425 vehicles per day when the contribution of LNG facility traffic is 300 vehicles per day. This assumes that there are approximately 15 % heavy vehicles on the existing roads (typical of a rural highway) and that the percentage of heavy vehicles from LNG facility traffic is 10 %.

If current traffic volumes per day and/or the percentage of heavy vehicles are higher than those nominated above, the incremental increase in road traffic noise levels will be lower than 2 dBA.

It should be noted that incremental changes in road traffic noise levels of greater than +2 dBA would only occur for roads where the existing traffic volumes are low. Therefore the overall noise emissions from road traffic would also be minimal.

8.10.1.9 Cumulative Noise Impacts

Including the GLNG project there are a number of industrial facilities that are proposed for Curtis Island (as described in section 1.7). There is limited information available as to the planned development of these proposed projects or the scale and timing of their development. However, a qualitative assessment can be made of the possible cumulative impacts.

Cumulative noise impacts were inherently assessed through the background creep (progressively increasing background noise levels over time with the establishment of new developments) (L_{A90}) and planning noise level (L_{Aeq}) criteria (see Section 8.10.2) contained within EcoAccess. The criteria takes into account the existing ambient noise level associated with existing industry and road/railway traffic and a comparison with recommended ambient noise levels for various land use types.

The cumulative effect of noise emission from the LNG facility and any other proposed industrial developments (including any other proposed LNG facilities) is assessed to not exceed the recommended ambient noise levels, on the basis that any other proposed industrial developments would be required to achieve the same noise criteria which are applicable for the GLNG Project. In some circumstances the existing ambient noise level may already be above the recommended noise levels. Where this is the case, noise generated by the LNG Facility will be maintained at approximately 8 or 10 dBA below the existing ambient noise level. This should ensure that the cumulative noise impacts of the project will be negligible.

Also other proposed industrial developments (including potential LNG facilities) are likely to include some or all of the proposed mitigation measures outlined within, thereby minimising cumulative impact on the receiving environment.

A summary of potential impact and mitigation measures are presented in Table 8.10.14.

Table 8.10.14 Potential Noise Impacts and Mitigation Measures

Aspect	Potential Impact	Mitigation Measures	Objective
Construction			
Traffic noise.	Increased traffic noise associated with workers, plant and materials transport to Curtis Island.	• Avoid use of roads near sensitive receptors as haulage routes. • Provide on-site accommodation to reduce traffic movements. • Limiting construction associated traffic during evening and night-time periods (6.30 pm to 6.30 am) and on Sundays/Public Holidays where sensitive noise receptors are present.	Minimise increase in traffic noise.
Construction noise.	Excess noise associated with plant construction activities.	• Install attenuation devices on all noise generating equipment including: – Combustion turbines; – Air-cooled exchangers; – Generators; – Compressors; – Pumps (lean solvent charge pump); and – Boil off gas compressor. • Monitor noise sources to identify compliance and determine if any additional mitigation measures are required. • Avoid use of roads near sensitive receptors as haulage routes. • Fit all plant and construction equipment with noise attenuation mufflers. • Maintain equipment to reduce noise generation. • Limit construction work during evening and night-time periods (6.30 pm to 6.30 am) and on Sundays/Public Holidays.	Minimise impacts of construction noise.
Operation			

Aspect	Potential Impact	Mitigation Measures	Objective
Plant noise.	Operation of plant may exceed noise creep guidelines.	• Noise attenuation of noise generating equipment including: – Combustion turbines; – Air-cooled exchangers; – Generators; – Compressors; – Pumps (lean solvent charge pump); and – Boil off gas compressor. • Monitor noise sources to identify compliance and determine if any additional mitigation measures are required.	Minimise impacts of operations noise.
Traffic noise.	Increased traffic noise associated plant workers, material supply to Curtis Island.	• Provide sealed access road to the LNG facility. • Avoid use of roads near sensitive receptors as haulage routes.	Minimise increase in traffic noise.
Plant construction simultaneous with operations	Excess cumulative noise associated with plant operation and plant expansion construction activities.	• Refer to the construction section above.	Minimise impacts of cumulative noise of operations with construction.
Decommissioning			
Decommissioning noise.	Decommissioning works including equipment salvage and removal generating noise.	• Monitor noise sources to identify compliance and determine if any additional mitigation measures are required. • Avoid use of roads near sensitive receptors as haulage routes. • Fit all plant and construction equipment with noise attenuation mufflers. • Maintain equipment to reduce noise generation. • Limit construction work during evening and night-time periods (6.30 pm to 6.30 am) and on Sundays/Public Holidays.	Minimise impacts of decommissioning noise.

Aspect	Potential Impact	Mitigation Measures	Objective
Traffic noise.	Increased traffic noise associated with construction workers, plant and materials transport to Curtis Island.	• Refer to the construction section above.	Minimise increase in traffic noise.

8.10.1.10 Summary of Findings for Terrestrial Noise

The noise and vibration assessment identified compliance with the applicable noise criteria can be achieved with the inclusion of the appropriate noise mitigation measures.

Construction

The potential construction noise and vibration associated with the LNG facility were predicted to meet noise criteria at all assessment locations.

Operation

The noise assessment identified non-compliance with overall noise criteria. The results indicate that mitigation measures are required (Mitigation Scenario 3) to meet noise criteria at all sensitive receivers.

The low frequency noise predictions for the LNG facility show that there are significant low frequency components in the overall noise levels predicted at receiver locations in the Gladstone region.

Based on the initial assessment of low frequency noise, it is expected that compliance with the applicable noise criteria is able to be achieved with the incorporation of appropriate noise mitigation measures to the LNG facility. The details of such noise mitigation measures would be determined during the detailed design phase, when more detailed information relating to plant items is available.

The road traffic noise assessment carried out for project-related vehicle movements revealed that impacts from road traffic noise are predicted to be minimal.

There are no major vibration sources associated with the operational phase of the project likely to generate vibrations at sensitive receivers.

8.10.2 Marine Noise

8.10.2.1 Introduction

A study has been carried out to assess the underwater acoustic impacts associated with the construction and operation of the LNG facility, the potential bridge and access roads from Friend Point (mainland) to Laird Point (Curtis Island) and MOF and PLF. This chapter summarises the results of the marine noise study including existing environmental values, potential impacts and proposed mitigation measures to minimise the project's impacts on existing environmental values.

The detailed technical report is provided in Appendix U2 of the EIS.

8.10.2.2 Methodology

The study has considered whether sounds from construction (including pile driving and dredging) and future operations are likely to disturb marine fauna including whales, dugong, dolphins, turtle or fish.

To identify significant marine species potentially present in the study area of the project, a search of the threatened species database (Environment Protection and Biodiversity Conservation (EPBC) Act 1999) has been conducted.

Noise from construction activities including impulsive sounds from pile driving and consistent sounds from dredge operations are considered in this assessment. The noise impact of shipping movement at the LNG facility during operations is also assessed.

Until recently, there has been little detailed measurement of underwater noise emissions from dredge and piling operations. Studies on the estimated underwater sound emissions from the Port of Melbourne Channel Deepening Project (Port Phillip Bay, Victoria) have been referred to in carrying out this assessment. The conditions under which the trial studies have been performed in Port Phillip Bay are

representative of the conditions in which works in Port Curtis are proposed (depth of water for trial piling operations are similar to that around proposed piling operations at the MOF and PLF). In addition, underwater noise emissions from general shipping in Port Phillip Bay have been measured.

8.10.2.3 Existing Environmental Values

Construction at Fisherman's Landing Wharf has recently commenced by the Gladstone Ports Corporation for an extension of the wharf. The construction program involves piling, which will continue for approximately five months and started in early September 2008. Dredging works will create access to the new berths at the wharf. Dredged material will be used to reclaim an area of land to the north of Fisherman's Landing (see Figure 8.10.3). These construction activities have received approval without special underwater noise related conditions and are similar in scope to those proposed for the GLNG Project.

Marine Fauna Response to Noise

The likelihood of an adverse acoustic impact upon a species depends upon the likelihood that the species will be in an area that contains high sound levels. If a species is likely to be within an area influenced by high sound pressure levels it will depend upon available food sources or documented migration paths, for example, that are in or traverse the area.

Turtle, dugong, dolphin, whale shark and humpback whale are considered in this assessment insofar that they *could* be present within the area. The most likely coincidence of species in the areas identified to have elevated underwater noise levels relate to turtle and migrating dugong and dolphin. The water rat and yakka skink would only inhabit the fringe coastal areas and are unlikely to be impacted by underwater sound levels from construction activities and are not considered further.

Manatee and dugong have similar vocalization and it is presumed that dugong have similar audiograms to manatee. A study of the effects of environmental noise on Manatee (Miksis-Olds, 2006) demonstrated a preference for sea grass habitat that has particular acoustic conditions. A preference was shown from observations and sound recording correlations that the grass beds manatees selected were those that had lower ambient noise below 1 kHz and above 2 kHz.

Dugong vocalization is characterized into two general groups of sound. Low frequency barks (500 Hz to 2.2 kHz) and higher frequency clicks and chirps (3 kHz to 18 kHz) (Anderson and Barclay, 1995). Audiograms for the manatee show a lower frequency limit of 400 Hz and an upper frequency limit of 46 kHz (Gerstein et al, 1999) with optimal sensitivity in the 16 kHz to 18 kHz range. Gerstein suggests that the poor sensitivity of the manatee to sounds below 1 kHz explains why slow moving vessels are not readily observed and localized by manatee.

The manatee audiogram shows a threshold of audibility at 500 Hz of 105 dB and at 1 kHz it is 80 dB. Therefore, dredge operations could be inaudible if dredge sound emissions predominate in the frequency range below 500 Hz.

The sound level compensation ability for manatee/dugong and the vocalization frequency range means that they can still communicate during the manoeuvring operations of a dredge located less than 1km away in shallow water that will produce sounds below 1 kHz. Sound level amplitude and frequency would not cause masking of communication sounds.

Dredge operations produce sound emissions that are also at frequencies where the audiogram of the bottlenose dolphin, for example, is less sensitive (Salgado Kent and McCauley, 2006). The threshold of hearing for a bottlenose dolphin is 130 dB at 100 Hz, 95 dB at 1 kHz and 50 dB at 10 kHz. It is most sensitive at a threshold of 40 dB between 20 kHz and 100 kHz. The upper threshold hearing frequency is around 200 kHz (Johnson, 1967).

The EPBC Act database lists the humpback whale as 'breeding known to occur in the area'. The hearing response of the humpback whale is predicted to be between 700 Hz and 10 kHz with maximum sensitivity in the 2 kHz to 6 kHz range. This follows the typical mammalian U-shape with lower sensitivity at the extremes of the audible range (Houser et al 2001).

A sound pressure estimate of 150 dB at 10 m was measured from 100 hp and 115 hp outboard engines moving at 5 mph (Miksis-Olds, 2006). Frequency weighting of the sound to account for the hearing characteristics of the Manatee shows that such operations (outboard motor) provide peak audibility in the 2 kHz frequency range, although maximum sound energy is below 1 kHz. Playback of these sounds to wild manatee (150 dB received level) showed no significant response; however sounds from typical personal watercraft approaches (typically 160 dB received level) that contain similar high frequency sounds at some 15 dB higher sound pressure level in the 5 kHz to 20 kHz region, showed significant response, with 20 % of the animals exposed leaving the area. The tests were completed using recordings played to manatees 10 m away and under these circumstances high frequencies would not be attenuated significantly.

Sound emissions from larger ships are greater due to the higher power requirements (around 3000 hp) but the frequency range within they emit is generally lower. Green (1987) reported that hopper dredges emit the highest sound levels during loading but that at all times low frequency sound energy predominates. This is confirmed from measurements in Port Phillip Bay (referenced above) showing dredge noise emissions to be up to 5 dB higher than general shipping.

Sonar is used to profile the dredge area and for normal depth sounding when travelling across the bay. Sonar equipment on the dredge could operate within the most sensitive audible region of the dolphin but high frequency sonar generally points towards the sea bed and at shallow angles laterally.

Sonar having a transducer operating frequency above 200 kHz is recommended to avoid interference with dolphin and dugong.

8.10.2.4 Predicted Noise Impacts and Mitigation

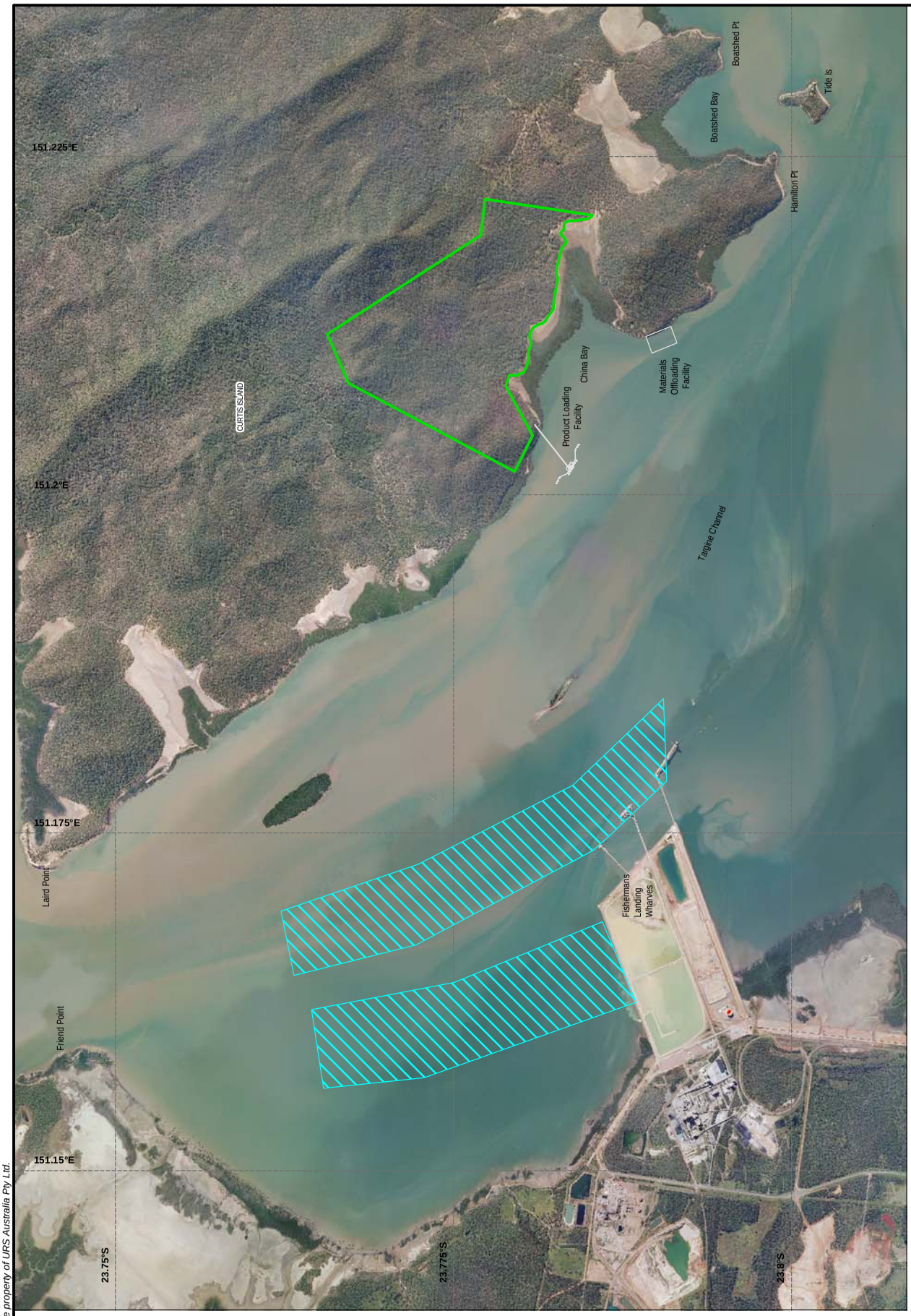
Noise Impact Assessment

A discussion of potential marine noise impacts and proposed mitigation strategies is provided below, with a summary of these impacts and mitigation measures provided in Table 8.10.16. The most likely coincidence of species in the areas identified to have elevated underwater noise levels relate to turtle and migrating dugong and dolphin. Notwithstanding this, the mitigation measures suggested also protect whale shark and humpback whale.

Potential Noise Sources

In general, for a given frequency, any noise above an ambient background level has the potential to disrupt communication between marine mammals and can cause avoidance of an area. However, communication between different mammals is achieved in different frequency ranges and with often different time scales. For example, a dolphin communicates with repetitive short clicks whereas a whale communicates in song having longer relative time duration. This fact is important since noise from pile driving, for example, may not affect the communication between whales as much as it may between dolphins. Furthermore, the higher frequency communication of the dolphin may be affected over a smaller area by pile driving operations because higher frequencies are attenuated very quickly with distance of propagation in shallow water.

Until recently, there has been little detailed measurement of underwater noise emissions from dredge and piling operations. The Port of Melbourne Channel Deepening Project for Port Phillip Bay in Victoria has been scrutinised extensively and previously estimated underwater sound emissions have been required to be measured under different trial dredge and piling studies that have formed part of the review process for the approvals. The conditions under which these trial studies have been performed are representative of the conditions in which works in Port Curtis Bay are proposed (depth of water for trial piling operations is similar to that around proposed piling operations at the MOF and PLF, for example). In addition, underwater noise emissions from general shipping in Port Phillip Bay have been measured.



Client

Project
GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Title
DREDGE OPERATIONS AND LAND RECLAMATION FOR THE FISHERMANS LANDING NORTHERN DEVELOPMENT

Drawn: CA	Approved: JB	Date: 04-03-2009	Figure: **8.10.3**
Job No: **4262 6220**	File No: 42626220-g-1013.wor		Rev:A **A4**

Dredging

It is currently envisaged that a cutter suction dredge (CSD) will be used for the berth pockets and swing basins. For simplicity, similar sound emission levels during construction work at the potential bridge site across Port Curtis between Friend Point and Laird Point has been assumed.

The size of equipment proposed CSD is 10,000 to 15,000 kW with 800 mm diameter discharge pipe. The dredges proposed for this project are slightly larger than previous capital works projects to widen and deepen the channels and berths in Gladstone.

Sounds levels for the proposed CSD were not available for this study, however levels for large trailer suction hopper dredge equipment (Queen of the Netherlands, 23000 m^3 hopper capacity) have been measured recently in Port Phillip Bay, Victoria. The sound levels measured were typically between 143 dB and 154 dB (Port of Melbourne Channel Deepening Project, report number AA/0172/DC/G01) at a distance of 100 m.

Shipping

The range of ships in the Port of Gladstone is not dissimilar in size to those in Port Phillip Bay, Victoria. Underwater sound levels from passing ships at 100 m were measured for the Port of Melbourne Channel Deepening Project. Report number AA/0172/DC/G01 provided the following data outlined in Table 8.10.15.

Table 8.10.15 Sounds levels of passing ships for Port of Melbourne Channel Deepening Project

Ship	Underwater sound pressure level (short term maximum dB re 1µPa)
ANL Bass Trader	143
British Laurel	149
Contship Aukland	150
CSL Kelang	145
Gerdt Oldendorff	154
Medi Monaco	150
MSC New Plymouth	152
Tasman Chief	145

On average, the typical maximum short term sound emission level is 149 dB (4 dB standard deviation) at a distance of 100 m.

Barge and Ferry Marine Noise

Transportation of materials and equipment to the LNG facility at Curtis Island for the construction of Train 1 is estimated to require 2500 barge/vessel round trip movements across Gladstone Harbour from the mainland to Curtis Island and back (5000 ship calls).

It is further estimated that approximately 1200 barge/vessel round trips will be required for Train 2 and 1200 barge/vessel round trips for Train 3. This is based on approximately 8400 truck loads for Train 1 and approximately 4400 for Train 2, and 4400 for Train 3. This includes aggregate, cement, piping, structural steel, electrical and instrument bulks and the like based on 4 trucks per barge trip. Some of these trips will include the ferry designed to carry labour.

The movements for Train 1 will be spread over 24 months but are likely to be in clumps for the purpose of moving aggregate and cement. The tonnage of material is subject to change depending on the type of

barge and the method to move aggregate. There may be some option of reducing the aggregate trucks by barging in aggregate if there is quarry material adjacent to a suitable load out location along the coast.

Construction of the LNG facility will require a workforce of approximately 3000 people. Accommodation for the workforce will be located on Curtis Island, therefore a ferry service is required to move the workforce on and off Curtis Island. The construction workforce will work on a 10 days on 4 days off rotation. A Marine Transport Strategy developed by Cardno Eppell Olsen (CEO) (2008) provided four options, but the preferred option is a ferry service from Auckland Point on the Mainland to the MOF on Curtis Island. This option requires 21 ferry trips to transport the construction personnel during each shift change and the total number of ferry trips for a 14-day work cycle.

During the operational phase of the LNG facility it is estimated that there will be 2 (includes return) ferry trips per day from Auckland Point on the mainland to the MOF on Curtis Island. Ferry capacities are expected to be approximately 150 passengers and will accommodate the estimated 80 staff required for operation of Train 1, which will increase up to approximately 130 staff for Train 3.

Due to the high volume of marine traffic already present on the waters of Gladstone Harbour, the addition of barges/ferries is expected to have negligible noise impacts on surrounding sensitive receptors (e.g. Tide Island).

Piling

Sound is generated from pile driving activities and this propagates underwater and in the air (terrestrial). The sound sources from piling operations include diesel engines, mechanical clatter from the pile driver mechanisms and the impact of the hammer on the top of the pile that transmits vibration along the pile into the sediment.

The characteristics of the sound observed underwater from impact type piling are a mixture of the different sound propagation mechanisms and the results can be very complex. However, in general there will be a larger pressure pulse propagated at hammer impact on the pile that will be followed by a ringing of the pile followed by sediment vibration effects. The contribution of each of the sound generating mechanisms change as the pile is driven deeper. The natural frequency ring from the pile also changes as the pile penetrates deeper. The sound observed also changes with increased distance from the pile because sound is attenuated at higher frequencies as it propagates in the shallow water and different time delays come into effect from the propagation paths of vibration in the sea bed and water (speed of sound in water is approximately 1500 m/s and the speed in sediment is generally higher at around 1700 m/s).

Diesel engine noise from the pile driver propagates in the air above the water and is observed as underwater sound, although the area that this influences is localised (typically < 20 m).

Pile driving sounds do not exhibit the potentially high pressure peaks associated with blasting but they are repetitive.

The impact evaluation and risk assessment for underwater noise from pile driving activities is not known for any fauna in terms of behavioural response, However, for behavioural response based upon 100 impulses it is expected that a source sound level of over 150 dB msp is a level that Temporary Threshold Shift (TTS), Permanent Threshold Shift (PTS) or Death could occur (Saldago Kent and McCauley, 2006).

Underwater sound levels measured at 350 m from piling operations at Swanson Dock were typically less than 150 dB msp (interim reports from trial pile driving surveys by Rob McCauley, May 2008 [and July 2008 (www.channelproject.com/global/docs/technical_reports/QRTR0809_CMST_(2008b).pdf) The GLNG project is projected to have relatively similar underwater sound levels, so the 350 m radius from piling activities would apply to predict noise impacts in Port Curtis.

Sound Propagation in Shallow Water

Sound propagation in Port Curtis is complex due to the array of sand banks and barrier islands. The proposed dredging activities in the region around the PLF and MOF are likely to propagate sound

predominately in north western and south eastern directions along the new access channel spur onto the Targinie channel, with greater attenuation of sound to the west across South Passage Islands and towards the Curtis Island shoreline. Greater attenuation of sound is generally observed in shallow or seagrass covered areas, or when the wavelength of sound in water is similar to or longer than the depth of the water. Sound having frequencies above 115 Hz could propagate along 13 m deep channels but would quickly attenuate in the shallower waters either side of the channels. In shallow water, when the one-quarter wavelength of the sound exceeds the water depth, the remaining sound energy is attenuated very rapidly and propagation losses from a shallow sound source to a shallow receiver will show approximately 12 dB per doubling of distance (35log r) spreading loss (Richardson et al 1995).

Propeller noise is generally shielded to the bow of a vessel by the hull structure and only becomes a sound source when there is a 'line of sight' to the propeller from the receiver location. The shallow sound source in shallow water also produces surface interference effects that also exhibit a similar spreading loss of 35log r.

Sound emissions from dredge operations could travel along the channels but attenuation rates of typically 6 dB per doubling of distance would be expected.

Impact of Noise on Marine Fauna

Research on the effects of human generated noise on marine mammals has shown that there is some level of tolerance. Stationary sources seem to have less effect on whales and dolphins than mobile sources, and avoidance responses occur when received noise levels reach levels well above ambient sound levels. Some marine mammals appear to ignore or tolerate, for at least a few hours, continuous sound at levels above 120 dB. Avoidance commences when received levels start to exceed 120 dB, and it is doubtful whether many marine mammals would remain in an area with over 140 dB continuous or long term impulsive sound.

Reports on whales and dolphins exposed to seismic operations in northern hemisphere waters (e.g. Geraci & St Aubin, 1987; Myrberg, 1990), suggest that behaviour patterns may alter within seven kilometres of sudden, pulsed sound sources, and marked avoidance responses may occur within two kilometres. No information has been found to suggest that dugong would not behave in the same manner. Marine turtles do not have an external hearing organ. However, it is thought that turtle may have an auditory perception through a combination of bone and water conduction.

An observation of a migrating dugong under the trestles of an outloading conveyor at Abbot Point demonstrates a tolerance to ship loading operations. At the time of the observation there were tug boats ready in attendance for an almost fully loaded ship ready to depart the berth. Travel within the dugong conservation area would not be impeded by shipping activities at the berth or beyond. Dugong in the Rodds Bay Sanctuary are accustomed to ship movements and the extra burden of one ship every two or three days is not significant.

Normal operating conditions for the PLF and MOF are not expected to produce noise levels significantly above ambient background levels such that there are communication problems or sound levels causing avoidance for marine mammals. As observed, fish often inhabit the area beneath berths during loading although they do temporarily vacate such areas whilst tugs manoeuvred a loaded ship from a berth at Abbot Point coal terminal. The movements of tugs and vessels to the loading berth are short term events and are unlikely to produce long term evacuations from the area.

Whilst pile driving for the new PLF and MOF is in progress, it is unlikely that marine mammals passing offshore will be able to hear the construction work as the noise levels will not be much higher than ambient noise levels. However, it is likely that any dolphin or turtle near the new berth sites during piling will temporarily avoid the immediate area. Figure 8.10.4 shows the area surrounding the MOF and PLF and the potential bridge crossing between Friend Point and Laird Point where temporary avoidance may occur during construction activities. These areas are determined from an approximate radius of influence 150 m from dredge or bridge building activities for constant sound emissions and 350 m radius from pile driving operations that generate impulsive sounds.

The radii chosen relate to underwater sound pressure levels expected from construction activities of less than 150 dB (constant type sounds) and 150 dB msp (impulsive pile driving sounds). The areas shown in Figure 8.10.4 assume a high tide with a pile in 13m of water. The sound emissions from piling are related to the depth of water through which the pile is driven. If a pile is in contact with a smaller water depth then the sound emissions underwater will be reduced. For a water depth of 6.5 m through which a pile is being driven, it is expected that sound emissions underwater would be reduced by 3 dB compared to a water depth of 13 m and the zone of potential impact would be reduced accordingly.

The sound levels from piling operations are not expected to harm marine fauna, even at close range. If any species identified in this assessment were close to a pile at the commencement of piling they would be startled and move from the immediate area. This type of response can be avoided by simple observation before commencement of piling or by using a 'soft start' to piling.

Similarly, dredging operations are likely to cause avoidance of the immediate area by mammals, although fish may be attracted to the areas where sediment is disturbed.

Underwater noise from dredge operations are up to 5 dB higher than that from normal shipping, however the dredge remains at the dredge site whereas shipping traverse Port Curtis. Despite the differences in noise emissions the overall impact upon marine fauna may be similar since sound sensitive species would avoid approaching a dredge, yet sound sensitive species would need to move away from whatever they may be doing to avoid oncoming ships. The overall zone area of adverse impact from a moving ship would be larger than for static dredge operations but would last for a shorter time.

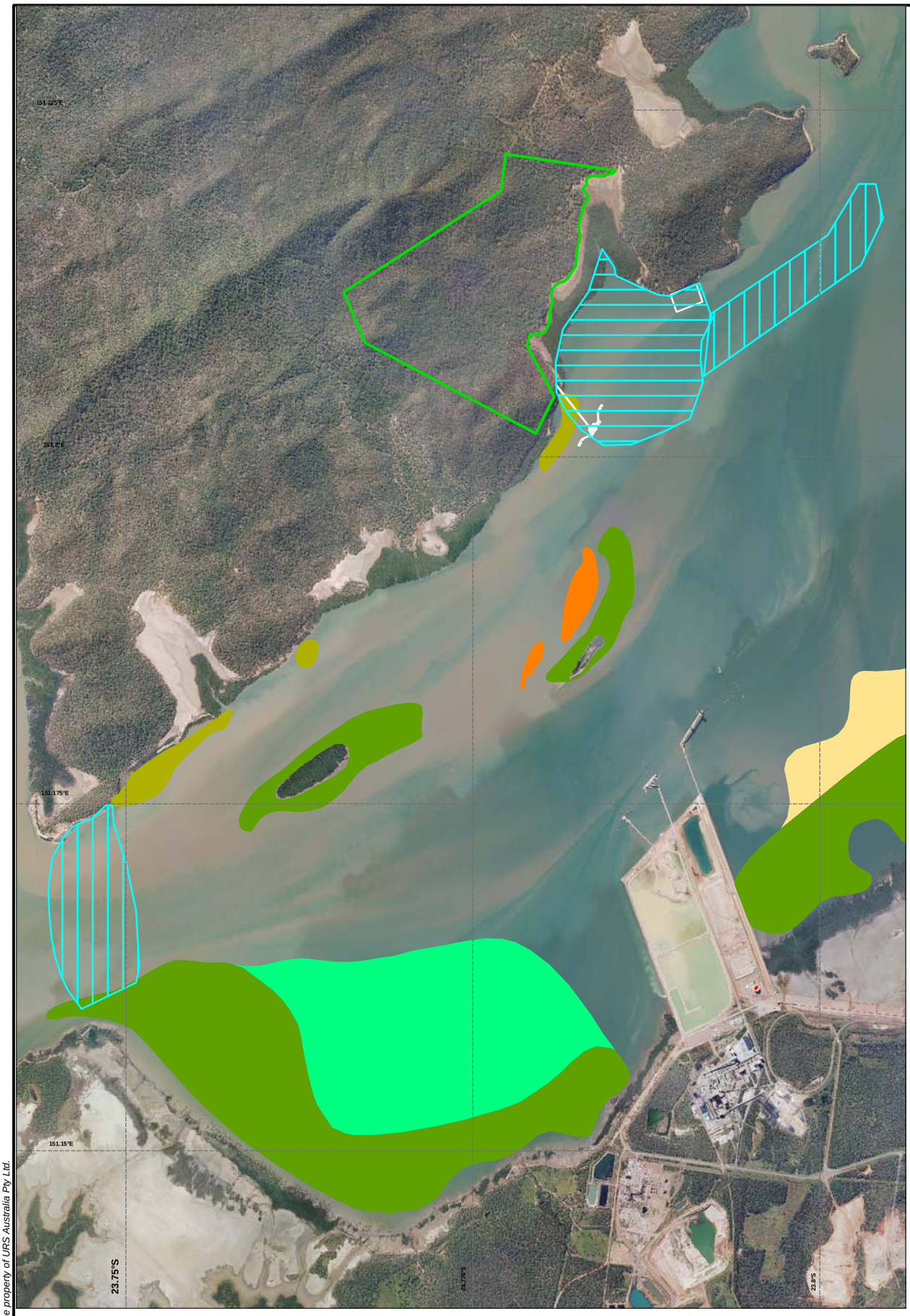
Mitigation Strategies

The following summarises suggested mitigation strategies during construction:

- To prevent a startle response from dugong or dolphin at the start of impact piling in deeper water (> 3 m); observations should be made of an area approximately 350 m radius around the pile before commencement of impact piling on any day or after an extended time when piling has stopped. If dugong or dolphin is observed within the area, there will be a soft start to piling;
- To prevent a startled response from dugong or dolphin at the start of impact piling in shallower water (< 3 m); observations should be made of an area approximately 150 m radius around the pile before commencement of impact piling on any day or after an extended time when piling has stopped. If dugong or dolphin are observed within the area, there will be a soft start to piling;
- Impact piling operations on land (when at low tide for example) do not require any observation or soft start procedures; and
- Sonar devices on dredges should have operating frequencies above 200 kHz to minimise the impact upon dolphin and dugong.

The following are mitigation strategies for barge/ferry movements:

- The use of fewer larger craft, rather than many smaller craft movements;
- Use of existing deepwater channels wherever possible; and
- Strict adherence to speed limits.



Source 1: Copyright HR Wallingford Ltd 2009. All rights reserved. With regard to Product Loading Facility and Material Offloading Facility - These layouts are subject to alteration during detailed design development and ongoing consultation with the Gladstone Ports Corporation and the Gladstone Regional Harbour Master to ensure issues of navigation safety are appropriately addressed.

Source 2: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client: LNG	Project: GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	Title: **AREAS WHERE TEMPORARY AVOIDANCE MAY OCCUR DURING CONSTRUCTION ACTIVITIES**	
URS	Drawn: CA / Approved: JB / Date: 25-02-2009 Job No: **4262 6220** / File No: 42626220-g-1014.wor	Figure: **8.10.4**	Rev:A **A4**

Table 8.10.16 Potential Marine Noise Impacts and Mitigation Measures

Aspect	Potential Impact	Mitigation Strategy	Objective
Construction			
Dredging.	Disturbance to marine fauna (avoidance/vacating noise affected area).	• Sonar devices on dredges should have operating frequencies above 200kHZ.	Reduce interference with sonar frequencies used by marine fauna.
Piling.	Disturbance to marine fauna (avoidance/vacating noise affected area.	• Soft start to piling.	Avoid damage to marine fauna hearing and reduce startle.
Operation			
Shipping.	Disturbance to marine fauna (avoidance/vacating noise affected area).	• Vessels working on the GLNG project should adhere to the speed restrictions within the Port Curtis.	Reduce/eliminate the occurrence of marine fauna fatalities due to boat strikes.

8.10.2.5 Summary of Findings for Marine Noise

Sound pressure levels produced underwater from construction and ongoing operations of the proposed Gladstone LNG Project are not predicted to have any long term detrimental effects upon marine fauna identified within the area. Short term avoidance of areas surrounding pile driving or dredge activities is expected.

Short term avoidance of areas surrounding piling activities is expected inside a range of 350 m from the pile. It is recommended that soft start procedures for piling operations be used when commencing work if whale shark, humpback whale, turtle or dolphin are observed within a 350 m radius of the area around piling operations.

The areas where short term avoidance would be expected during project construction activities do not contain any significant seagrass beds and the avoidance areas would only affect migration across a small part of Port Curtis. The overall impact of dredging operations for the GLNG Project caused by underwater noise is similar to that caused by a single ship traversing Port Curtis.

The use of sonar having a transducer operating frequency above 200 kHz is recommended to minimize interference with dolphin and dugong.