LONG TERM TURTLE MANAGEMENT PLAN

LNG FACILITIES – CURTIS ISLAND, GLADSTONE

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1.0 INTRODUCTION

1.1 Background

Queensland Curtis LNG (QGC) commissioned Sinclair Knight Merz (SKM) to prepare a ten year Long-Term Turtle Management Plan (LTTMP) for marine turtles in the Gladstone region on the central Queensland coast, on behalf of the liquefied natural gas (LNG) proponents of QGC, Australia Pacific LNG (APLNG) and Santos GLNG (GLNG). The Gladstone region, for the purposes of this plan, extends from the northern tip of Curtis Island in the north, throughout Port Curtis and the Narrows, to Bustard Head in the south, and offshore throughout the Great Barrier Reef Lagoon to the Capricorn Bunker group of islands, 70 km east of Gladstone (*Figure 1*). The assessment of risks, development of mitigation strategies and associated monitoring tasks within the LTTMP are focussed on the Port Curtis, Curtis Island and Facing Island areas, as these are the locations where environmental risks to marine turtles associated with the LNG developments are highest. However, potential impacts of increased shipping activity and lighting on turtles utilising mid-shelf and offshore habitats are also assessed and discussed, where relevant.

All three LNG proponents have been granted State and Commonwealth Government approvals to develop LNG and associated export facilities on Curtis Island, near Gladstone. The LNG facilities are part of a larger infrastructure network to extract coal seam gas from reserves located in either the Surat or Bowen basins of Queensland and transport it via pipelines to the liquefaction facilities on Curtis Island, where it is converted to LNG and exported by ship to overseas markets. Collectively, the construction of coal seam gas wells, their associated transport pipelines and LNG facilities are among the largest infrastructure projects ever developed in Australia.

Shell / Arrow LNG is currently preparing an Environmental Impact Statement (EIS) for a fourth LNG facility on Curtis Island, with the assessment of environmental approvals for this project unlikely to be completed until late 2013. Given the current program of approved works, export of LNG from the three approved Curtis Island facilities is likely to commence in late 2014 for the QGC facility, in 2014 for the Santos GLNG project, and in 2015 for the APLNG facility.

QGC, APLNG and GLNG (hereafter referred to as the LNG proponents) have completed significant EIS studies in order to gain approval from State and Commonwealth agencies for the development and operation of their LNG facilities on Curtis Island. The potential impacts of construction activities and operation of the LNG facilities on marine fauna, and in particular marine turtles, were key considerations of regulatory authorities when assessing the projects.

The Gladstone region hosts a range of industrial facilities, including an aluminium refinery and smelter, chemical plants, a power station, cement production facility, coal handling terminals and soon, LNG facilities. The majority of these industrial facilities make use of Gladstone Harbour, also known as Port Curtis, a tidal passage between the mainland and the near-shore Curtis Island and Facing Island. Other major infrastructure projects under development in Gladstone Harbour include the Wiggins Island Coal Export Terminal (WICET), which will provide an additional coal export capacity of over 80 million tonnes per annum. In this context, it is important to recognise that Gladstone has been an industrial port for several decades, and is currently undergoing significant expansion to accommodate a range of new developments, of which the LNG facilities are only a part.

The Commonwealth approval for each LNG facility under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) requires a LTTMP to be developed, to provide for appropriate management of marine turtles during development and operation of the LNG facilities on Curtis Island. The EPBC Act approvals specify that the LTTMP must be submitted for approval of the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (SEWPaC) within 3 months of commissioning the LNG facility. Following Commonwealth machinery of government reforms in 2013, the relevant minister and department are now the Commonwealth Minister for the Environment, and the Department of the Environment, respectively.

Full details of the EPBC Act approval numbers and their relevant conditions for each proponent are provided in Appendix A. In summary, the relevant approval conditions are Conditions 34-39 of EPBC 2008/4057 (GLNG), Conditions 34-39 of EPBC 2008/4402 (QGC), and Conditions 52-57 of EPBC 2009/4977 (APLNG).

The EPBC Act approval conditions encouraged LNG proponents to take a collaborative approach in the development of a LTTMP by working together, rather than developing separate plans for their respective projects. Accordingly, this LTTMP has been prepared jointly by the LNG proponents to address the conditions of their respective EPBC Act approvals. The LTTMP outlines the key management and monitoring strategies that will be implemented to protect marine turtles of the Gladstone region during development and operation of the LNG facilities.

1.2 Description of the Project

Gladstone was first established as a township in 1853, with a Gladstone Harbour Board first formed in 1914. Since then, there has been significant industrialisation of the city and Gladstone Harbour, particularly since the 1960s. In recognition of Gladstone's growing industrial activities, the Queensland Coordinator General has designated the city as a State Development Area, to promote economic development within Queensland. State Development Areas are generally located within industrial hubs, multi-user infrastructure corridors or at major infrastructure sites within the state. The three LNG facilities are currently in various stages of construction and are located on the south-western tip of Curtis Island, within the Curtis Island Industry Precinct of the Gladstone State Development Area, between 9 and 13 km north west of the Central Business District of Gladstone. A map showing the location of the LNG facilities and other significant industrial developments within Port Curtis is provided in *Figure 2*.

Each LNG facility is generally comprised of a minimum of 2 trains (infrastructure used to compress natural gas into LNG), 2 storage tanks and marine loading or jetty facilities for the berthing and loading of cargo ships. Control rooms, a passenger transfer terminal, maintenance and administration buildings and a temporary accommodation building for construction staff are also in place at each facility. The three LNG facilities are located on the western foreshore of Curtis Island, with a 4,590 ha Curtis Island Environmental Management Precinct located to the east, and Port Curtis bordering the sites to the west. The nearest turtle nesting beaches are located approximately 10 km to the east of the LNG facilities on the south eastern tip of Curtis Island in *Figure 3*.

The construction and operation of LNG facilities on Curtis Island involves several activities with the potential to cause impacts to marine turtles and their habitats. Disturbance of turtles may arise from boat strike through increased shipping and vessel activity, displacement of turtles from foraging and nesting areas and disturbance of natural behaviours through the creation of vibration, noise and artificial lighting regimes. Indirect impacts may also result from a deterioration of habitat quality in the Gladstone region associated with further development of industrial operations in the area.

An important consideration for development of the LTTMP is that several infrastructure projects are presently being completed or are planned within Port Curtis, which also have the potential to impact upon marine turtles and their habitats. Some of these projects have links with the development of the LNG facilities, including the Gatcombe and Golding Cutting Channel Duplication Project and the Western Basin Dredging and Disposal Project, both of which involve capital dredging of new shipping channels. The Gladstone Ports Corporation (GPC) coordinates and manages these port-wide dredging projects on behalf of relevant proponents, and these projects are subject to their own EIS processes, approval conditions and monitoring plans.

The Western Basin Dredging and Disposal Project involves the dredging of approximately 46 million cubic metres of material as part of future industry development in the Gladstone region. Approximately 26 million cubic metres of this dredging is associated with the new LNG facilities on Curtis Island. As part of its management of this project, the GPC coordinates the Ecosystem Research and Monitoring Program (ERMP) within Port Curtis to supply information on the environmental health of Port Curtis and Port Alma and to provide advice on the potential environmental impacts caused by dredging.

The ERMP has established a program to fund research projects from 2011 to 2020 in order to examine the impacts of dredging on environmental values and is overseen by an independent scientific expert panel.

In this context, the impacts of the port-wide dredging activities on marine turtles are not directly considered in this LTTMP, as these are managed by GPC as part of their existing approvals for the project and are outside of the scope of the LTTMP. However, the potential impacts of capital dredging and ongoing maintenance dredging at the LNG facilities' berth areas have been described in the LTTMP, to provide for a comprehensive assessment of project risks. Aspects of the LTTMP relating to dredging are therefore included only for completeness and will be implemented by GPC as part of the Western Basin Dredging and Disposal Project. Given the relevance of the ERMP to future monitoring activities in the LTTMP, there are also potential synergies between the two projects which have been considered and further developed within this plan.



LEGEND

Gladstone Region

Land Tenure

Australia Pacific LNG Project (APLNG)
Origin Energy/Conoco Phillips

Gladstone LNG Project (GLNG)
Santos/Petronas/Total/KOGAS

Queensland Curtis LNG Project (QCLNG)
Queensland Gas Company

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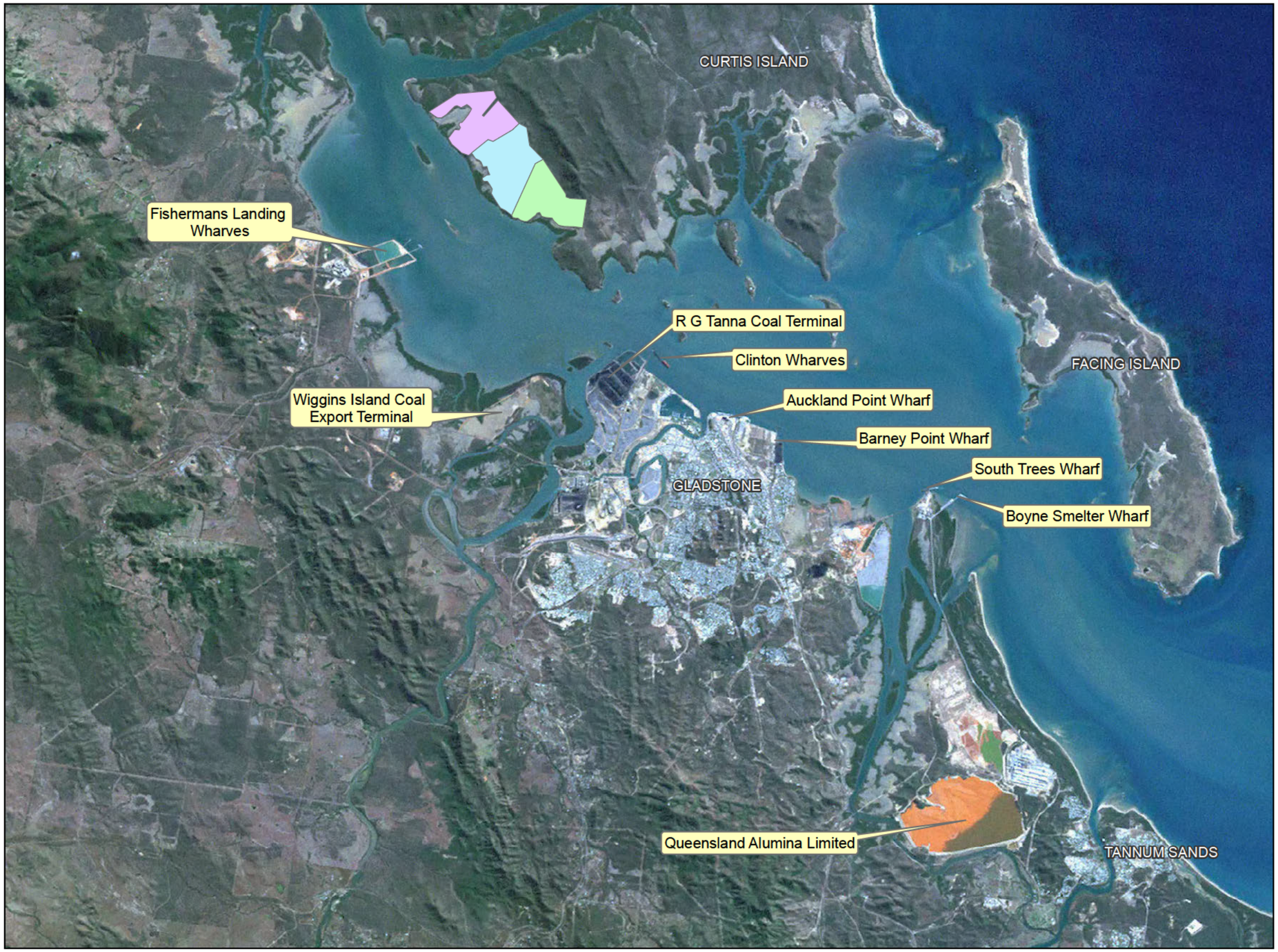
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FIGURE 1 | AREA MAP SHOWING THE GLADSTONE REGION

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LEGEND

Land Tenure

- Australia Pacific LNG Project (APLNG) Origin Energy/Conoco Phillips
- Gladstone LNG Project (GLNG) Santos/Petronas/Total/KOGAS
- Queensland Curtis LNG Project (QCLNG) Queensland Gas Company

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FIGURE 2 | EXISTING INDUSTRIAL FACILITIES OF GLADSTONE HARBOUR

QE99078 | Long Term Turtle Management Plan

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Brisbane Spatial Team - Prepared by : NK



LEGEND

- Flatback Turtle
- Green Turtle

Turtle Nest Rates

- Not Quantified
- 1-10 Females/year
- 10-100 Females/year

- Turtle Nesting Beaches
- Historical Seagrass Mapping (2002-2011)

Land Tenure

- Australia Pacific LNG Project (APLNG) Origin Energy/Conoco Phillips
- Gladstone LNG Project (GLNG) Santos/Petronas/Total/KOGAS
- Queensland Curtis LNG Project (QCLNG) Queensland Gas Company

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Source:
1. Turtle nesting data sourced from QGC Environmental Impact Statement
2. Previous Seagrass Meadows (2002-2011) – DAFF provided by GPC

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FIGURE 3 | TURTLE NESTING BEACHES AND SEAGRASS DISTRIBUTION IN THE VICINITY OF THE LNG FACILITIES

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1.3 Requirement of the Long-Term Turtle Management Plan

Preparation of a LTTMP is a requirement of the EPBC Act approvals 2008/4402 (QGC, Condition 34-39), 2009/4977 (APLNG, Condition 52-57) and 2008/4057 (GLNG, Condition 34-39) for each LNG proponent, with details of condition numbers for each approval provided in Appendix A. As the condition numbers vary among proponents, the roman numerals below are used as a proxy for the six identical conditions relating to the development of a LTTMP:

I. Within six months of this approval, the proponent must:

a) Contribute an initial amount of $150,000 towards preparation of a long term marine turtle management plan; and

b) Participate in industry wide discussions with the Gladstone Ports Corporation and other port users (including LNG proponents) with a view to establishing a long term marine turtle management plan and future funding requirements for the plan.

II. If terms of the long term marine turtle management plan cannot be agreed on an industry wide basis (within the Port of Gladstone) within six months of this approval, then the proponent must prepare a long term marine turtle management plan in consultation with other LNG proponents who have confirmed an intention to establish an LNG Facility on Curtis Island.

III. The plan (in either case referred to above), must include:

a) A program to establish comprehensive baseline information on populations of marine turtles that utilise the beaches and nearby waters of Curtis and Facing Island (including the Green Turtle Chelonia mydas, the Loggerhead Turtle Caretta caretta, and the Flatback Turtle Natator depressus);

b) A monitoring program to measure and detect changes to the marine turtle populations over a period of at least 10 years from commencement of the program. Monitoring methods must have the ability to detect changes at a statistical power of 0.8, or an alternative statistical power as determined in writing by the Minister;

c) The identification of significant activities relating to the construction and operation of LNG facilities (or in the case of an industry wide plan, activities within the Port of Gladstone) with the potential to cause adverse impacts on marine turtles;

d) Management measures including operating controls and design features to help manage and avoid adverse impacts to marine turtles shown to be adversely impacted by LNG operations (or in the case of an industry wide plan, activities conducted within the Port of Gladstone). In relation to the LNG operations, management measures will include any reasonable and practicable measures found necessary or desirable to minimise disturbance to marine turtles from gas flaring, and from lighting of the LNG plant and ships moored at the loading berth (except where the adoption of measures would be in contravention of health and safety legislative requirements).

e) Identification of annual contributions by the proponent, other LNG proponents who have confirmed an intention to establish an LNG facility on Curtis Island and, in the case of an industry wide plan, contributions by other port users.

IV. The Turtle Management Plan must be submitted for the approval of the Minister at least 3 months before the planned date of the commissioning of the first LNG train. The approved Plan must be implemented.

V. Within 60 days of each anniversary of the approval of the plan the proponent must provide a review report ("the Report") of the effectiveness of the management measures and operating controls directed at avoiding impacts on the marine turtle species. Note: the review report may be provided by the Gladstone Ports Corporation or another entity on behalf of the proponent.

VI. *If an impact on any of the marine turtle species is identified, the report must recommend improvements to the conduct of those operations and activities which are found to have a causal connection with the identified impact. The Minister may require improvements to be implemented. Note: To avoid doubt, if a condition of another approval held by the proponent requires a Turtle Management Plan, the proponent may simultaneously meet the relevant requirements of both conditions by submitting a single plan. The plan may also be prepared and implemented in consultation with the Gladstone Ports Corporation or other bodies.*

The LNG proponents have complied with Condition I by providing the specified funding amounts and participating in industry-wide discussions with stakeholders located within the Port of Gladstone, with a view to determining the feasibility of developing an industry-wide plan. These discussions included consultation with a variety of relevant industry and government stakeholders, including other LNG proponents, the Queensland Parks and Wildlife Service, the Gladstone Area Water Board and the Queensland Department of Environment and Heritage Protection (DEHP). Following these discussions, the LNG proponents came to a view that development of an industry-wide LTTMP was not possible, due to the diversity of activities occurring within the region and the short timeframe available to reach consensus and develop such a plan, prior to commissioning of the first LNG facility in late 2013. Rather, the three LNG proponents who have approval to construct and operate their facilities agreed to work collaboratively on a joint management plan covering their collective operations (in accordance with Condition II). A summary of this plan's compliance with the above-specified EPBC Act approval conditions is provided in Appendix A.

A joint management plan is considered to be highly beneficial for development of an effective LTTMP, because the LNG facilities are:

- located immediately adjacent to each other along a 4 km stretch of Curtis Island;
- of a similar design, with risks to marine turtles being relatively consistent among sites; and
- all currently approved by Commonwealth and State agencies, providing certainty in design and operational factors which may influence impacts on marine turtles and their habitats.

As a Final Investment Decision to proceed with the Arrow LNG Plant Project has not yet been made, and is not expected to be made prior to commissioning of the first LNG Train by QGC, Arrow has not been involved in the preparation of the LTTMP. We note approval under the EPBC Act also has not yet been granted for the Arrow LNG Plant Project. Should Arrow make a Final Investment Decision to proceed with the Arrow LNG Project, the LNG proponents would welcome Arrow's contribution to and participation in the implementation of the LTTMP.

1.4 Methodology and Structure of the LTTMP

A review and synthesis of available information on marine turtles in the Gladstone region was the first step in the development of the LTTMP. The information reviewed comprised scientific publications, the DEHP annual turtle stranding reports and database, monitoring reports for turtle nesting sites in the Gladstone region, EIS studies of Port Curtis and surrounding environments, information held by the LNG proponents and the e-Atlas (2012) habitat mapping tool. The suitability and relevance of existing information to the LTTMP were assessed as part of a gap analysis to identify existing knowledge and potential gaps.

The results of the gap analysis have been summarised within the Existing Environment section of the plan (Section 2.0), which provides an overview of the variety, value, conservation significance and condition of the Gladstone region in relation to marine turtle habitats and populations. This summary is not intended to be detailed, but rather provide sufficient introductory context for subsequent sections of the LTTMP, focussed on environmental risk, mitigation and monitoring.

All aspects of the turtle life cycle are described, with a focus on foraging and nesting habitats, which are most relevant to understanding and mitigating the environmental impacts of the LNG facilities. The findings of the gap analysis are outlined in Appendix B, which provides an assessment of the value of key references in development of the LTTMP.

A description of the risks posed by the construction and operation of the LNG facilities on Curtis Island on the marine turtle values of the Gladstone Region is provided in Section 3. Such risks include boat strikes from increased shipping activities, disturbance of habitat and marine turtles through the construction of new infrastructure, and the influence of new artificial lighting sources on the existing night time sky glow of the Gladstone region (which has the potential to impact on turtle nesting behaviour and on hatchling dispersal). A risk assessment of each activity with potential to cause adverse impacts has been completed, based upon an assessment of the likelihood and consequence of each impact occurring, to determine an overall risk for each activity on marine turtle populations and their habitats.

Strategies to manage and mitigate risks were reviewed and assessed for adequacy, based where possible on previous experiences with similar projects or relevant scientific literature (Section 4.0). Given the extensive EIS process that each LNG proponent has completed, consideration was initially given to existing commitments made by the LNG proponents to manage their impacts on turtles. Risks were reassessed following the implementation of mitigation strategies to determine the residual risk rating. Impacts identified with the highest risk required the development of the most significant management and mitigation measures, in order to minimise the risks to the lowest possible extent. Where a risk could not be completely mitigated, the predicted impacts were discussed in the context of the conservation of marine turtle populations of the Gladstone region.

A LNG proponents' monitoring program was developed to establish the baseline environmental situation and health status with respect to marine turtles and their habitats and to monitor changes to this baseline during construction and operational phases of the projects (Section 5.0). While some gaps exist, there is generally a good understanding of baseline environmental parameters relevant to project activities and their impacts on marine turtles. Establishment of the baseline situation was largely fulfilled by reviewing previous studies within the region completed prior to the commencement of construction works in mid 2010. This involved a review of existing monitoring programs, as identified during the gap analysis, and assessment of their value in monitoring the potential impacts of the LNG facilities on marine turtles. The collection of extensive new data on marine turtles and their habitats has been proposed, to provide additional means to detect change in key parameters relevant to project risks over time and to build upon existing information.

The monitoring program was designed to detect impacts on marine turtles in the Gladstone region caused by the LNG facilities and, where possible, distinguish between broader impacts associated with region-wide events such as flooding. The need to identify cumulative impacts of the LNG facilities was also considered in light of the existing and future development planned within the region. Integrating existing environmental and animal health monitoring was considered as a means to enable real-time and long-term effects to be identified. Management triggers have been developed for implementation in the event that change in is detected in relevant environmental variables.

An explanation of how the LTTMP will be implemented is provided in Section 6.0. This includes details of the administration and funding arrangements and is accompanied by a schedule for reporting and auditing of performance against plan commitments. The LTTMP provides a holistic synthesis of the management issues for marine turtles in the context of the LNG facilities and outlines practical solutions to mitigate and monitor these issues in the long term.

2.0 EXISTING INFORMATION

2.1 Overview of the Gladstone Region

The Gladstone region lies approximately 475 km north of Brisbane and is home to Australia's fifth largest and Queensland's largest multi commodity port, which is located within Port Curtis (GPC 2011a). The Port, which has operated for more than 50 years, is managed by the GPC and exports a wide variety of products, with periods of rapid expansion to meet past (coal) and future (LNG and WICET) development requirements (GPC 2011a). Part of the Port lies within an estuarine passage known as The Narrows, which is a protected landscape and is one of only five tidal passages in Australia (Australian Heritage 2012). Estuarine passages are an uncommon landscape and are characterised by a narrow tidal passage separating the mainland and an island.

The three LNG facilities will be situated on the south western coastal fringe of Curtis Island, which stretches approximately 47 km from north to south and is 58,000 ha in area. Curtis Island contains a small settlement on the south end of the Island and is used for recreational activities including camping, four wheel driving and bush walking (DNPRSR 2012a, b). The Island has one National Park (Curtis Island National Park), three Conservation Parks (Cape Capricorn Conservation Park, Southend Conservation Park and Curtis Island Conservation Park) and two State Forests (Curtis Island State Forest and North Curtis Island State Forest; DNPRSR 2010). Curtis Island supports a wide variety of flora and fauna and contains critical habitat for several species including the endangered yellow chat (small bird; *Epthianura crocea macgregori*), which breeds on the island's northern sections and the threatened flatback turtle (*Natator depressus*), which nests on the island's south-eastern beaches (DNPRSR 2012a, b), between 9 and 13 km from the LNG projects.

Marine habitats of the Gladstone region are generally located within the Great Barrier Reef World Heritage Area (GBRWHA), with areas within port limits excluded from the Great Barrier Reef Marine Park (GBRMP). Coastal areas of the Gladstone region comprise a variety of habitats which include intertidal and sub-tidal habitats supporting a variety of environmentally and economically important species. Intertidal communities include sand and mud flats, mangroves, salt marsh, rocky reefs and seagrass. Sub-tidal habitats include seagrasses, soft and hard coral communities, macroalgae communities and open soft substrate. The sub-tidal habitat of the Gladstone region potentially supports 74 EPBC-listed species including 21 species of marine reptiles, 14 species of marine mammals and 39 fish species (SEWPAC 2012).

The majority of the seabed habitats within the Gladstone region are comprised of open sandy and silty substrates which support a variety of macroflora communities and low-density macroinvertebrate communities (Thomas *et al.* 2010, Chatrand *et al.* 2009; GHD 2009; URS 2008; Rasheed *et al.* 2008; Taylor *et al.* 2007; Taylor *et al.* 2006; Rasheed *et al.* 2003). Extensive seagrass communities occur within the Gladstone region and are likely to be of regional significance as the only major area of seagrass between Hervey Bay and Shoalwater Bay, providing food for local and transiting animals (Thomas *et al.* 2010; Chatrand *et al.* 2009; Rasheed *et al.* 2008; Dobbs *et al.* 2007; Taylor *et al*. 2007; Taylor *et al.* 2006; Rasheed *et al.* 2003). Numerous seagrass surveys of the Gladstone region have been conducted including broad-scale and long-term monitoring programs by both scientists and local community organisations (McKenzie *et al*. 2012; Thomas *et al*. 2010; Chatrand *et al*. 2009; Rasheed *et al*. 2008; Taylor *et al*. 2007; Taylor *et al*. 2006; Rasheed *et al*. 2003; Lee Long *et al*. 1993). Seagrass meadows have shown considerable variability in distribution and abundance in response to regional and local climatic conditions (McKenzie *et al*. 2011).

Seven species of seagrass have been identified in the Gladstone region and include *Zostera capricorni, Halodule uninervis¸ Cymodocea rotundata, Halophila ovalis, Halophila decipiens, Halophila minor* and *Halophila spinulosa* (McKenzie *et al*. 2012; Thomas *et al*. 2010; Chatrand *et al*. 2009; Rasheed *et al*. 2008; Taylor *et al*. 2007; Taylor *et al*. 2006; Rasheed *et al*. 2003; Lee Long *et al*. 1993). These species provide an important food source and nursery habitat, while contributing to the primary production of the area (McKenzie *et al*. 2012; Thomas *et al*. 2010; Chatrand *et al*. 2009; Rasheed *et al*. 2008; Taylor *et al*. 2007; Taylor *et al*. 2006; Rasheed *et al*. 2003; Lee Long *et al*. 1993). Seagrass habitats of Port Curtis have showed signs of recovery following flood-related declines in early 2011 (Sankey *et al*. 2012).

Soft and hard coral communities occur throughout the Gladstone region, with communities surrounding islands and rocky outcrops. Inshore reef communities are characterised by low diversity but high abundance of algae, soft and hard coral communities (GBRMPA 2006). Studies of coral communities on the eastern

side of Facing, Rundle, Curtis and Hummock Hill Islands found hard coral communities were dominated by acroporids and favid species, and soft coral communities were dominated by *Xenia* spp., *Alcyonium* spp. and *Dendronepthya* spp. (Sea Research 2012, BMT WBM 2009).

The Capricorn and Bunker group of islands lies approximately 80 km east of Gladstone and consists of 22 reefs and 16 coral cays. The area provides food, habitat and nesting grounds for several species including turtles (DNPRSR 2012a, b; Commonwealth of Australia 2011; Limpus 2007). Loggerhead and green turtles are commonly seen in the mid and outer reef areas of the Gladstone region, with major rookeries present for both species within the Capricorn and Bunker group of islands (Limpus 2007). Within Port Curtis, green turtles are the predominant turtle species, with loggerhead turtles observed only occasionally.

Within the Gladstone local government area there are six Fish Habitat Areas (FHA) including Baffle Creek, Colosseum Inlet, Eurimbula, Fitzroy River, Seventeen Seventy – Round Hill and Rodds Harbour (DEHP 2012a). The closest FHA to the LNG facilities is the Fitzroy River FHA, which begins approximately 27 km to the north east. The Gladstone region also contains the Rodds Bay Dugong Management Area, which is inside the Port Limits and extends south of the Port of Gladstone. The Gladstone region is of low to medium conservation value for dugongs with highest densities within the Rodd's Bay area found adjacent to the south-western tip of Curtis Island and east of Hummock Hill Island (Grech and Marsh 2007).

There are no RAMSAR wetlands recorded within the Gladstone local government area (DEHP 2012a). However there are nine nationally important wetlands which are listed in the Directory of Important Wetlands in Australia (DEHP 2012a).

Further information on the environmental values of the Gladstone region, including detailed studies can be found in the following information sources:

- APLNG Environmental Impact Statement (APLNG 2010a);
- APLNG Supplementary Environmental Impact Statement (APLNG 2010b);
- QCLNG Environmental Impact Statement (QGC 2009a);
- QCLNG Supplementary Environmental Impact Statement (QGC 2009b);
- GLNG Environmental Impact Statement (GLNG 2009a), and
- GLNG Supplementary Environmental Impact Statement (GLNG 2009b).

2.2 Summary of Baseline Information on Marine Turtles

Marine turtles are an integral part of oceanic ecosystems throughout the world (Chaloupka and Limpus 2001, Chan 2006, Jackson *et al.* 2001). There are seven extant species of marine turtle: green (*Chelonia mydas,* Linnaeus 1758), loggerhead (*Caretta caretta,* Linnaeus 1758), hawksbill (*Eretmochelys imbricata,* Linnaeus 1766), flatback (*Natator depressus,* Garman 1880), leatherback (*Dermochelys coriacea,* Vandelli 1761), olive ridley (*Lepidochelys olivacea,* Eschscholtz 1829), and Kemp's ridley (*Lepidochelys kempii,* Garman 1880) (Healey 1997). Australia has resident or migratory populations of all marine turtle species except for Kemp's ridley (Limpus 1997), with the Gladstone region hosting populations of green, loggerhead, hawksbill and flatback turtles.

The conservation status of marine turtle species found in Australia is summarised in *Table 1*. All of the Australian resident turtle species are listed as vulnerable or endangered in Australian waters under the EPBC Act and in Queensland under the *Nature Conservation Act 1992*. Internationally, these species are listed as vulnerable to critically endangered, and the flatback turtle is listed as data deficient due to insufficient population data to comprehensively determine its conservation status (IUCN/SSC 2008). The conservation status of all marine turtles in Australian waters raises concern about the health and longevity of these species and the state of Australia's marine environment. Human-related threats to marine turtles occur across all life-cycle stages and during their pelagic and benthic life phases and have contributed to population declines. Such threats include marine debris and flotsams, bycatch in fisheries, aquaculture and shark control programs, boat strike, hunting, disruption to breeding processes from artificial lighting and predation from introduced pests.

Table 1: Conservation Status of Marine Turtle Species Found in Australia and their Presence in the Gladstone region

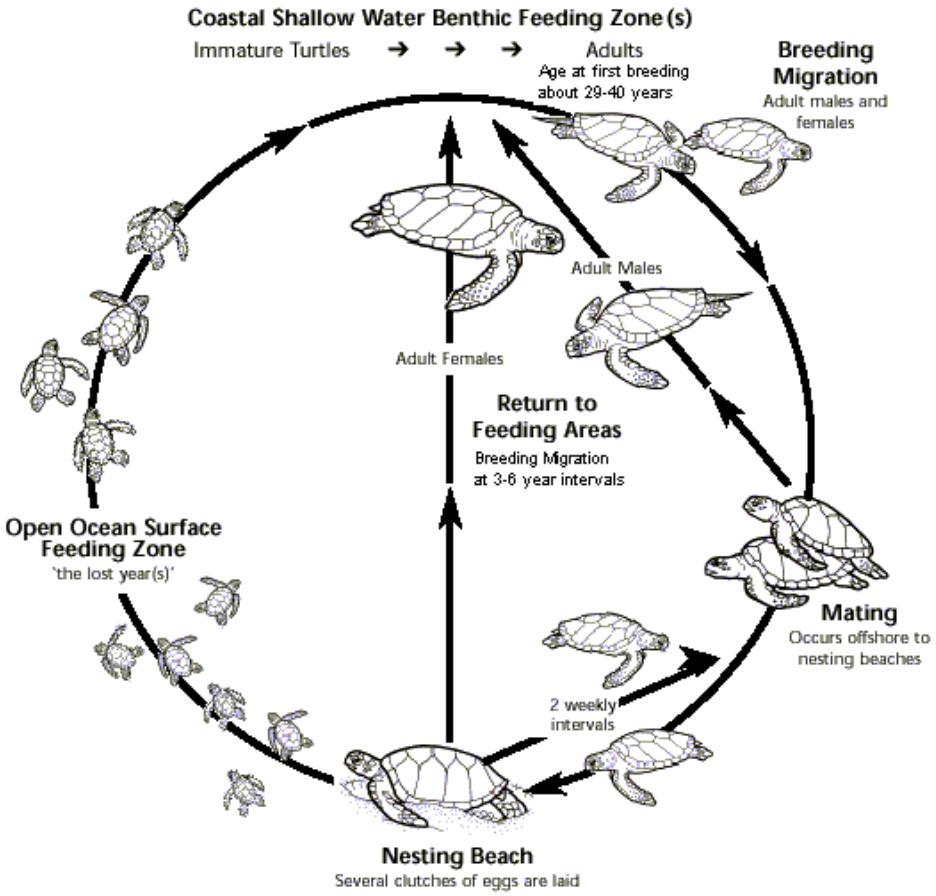
		Conservation Status			
Species	**Common Name**	**Queensland**	**Australia**	**IUCN**	**Likelihood of occurring in Gladstone Region**
Natator depressus	Flatback Turtle	Vulnerable	Vulnerable Migratory	Data Deficient	Highly Likely (breed in the region)
Chelonia mydas	Green Turtle	Vulnerable	Vulnerable Migratory	Endangered	Likely (occasionally breed in the region)
Caretta caretta	Loggerhead Turtle	Endangered	Endangered Migratory	Endangered	Likely (occasionally breed in the region)
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable	Vulnerable Migratory	Critically Endangered	Unlikely (may migrate occasionally through the region)
Lepidochelys olivacea	Olive Ridley	Endangered	Endangered Migratory	Vulnerable	Unlikely (may migrate occasionally through the region)
Dermochelys coriacea	Leatherback Turtle	Endangered	Endangered Migratory	Critically Endangered	Highly Unlikely (oceanic species, may occasionally migrate through the region)

Queensland – *Nature Conservation Act 1992*, Australia – EPBC Act

As a group, marine turtles have a wide geographic distribution. They are able to move between oceans (Dethmers *et al.* 2006) with annual migratory ranges of some individuals recorded at over 2,600 km (Dutton *et al*. 2007, Limpus 2008a, Limpus 2008b, Limpus *et al*. 1992). In contrast to this dispersive behaviour, marine turtles exhibit high fidelity to their feeding grounds, courtship grounds and nesting beaches, despite these regions potentially being separated by thousands of kilometres (Limpus 1997). These behaviours result in distinctive genetic subpopulations among regions despite having overlapping ranges of distribution (Dethmers *et al*. 2006, Limpus 2008b). Within the Gladstone region, green turtles have a high likelihood of being from a southern Great Barrier Reef population (Limpus 2007, 2008a, 2008b, 2009), with loggerhead turtles part of a South Pacific population, flatback turtles part of an Eastern Australian population and hawksbill turtles likely to be from one of the South Western Pacific populations (M. Hamann pers. comm.).

Irrespective of species, marine turtles share common lifecycle traits involving the development from egg to hatchling to juvenile to adult (*Figure 4*; Bolten 2003, Limpus 1997), undergoing ontogenetic shifts during different phases of their lifecycle. A reason for these shifts is postulated to be the need to utilise different habitats as a marine turtle's physiological (nutritional) requirements change from hatchling to breeding adult (Werner and Gilliam 1984). Precise details of these requirements and the exact phases of the lifecycle that they apply to are unknown. However, these transitions are thought to include at least one change from the "pelagic life phase" (open ocean phase of their life) to "benthic life phase" (near-shore stage of their life) feeding grounds and there is significant variation among species in the estimated duration of stages of pelagic and benthic life phases (Heppel *et al*. 2003). The complex ecology of marine turtles provides challenges for their effective management in response to human-related threats (Environment Australia 2003).

Figure 4: Generalised Life Cycle of Marine Turtles (Lanyon et al. 1989)



The Gladstone region provides a range of niche habitats for the green, loggerhead, hawksbill and flatback turtle, including nesting and foraging areas, making it an important location for the conservation of marine turtles in Australia. The historic and continued development of Port Curtis by a diverse range of industries and proponents presents challenges for the management of environmental health parameters relevant to marine turtle populations.

2.3 Marine Turtles and the Gladstone Region

This section provides an overview of the ecology and habitats of the four turtle species found most commonly within the Gladstone region, for the purposes of providing sufficient context for the subsequent sections of Ecological Risk Assessment (Section 3), Management and Mitigation Strategies (Section 4) and the Monitoring Plan (Section 5). A more detailed review of literature on marine turtles and their habitats in the Gladstone region has been developed in parallel with the LTTMP by the GPC (GPC, in prep.) and it is not intended to replicate this information here, beyond what is necessary to provide context for subsequent sections of the LTTMP.

2.3.1 Green Turtle

Populations of green turtles in Australia were severely depleted by previous commercial harvesting activities, with Heron Island a significant harvest site utilising Gladstone as its nearest port (Daley *et al*. 2008, Limpus 2008b, Limpus *et al*. 1994). Exact figures for the population decline in Australia are not known, however a recent study of the southern Great Barrier Reef (sGBR) green turtle population has shown that this genetic unit has been increasing over the past 25 years along with a number of other well-managed populations

(Chaloupka *et al*. 2008). The cessation of commercial harvesting of green turtles along the coast of Queensland south of Cooktown is thought to be the major contributor to the population increases (DEHP 2013).

Green turtles are listed as vulnerable in Queensland and Australia under the *Nature Conservation Act 1992* and EPBC Act, and as endangered on the international scale under the International Union for Conservation of Nature. The green turtle has been proposed as a sentinel indicator of environmental health, due to its high site fidelity, use of local resources and longevity (Aguirre and Lutz 2004). Studies on the causes of mortality of this species in southern Queensland have identified several prevalent diseases that appear to be increasingly evident with growing environmental pressure (Flint *et al*. 2010). Used as a baseline, these findings are facilitating environmental monitoring in industrialised areas such as Gladstone (Eden *et al*. 2011). From a management perspective, it is important that the resident foraging grounds for all age classes are preserved.

Of the seven species of seagrass within the Gladstone region, *Halophila ovalis*, *Zostera capricorni*, *Halodule uninervis* and *Halophila spinulosa* predominate (Sankey and Rasheed 2011) of which the *Halophila* and *Halodule* species are preferred foods of green turtles. Within the southern Great Barrier Reef population, dietary studies on green turtles indicate that macroalgae such as *Gracilaria* sp. are also consumed (Brand-Gardner *et al.* 1999, Chaloupka *et al.* 2004) and algae is the major food source for many green turtles (Limpus 2008b; C. Limpus pers. comm.). Mangrove shoots and fruits have also been reported to comprise a part of the diet of some green turtles (Limpus and Limpus 2000). With a rich diversity of these seagrasses, reef algae and mangroves, the Gladstone region provides an important resource to foraging green turtles, which has supported the local recovery of this species. The region provides inter-nesting habitat for females breeding on the Capricorn Group of islands (including Heron Island, Tryon Island and North West Island) during the breeding season and a small immature turtle foraging and basking ground.

Green turtles also nest occasionally on the beaches of Curtis Island and Facing Island (Limpus *et al*. 2006, QGC 2009a). The peak period of nesting is mid-December to mid-January, with the peak period of hatching during February and March. Large immature and adult non-breeding turtles are also present within the region, feeding on the seagrass meadows, algal turfs, and to an unknown extent, invertebrates found on the tidal and intertidal sand and mudflats (Limpus 2008b). The densities of these local cohorts are not well documented, although GPC noted a large number of juvenile and sub-adult green turtles during aerial surveys in 2011, highlighting the importance of this inshore region for young turtles (GPC 2011a).

2.3.2 Loggerhead Turtle

The number of loggerhead turtles in Eastern Australian waters has declined by 86% in recent decades (Limpus 2008a, Limpus and Limpus 2003) in response to a variety of human-related activities, including trawling and the predation of eggs and hatchlings by foxes at nesting beaches. For example, there were 3,500 nesting female loggerhead turtles in 1977 at a nesting beach at Mon Repos, but only 500 were found in 2000 (Chaloupka and Limpus 2001). Mon Repos supports one of eastern Australia's largest loggerhead turtle nesting populations, but the decline in the number of nesting females continues. During the 2011-2012 nesting season, only around 350 loggerhead turtles nested at this site (C. Limpus unpubl data). There is evidence that the population decline has stabilised in recent years, most likely due to the introduction of turtle exclusion devices in the Queensland trawl fishery in 2001 and the introduction of fox baiting programs at key nesting beaches (GBRMPA 2012).

The Gladstone region and southern Great Barrier Reef provide a potential foraging resource for breeding loggerhead turtles, with turtles known to nest occasionally on the beaches of Curtis and Facing Islands (EPA 2003). The peak period of nesting is during December, with hatching occurring in the following months up until the end of April (DEHP 2005). In addition to Mon Repos, other nesting rookeries for loggerhead turtles include Wreck Rock (to the south of Gladstone), Tryon Island, Wreck Island and Erskine Island (to the north east). These nesting habitats collectively form the major rookery of the Capricornia Cays National Park (Limpus 2008a) with breeding loggerhead turtles supported by the foraging resources of the Gladstone region.

Therefore, preservation of the resident foraging grounds for loggerhead turtles such as Moreton Bay and the embayments of the Great Barrier Reef is vital to provide a food-rich habitat that will support the species and minimise potential stressors that are negatively impacting on the survivorship of the sGBR loggerhead population.

Loggerhead turtles are listed as endangered in Queensland and Australia under the *Nature Conservation Act 1992* and *EPBC Act*, and on the international scale under the International Union for Conservation of Nature. Fisheries and shipping activities can significantly impact on loggerhead survivorship (Greenland and Limpus 2008), with disease also playing an important role in the causes of mortality (Flint 2010).

Loggerhead turtles recruit to coastal benthic zones from the open ocean at approximately 13 years of age having reached sub-adulthood. Here they continue their carnivorous diet, feeding on over a 100 recorded taxa, predominantly invertebrates such as gastropods and bivalve molluscs, and to a lesser extent on soft invertebrates and fish (Limpus 2008a). The Gladstone region offers a diverse perennial resource for feeding grounds of inter-nesting females and resident loggerhead turtles. The invertebrate biomass is supported by the rich diversity of seagrasses, algal turfs, and sand and mud flats, the latter of which are utilised by loggerheads during high tides.

From a management perspective, the preservation of resident foraging grounds and surrounding reefs for sub-adult and adult age classes is important. Minimising anthropogenic impacts is a key management objective, given the conservation significance of the species.

2.3.3 Hawksbill Turtle

Heavily harvested for trade due to their patterned carapace, the hawksbill turtle continues to face human pressures on a global scale. Despite northern Queensland containing a collection of nesting beaches that comprise an internationally significant nesting ground for this species (Meylan and Donnelly 1999), very little is known about the biology, population structure and habitats of hawksbill turtles in southern Queensland (Limpus 1992). Information that is available is primarily based on foraging population surveys around Heron Island (Limpus 1979).

There are no known hawksbill turtle nesting beaches in Queensland outside of the northern Great Barrier Reef and Torres Strait. However, small populations of predominantly sub-adult and juvenile turtles are found in resident populations in the southern parts of Queensland. This is in contrast with the northern parts of Queensland, where larger populations of predominantly adult animals are found (Limpus 2009). Based on a decline in the number of turtles at index nesting beaches of northern Queensland, there is a predicted localised loss of >90% of the Queensland population within one generation, by 2020 (Limpus 2009). Further monitoring and adding to the body of knowledge of hawksbill turtles in the sGBR are required to understand the reasons for the decline.

Similar to the green turtle, disease is a significant cause of mortality in hawksbill turtles and may be utilised as an indicator of environmental health (M. Flint unpubl data). Fishing activities and other anthropogenic activities are also known threats to this species (Limpus 2009). Based on current population figures, hawksbill turtles are listed as vulnerable in Queensland and Australia under the *Nature Conservation Act 1992* and EPBC Act, and as critically endangered on the international scale under the International Union for Conservation of Nature.

Although there is a significant hawksbill turtle population in the coral reefs offshore from Port Curtis, and hawksbill turtles may forage in Port Curtis, it has not been demonstrated that there is a significant feeding population within Port Curtis. However, the broader Gladstone region (including areas of the Great Barrier Reef east of Port Curtis) includes areas of soft coral, algae and seagrass, which form part of their dietary requirements (Limpus 2009), making the Gladstone region a potential resident feeding ground and resource for the omnivorous hawksbill turtle. In this context it is important for conservation of the species that resident foraging grounds and surrounding reefs for juvenile and sub-adult age classes are preserved.

2.3.4 Flatback Turtle

With a global distribution restricted to Australia and southern Asia (Limpus 2007), the flatback turtle is of great significance to Australian marine conservation. A carnivorous species with a diet that includes soft corals, jellyfish, cuttlefish, sea-pens and sea-cucumbers (Chatto 1998; Limpus 2007), flatback turtles utilise the abundant invertebrate resources of the Great Barrier Reef and its coastal areas, including the Gladstone region.

Flatback turtles have a high degree of site fidelity and significant stable nesting occurs along the coastal islands of Queensland, several of which are within the sGBR region (Limpus *et al*. 2002). Three major rookeries occur at Wild Duck Island, Peak Island and Curtis-Facing Islands, with several rookeries of lower density also present in the southern and central Great Barrier Reef region (Limpus *et al*. 2002). Around 20% of Queensland's flatback turtle population nests on inshore islands of the Gladstone region (EPA 2003). The southern section of Curtis Island is an index beach for monitoring (Limpus 1971a) and consistently records approximately 50 breeding females nesting each season (Hodge *et al*. 2006). Nesting also occurs in lower numbers at the eastern side of Facing Island, Hummock Hill Island and at Tannum Sands (Limpus 2007). The peak period of nesting activity is mid-November to mid-December, with the peak period of hatching during February (QGC 2009a; Limpus 2007).

At a national scale, other significant flatback turtle nesting areas include northern Australia and the mid-coast of Western Australia, where a separate genetic stock exists and is of interest to offshore gas developments. In Australia, flatback turtles from the large and moderate nesting rookeries, including Curtis Island, are not believed to be negatively impacted by light from coastal development due to most nesting occurring on remote islands (Limpus 2007). However, at-sea lighting and increased mainland urbanisation may have impacts on turtle orientation around the smaller nesting beaches used by this species.

The biological data on flatback turtles is limited, due to the species' utilisation of water depths greater than 40 m when foraging (Limpus 2007). Limited data are available on the diseases of flatback turtles other than incidental pathogens isolated during nesting (Phillott *et al*. 2002). However, given the conservation importance of the species, efforts should be directed to opportunistically expand this limited existing database. Threats to the conservation of flatback turtles include bycatch in fishing and netting activities, coastal development, hunting and climate change.

Flatback turtles are listed as vulnerable in Queensland and Australia under the *Nature Conservation Act 1992* and EPBC Act, and as data deficient on the international scale under the International Union for Conservation of Nature Vulnerable. Based on tag recoveries, the majority of nesting flatback turtles in the Gladstone region feed further afield within the Great Barrier Reef lagoon (Limpus *et al.* 2002). It is believed that flatback turtles do not feed during the inter-nesting period (Sperling *et al.* 2010), however, the broader Gladstone region provides an important food resource for the species, with an abundance of invertebrates available throughout the coral reefs and within their adjacent waters. Inter-nesting flatback turtles are likely to enter Port Curtis for periods of time, but little data is available on inter-nesting habitat utilisation.

It is important that management actions for the flatback turtle in the Gladstone region are focussed on the preservation of deep water foraging grounds and maintenance of the index beach on Curtis Island. Australia has a distinct east coast genetic stock of flatback turtles, with the animals not believed to leave the continental shelf. As such, preservation of all breeding sites within the Great Barrier Reef is important for conservation of the species. Close monitoring is desirable to assist in the long-term conservation and management of flatback turtles, as occurs in locations such as Barrow Island off the Western Australian coast.

2.4 Gap Analysis and Assessment of Values

A review of relevant literature on the values of the Gladstone region to marine turtles was completed as a first step in development of this LTTMP. The review identified approximately 50 sources of information on marine turtles in the Gladstone region, with 14 studies on the distribution, health and abundance of seagrass. Several papers were also identified on the potential effects of lighting, boat strike and dredging on marine turtles and their habitats which have served as useful references for development of the LTTMP.

References identified during the gap analysis with relevance to the project are summarised in Appendix B, with notes on the implications of study findings for development of the LTTMP.

In summary, the gap analysis identified the following strengths in the existing information:

- Some long-term baseline data are available for a small number of important nesting beaches in the Gladstone region, collected by DEHP, James Cook University and Central Queensland University.
- Long-term monitoring has been completed by DEHP for turtles nesting at Curtis Island since 1969;
- There is continuous, long-term monitoring of turtle strandings in the Gladstone region including Port Curtis since 1999, with responses to floods and other disturbance events described in some reports.
- Several impact assessment studies in the Gladstone region have mapped the location of key turtle habitats including nesting beaches.
- Seagrass foraging habitats are well mapped, with impacts of a 2011 flood event described, in addition to the subsequent recovery;
- Existing management plans are in place for some shipping and construction operations to mitigate risks to turtles;
- An existing Gas Industry Social and Environmental Research Alliance (GISERA 2011) project sponsored by CSIRO and APLNG involves monitoring of turtles and seagrass for an initial period of three years and extensions likely thereafter.
- The GPC ERMP has a 10 year monitoring program in place, targeting marine turtles and seagrass habitats among other environmental variables, and
- There is a strong literature base on the general effects of light on marine turtles across many locations globally. A baseline assessment of the ambient night time light conditions of the Gladstone region was conducted on nesting beaches of Curtis and Facing Islands in 2011.

Some key knowledge gaps identified by the gap analysis task of the project included:

- Detailed data on turtle nesting beaches only exists for a small number of sites and does not appear to be regularly published;
- Knowledge of the health of foraging turtle populations in the Gladstone region is not comprehensive, although preliminary baseline information can be built upon. Conclusions are generally reliant on data from stranded turtles;
- The influence and relative contribution of multiple threats to marine turtle populations for both natural and human stressors (e.g. predation of turtle hatchlings, impacts from multiple industrial uses) have not been well quantified, and
- Inter-nesting habitat use for flatback turtles and the orientation of turtle hatchlings on nesting beaches with respect to light have not been studied in detail.

A summary of the findings of the gap analysis in relation to the key approval conditions is provided in *Table 2*.

Table 2: Summary of key findings of the gap analysis in relation to the EPBC Act approval conditions.

EPBC Approval Condition Requirement of Plan	Adequacy of Existing Information
A program to establish comprehensive baseline information on populations of marine turtles that utilise the beaches and nearby waters of Curtis and Facing Islands (including the Green Turtle *Chelonia mydas*, the Loggerhead Turtle *Caretta caretta*, and the Flatback Turtle *Natator depressus*);	Extensive baseline information exists, relative to the project risks, although several gaps are also present. New studies are currently underway and will add to the existing knowledge. Not all information and data collected has been published, with the most notable example being the annual monitoring of the Curtis Island Index Nesting Beach, which has been in place since 1969, but has minimal published results. Gathering unpublished data will be an important first step in implementing the LTTMP during the first year.
A monitoring program to measure and detect changes to the marine turtle populations over a period of at least 10 years from commencement of the program. Monitoring methods must have the ability to detect changes at a statistical power of 0.8, or an alternative statistical power as determined in writing by the Minister;	Some existing monitoring programs are in place and are coordinated by a variety of stakeholders. The programs include the GPC ERMP (10 year plan), the annual monitoring of nesting beaches on Curtis Island by DEHP (since 1969) and studies of seagrass and foraging turtles (GISERA).
The identification of significant activities relating to the construction and operation of LNG facilities (or in the case of an industry wide plan, activities within the Port of Gladstone) with the potential to cause adverse impacts on marine turtles;	There have been comprehensive EIS assessments completed on the construction and operation of LNG facilities, with management plans developed for some activities. These documents identify the activities with the potential to cause adverse impacts on marine turtles. This requirement of the LTTMP is well covered by the existing information.
Management measures including operating controls and design features to help manage and avoid adverse impacts to marine turtles shown to be adversely impacted by LNG operations (or in the case of an industry wide plan, activities conducted within the Port of Gladstone). In relation to the LNG operations, management measures will include any reasonable and practicable measures found necessary or desirable to minimise disturbance to marine turtles from gas flaring, and from lighting of the LNG plant and ships moored at the loading berth (except where the adoption of measures would be in contravention of health and safety legislative requirements).	Management measures to reduce impacts on marine turtles have been outlined during the EIS assessments and in their associated management plans, including those developed for activities such as shipping and operation of the LNG facilities. A useful baseline assessment of the ambient night time light conditions of the Gladstone region is also in place. The adequacy of mitigation and management measures to protect marine turtles and their habitats can be assessed in accordance with the requirements of this EPBC condition. GISERA has also commenced radio tracking of turtles to better understand habitat use within Gladstone Harbour.
Identification of annual contributions by the proponent, other LNG proponents who have confirmed an intention to establish an LNG facility on Curtis Island and, in the case of an industry wide plan, contributions by other port users.	Funding arrangements for implementation of the plan will be shared among the three LNG proponents and reported in their annual returns.

3.0 ECOLOGICAL RISK ASSESSMENT

3.1 Description of Risks

The development and operation of LNG facilities on Curtis Island has the following potential impacts on marine turtles:

- Boat strike from temporary increases in vessel activity during construction and from export shipping activities associated with LNG facility operations;
- Lighting disturbance to nesting female turtles and hatchling turtles during construction and operation, arising from an increased contribution to the existing sky glow of the Gladstone region;
- Direct impacts of construction through habitat disturbance, vibration and noise from piling and injury caused by dredging equipment, and
- Indirect disturbances associated with a decrease in water quality and impacts on seagrass foraging areas, which may in turn affect the overall health of foraging turtle populations.

Each of these potential impacts are summarised in the following sections, with a description of the predicted likelihood and consequence, based upon a review of existing literature.

3.1.1 Boat Strike

Marine turtles move at a slow speed when compared with that at which most marine vessels are operated. This combined with the need to breathe air at the water's surface at frequent intervals can make marine turtles vulnerable to collisions with fast-moving vessels. Such collisions may result in injury or death to the turtle arising from blunt trauma from the vessel hull or from cuts inflicted by the vessel's propeller. The anatomy of turtles is such that even shallow propeller cuts on the carapace can result in fatal injuries through the puncture of underlying lung tissue (Wyneken *et al*. 2006). Marine turtles exhibit a high degree of site fidelity in their foraging areas, and may therefore be unlikely to leave their foraging areas in response to increasing vessel traffic around them. Such behaviour could result in continued exposure to vessel traffic (and the risk of boat strike), or avoidance of some foraging areas within the broader home range utilised by the turtle.

It is generally well accepted that the risk of boat strike on turtles increases with the speed at which a vessel is travelling, due to the reduced time available for the turtle (and in some cases vessel operator) to take action to avoid a collision (e.g. Hazel *et al*. 2007). Water depth is also thought to play an important role in determining the risk of collision, with shallow seagrass habitats used for foraging and resting considered being of higher risk than deeper areas where there is significant clearance between the vessel hull and the seabed (e.g. Hazel 2009).

While no speed limit has been determined at which the risk of boat strike can be considered minimal, published studies indicate that the risk of collision significantly reduces at speeds less than 10 knots (e.g. Hazel *et al*. 2007). In some parts of Queensland, the reduced risk of boat strike from low vessel speeds has been formalised into management arrangements through marine park zoning plans. For example, in sections of the Moreton Bay and Great Sandy Marine Parks, some important turtle foraging areas which coincide with high volumes of vessel traffic have been gazetted as Turtle and Dugong Go Slow Areas to reduce the risk of boat strike. Within these Go Slow Areas, vessels must be operated 'off the plane', effectively reducing their speed to below 10 knots for most vessel designs.

Prior to construction of the LNG facilities, there were already a number of recreational and commercial vessel movements within, and to and from Port Curtis. A temporary increase in vessel traffic in Port Curtis and, in particular, within the vicinity of the LNG facilities can be expected during construction activities. APLNG estimated that there will be 140 additional ferry journeys per month and 70 additional barge journeys per month at the peak of its construction activities (APLNG 2010a).

Depending on the project, this construction phase will cease between 2014 and 2016. GLNG estimated that approximately 45 additional ferry and 45 to 90 barge trips would be required per month during construction, depending upon the timing and nature of works being undertaken (GLNG 2009a). These numbers represent a significant increase on background commercial vessel movements transiting Gladstone Harbour, which comprised 1,417 cargo vessels in 2008 (APLNG 2010a). As the vast majority of the projects' workforce is fly in fly out, it is unlikely that recreational vessel use will increase significantly in the Gladstone region as a result of the LNG facilities.

The number of cargo ships servicing the LNG facilities during operational phases of the project will be relatively low, with GLNG estimating four (4) ships a month during early stages, increasing to 13 ships a month as production increases (GLNG 2009a). A small number of ferry journeys will also be required to transport staff to the LNG facilities from the mainland during operational phases. For example, GLNG estimated approximately four (4) ferry trips per day would be required for its LNG facility (GLNG 2009a). Such increases in the intensity of vessel traffic above those existing before the LNG projects began have the potential to increase the rate of boat strike on marine turtles. Ferries probably represent the greatest boat strike risk, as they travel at relatively fast speeds (often in excess of 20 knots), when compared with barges, and with cargo ships on their approach to docking facilities. Vessel routes used intensively by ferries have the potential to become boat strike 'hot spots' under some circumstances, as described by Yeates and Limpus (2002) for dugong in southern Moreton Bay. Go Slow areas have been established in shallow waters (< 5 metres) surrounding the LNG facilities with maximum speed limits of six knots imposed.

The main seagrass habitats occur approximately 3 km west of the LNG facilities, with some small patches of seagrass located immediately adjacent to the LNG facilities along the western coast of Curtis Island. Small patches of *Zostera* and *Halophila* occur approximately 600 m west of Curtis Island along a network of sand banks and adjacent to a small mangrove island (*Figure 3*). These small patches are located within the direct approach to the LNG facilities, in locations where vessel speed will be reduced as part of the vessel management procedures during construction phases of the projects (QGC 2011). In this context, seagrass foraging areas immediately surrounding the LNG facilities, while present, are of relatively low quality and are unlikely to host dense populations of marine turtles.

Existing mitigation measures in place for the LNG projects include speed limits on project construction-related vessels (< 6 knots in waters less than 5 m in depth). APLNG have also constructed a purpose-built facility at Fishermans Landing Northern Expansion (FLNE) which has reduced marine transport distances for ferry and barge transport significantly from approximately 10 km to 3 km and therefore associated boat strike risks.

During operational phases of the projects, a relative increase in shipping activities adjacent to the LNG facilities within Port Curtis and within the broader Great Barrier Reef Marine Park and lagoon also have the potential to impact on turtles through boat strike. The risk of such impacts are considered less than those associated with ferries, as most of the shipping routes are located within relatively deep waters and ships operate at slower speeds than ferries. During operational phases of the project, ferries will remain in use, but at much lower frequencies than during construction.

3.1.2 Lighting

There are numerous studies on the effects of lighting on the disorientation of both nesting and emerging hatchling turtles (Bertolotti and Salmon 2005, Lohmann *et al*. 1997, Pendoley 2005, Salmon 2003, Salmon 2006). Lighting includes the general glow produced by artificial lights within towns and on large structures, which can be seen as a glow on the horizon, or lights that shine directly on a beach or the adjacent water. For both forms of lighting, problems for marine turtles arise where the nesting adult turtle or dispersing hatchling becomes disorientated. This is caused by a disruption of navigational cues such as the moon and other celestial bodies, which requires a minimisation of other 'background' lights, used in "sea finding" (to direct the turtle up the beach for nest digging and egg laying, or down the beach into the ocean and towards the open ocean for dispersing hatchlings). The result of artificial lighting can be a reduced breeding success in adults and increased hatchling mortality (Salmon 2006).

Where artificial lighting is present, turtles are found to navigate away from the moon (e.g. a full moon is approximately 1 lux) and towards the brighter non-natural light (e.g. a residential street lamp is 1-10 lux and a night sports ground 200-1000 lux; Pendoley 2005). Studies have suggested that artificial light at wavelengths less than 530-570 nm repels loggerhead turtles coming ashore to nest. Filters designed to cover artificial lights are opaque to these shorter wavelengths and only emit longer-wavelength light, significantly reducing the impact of the light (Salmon 2006). Low pressure sodium lights and the use of directional shrouds can also be effective at minimising the impacts of lights on turtles (Salmon 2006).

In adults, disturbance from lighting manifests in several forms. Nesting females may fail to locate the beach (shy away from landing) or fail to successfully dig a nest (land but abort the nesting ritual; Salmon 2003). If nesting is successful under these circumstances, nests tend to be dug in shaded sections of the beach. In places where industry or tourism is mixing with turtle nesting, large structures such as buildings have been shown to offer areas of shade for nesting. The result is nests that aggregate within the lighting lee side of the beach, causing higher nesting densities and nest site competition as nests are dug over one another. This reduces the overall number of hatchlings that successfully emerge.

In hatchlings, lighting disorientation can have fatal outcomes. Hatchling mortality occurs when emerged turtles do not disperse into the ocean, but rather desiccate from failure to reach the water or through predation from foxes and birds, caused by turtle aggregation under lights (Salmon 2006). A common example is hatchlings emerging from their nests moving over sand dunes up the beach and towards nearby lit roads where they are run over by cars or dehydrate when they get caught in man-made obstacles. This is in contrast to the natural behaviour of moving down the beach and entering the water, guided by the moon and its reflection on the water.

The Gladstone region is likely to be increasingly subject to the above identified negative lighting effects due to development and population expansion, with increasing industrial activity likely to exacerbate these effects if suitable control mechanisms are not implemented. Hodge *et al.* (2006) suggested from their analysis of nesting tracks that the sky glow from Gladstone and direct lighting up to 18 km away was influencing the nesting behaviour of flatback turtles on the minor nesting beach of Hummock Hill Island. Further, they identified lights from ships at anchor were contributing to disorientation (Hodge *et al*. 2006).

Although nesting on Curtis, Hummock Hill and Facing Islands occurs on the eastern beaches, protected from direct lighting on the mainland and the industrial areas a few kilometres to the west, sky glow and lights at sea may, depending on climatic conditions and moon phases, add to the overall luminance of the local region and have negative impacts on nesting turtles and emerging hatchlings. With the development of LNG facilities, additional considerations include disorientation caused by lights from intermittent gas flaring, long jetties with ships at berth, and ships at anchor or in transit out to sea.

Intermittent gas flaring is predicted to be as little as a few hours every few months (GLNG 2009a), but operational needs may increase this frequency. Ships, navigation beacons and jetties must be lit at night for navigational safety but bring potential risks of nesting failure and hatchlings attracted to the direct light sources, along with potential aquatic predators. Such impacts are likely to be manifested as a function of the number of ships in the region and whether they are anchored at sea for prolonged periods or are present for only short periods when in transit. Existing mitigation measures also include locating flares as low as practicable to the ground, and in the case of APLNG, actually on the ground through use of a ground flare.

3.1.3 Dredging and Piling

The establishment of new LNG facilities on Curtis Island requires significant capital dredging with ongoing maintenance dredging also likely to be necessary in the future. The WICET project which is currently under development in Gladstone Harbour also has extensive dredging. All dredging associated with construction of the LNG facilities is being completed by the GPC as part of the Western Basin Dredging and Disposal Project, which has been the subject of extensive environmental impact assessment and has been granted separate approvals and environmental management conditions. In this context, dredging is technically outside of the scope of this management plan.

However, the activity of dredging has been considered in this management plan for completeness and to provide a conservative approach to the management of cumulative risks. Such an approach is also consistent with the long-term nature of the management plan and the possible need for maintenance dredging to be carried out within the life of the plan. The description of dredging activities and mitigation strategies within this LTTMP are therefore what the LNG proponents understand to be proposed by GPC.

Dredging is to be conducted using a cutter suction dredge (which uses a rotating cutter head to loosen sediments on the sea floor before they are sucked up by the suction inlet using centrifugal pumps) and a trailer suction hopper dredge. The primary risk to turtles during dredging works is an interaction between the dredging equipment (cutter head or suction inlet) and a turtle. This may result in death or injury to the turtle, although results of the DEHP marine animal stranding program suggest that few turtles are killed by dredge vessels in Queensland each year (Biddle and Limpus 2011). The underwater noise generated during dredging is generally 5 db above background shipping noise and therefore represents a low risk to turtles (GLNG 2009a).

The noise exposure criteria for a variety of marine animals are described by Southall *et al*. (2007), although none exist for marine turtle. This is because there is little known of the levels of acoustic energy that may harm the auditory function of marine turtles, which have an external ear drum (APLNG 2010a). The auditory range of marine turtles is significantly less than marine mammals such as dolphins and dugong with estimates for turtles in the range of 50 Hz to 1000 Hz (Lenhardt *et al.* 1983; Ketten and Bartol 2005). In the absence of specific noise criteria for marine turtles, the criteria for marine mammals are generally applied and are extremely conservative as turtle hearing is much less sensitive than marine mammals. In this context, the noise associated with piling is anticipated to have only minor impacts on marine turtles by causing temporary disturbance and changes in behaviour. Sound pressure levels produced underwater during construction and operation are not expected to have any long-term detrimental effects (GLNG 2009a).

Seagrass habitats in the vicinity (within 1 km) of the LNG facilities are small and patchy and generally disconnected from larger habitats further west. They are therefore likely to provide general foraging habitat for green turtles in low numbers, with other turtle species likely to be present in the area only occasionally. Some small areas of seagrass will be destroyed as a result of the capital dredging works.

Modelling studies undertaken during the EIS stage indicate that turbidity plumes generated by dredging are expected to return to background levels within 500 m of the source point in the vicinity of the LNG facilities. Suspended sediment threshold limits will be set at nearby sensitive receptors, with dredging halted in the event that trigger levels are exceeded (e.g. GLNG 2009a). The cumulative effects of dredging activities, when considered in the context of other works occurring within Port Curtis, are discussed in Section 3.1.4.

3.1.4 Indirect Disturbance and Effects on Turtle Health

Indirect disturbances to the environment can have a significant impact on turtle health (Aguirre and Lutz 2004). Water quality parameters including salinity, turbidity, acidity and nutrient load play a significant role in the health of all aquatic animals (Noga 2009). In Port Curtis, a number of water quality monitoring programs are operating (DEHP 2012b). In conjunction with seagrass health studies, these data have been used to estimate the environmental health of the region (EHMP 2006). Further, there are several key investigations that show a direct link between environmental health parameters such as nutrient flow causing algal blooms and adverse effects on the health of sea turtles (Arthur 2006, Arthur *et al*. 2008). Consequently, marine turtles can be exposed to environmental stressors that cause immunosuppression and subclinical diseases that decrease their ability to fend off otherwise innocuous pathogens (Flint *et al*. 2010, Work *et al*. 2003). These cumulative stressors can cause poor health (“non-lethal impacts”) among a population of turtles, without directly causing death.

With capital and maintenance dredging adjacent to Curtis Island, temporary changes in water quality are unlikely to directly cause mortality in turtle populations of the Gladstone region if the approved mitigation and management plans are followed. There is also a low potential for increased turbidity, sedimentation of silts and development of anoxic sediments to impact on seagrass habitats, with the approved mitigation and management plans being implemented.

However, if combined with other chronic environmental disturbances, the potential increases for a high proportion of individuals within a turtle population to be affected by sub-clinically illness. While under physiological stress, random events such as contaminant spills, algal blooms or flooding, as was seen in this region in 2011, have the potential to cause disease which may result in increased mortality in the turtle populations of the Gladstone region (e.g. DEHP 2012c; Limpus *et al*. 2012). The first stages of this epidemiological phenomenon, in the form of chronically emaciated turtles, were seen after the 2011 flood event (Eden *et al*. 2011). The current health status of the sea turtles utilising the Gladstone region is unknown.

3.2 Risk Assessment

A risk assessment of each of the potential impacts on marine turtles has been completed to identify the hazards associated with each activity, and their likelihood and consequence, in the context of the marine turtle populations of the Gladstone region. The risk assessment approach adopted within this LTTMP has been modified from the Great Barrier Reef Marine Park Authority Environmental Assessment and Management (EAM) Risk Management Framework (GBRMPA 2009), which involves assessing risk both before and after the implementation of mitigation actions. The criteria used to determine the likelihood (of an impact occurring to marine turtle populations) and consequence (for marine turtle populations) of each potential impact are described in *Table 3*.

Risks have been assessed in four broad categories as follows:

- Boat strike;
- Dredging and piling;
- Lighting, and
- General indirect impacts.

Table 3: Risk Assessment Matrix

To determine the likelihood and consequence of an impact on marine turtles or their habitat, adapted from the Great Barrier Reef Marine Park Authority Environmental Assessment and Management Risk Assessment Framework (GBRMPA 2009).

	Consequence Rating				
Likelihood (probability of occurring)	Insignificant – little to no impact on the overall ecosystem. Very small levels of impact on turtles and their habitats. Only occasional injury to or mortality of turtles.	Minor – Impacts are present, but not to the extent that the overall condition of turtle populations or their habitats are impaired in the long term. Low levels of mortality of turtles and their habitats. Recovery would generally be measured in years for habitats.	Moderate – Turtle populations and their habitats are significantly affected, either through elevated mortality of turtles or a minor disruption to a population over a widespread geographic area. Recovery at habitat level would take at least a decade, with recovery of turtle populations taking several decades.	Major – Significant impact on sea turtle populations and their habitats, with high levels of turtle mortality. Recovery of habitats would take a few decades, with turtle populations taking several decades.	Catastrophic – Turtle habitats irretrievably compromised. Mass mortality of sea turtles and/local extinction of species. Recovery over several decades for habitat values and centuries for turtle populations.
Almost Certain (95-100%)	Medium	Medium	High	Extreme	Extreme
Likely (71-95%)	Medium	Medium	High	High	Extreme
Possible (31-70%)	Low	Medium	High	High	Extreme
Unlikely (5-30%)	Low	Low	Medium	Medium	High
Rare (0-5%)	Low	Low	Medium	Medium	Medium

Results of the risk assessments are presented in the following sections, identifying inherent (unmitigated) risk and the residual risks to sea turtle populations and their habitats following the implementation of mitigation and management strategies which have already been committed to by the LNG proponents in their EIS documentation, approval conditions or environmental management plans. Risks have been assessed by considering the likelihood of an impact occurring on a sea turtle population or its habitat, rather than the risk of a single incident occurring. The consequence rating is based upon the most probable consequence for sea turtle populations and their habitats given the nature of the activity.

All inherent risks were assessed as either Low, Medium or High prior to the consideration of existing mitigation and management strategies to reduce risk. This indicates that without appropriate mitigation strategies, some aspects of the construction and operation of LNG facilities on Curtis Island have the potential to cause significant impact to marine turtle populations and their habitats. However, once the implementation of existing management commitments to mitigate risks were also considered and assessed, the residual risk was reduced to Low or Medium ratings across all activities. This indicates that activities with the potential to impact on marine turtle populations are well controlled under existing approval conditions and commitments made in environmental management documentation.

The mitigation actions described in the following tables are summaries of the general commitments made by the three proponents when considered collectively for the purposes of a joint LTTMP. Specific, approved mitigation measures vary slightly among LNG proponents and can be found in relevant EIS and approval documentation for each proponent. Such specific measures have been approved and are being implemented where relevant to each project, not unilaterally across all projects.

3.2.1 Boat Strike

Risks to turtles from boat strike are assessed to be highest during construction phases of the projects, due to the large number of vessels in place to support works and the transportation of construction staff to and from Curtis Island (*Table 4*). Ferries generate the highest risk of boat strike due to their high speed and frequency of operation, when compared with barges and cargo ships. However, such impacts are well managed through the implementation of reduced speed limits imposed by Maritime Safety Queensland for safety reasons and by the LNG proponents to protect marine wildlife. During operations, the number of ferry and barge vessels decreases significantly from periods of construction, reducing the risks from boat strike accordingly. In the Great Barrier Reef lagoon, risks from LNG ships are lower than when inside Port Curtis, due to the increased water depth at sea.

Table 4: Risk Assessment Table Considering the Likelihood and Consequence of Boat Strikes Impacting on Marine Turtles Arising from Development and Operation of the LNG Facilities

Activity with Potential to Cause Harm	Hazard	Factors Important in Determining Risk	Potential Impact(s) and Consequences to Sea Turtle	Likelihood (Population)	Consequences (Population)	Inherent Risk	Approved Mitigation and Management (Already Being Implemented)	Likelihood (Population)	Consequences (Population)	Residual Risk
Increased vessel activity during construction of LNG facilities	Collision between ferry or barge and marine turtles	Vessel speed, location of turtle habitat in relation to vessel routes. Nutritionally-compromised turtles may be more prone to boat strike than healthy turtles.	**Potential Impacts:** Increased incidence of collision between turtles and ferries, barges and construction support vessels Turtles may be deterred from foraging in the areas of seagrass adjacent to the LNG facilities due to the constant presence of vessels. As turtles have a high degree of site fidelity, the net effect of increased vessel activity may be a reduction in the foraging area or continued foraging throughout the home range, with an increased risk of boat strike **Potential consequences:** Death or injury from boat strike (blunt trauma from hull or propeller cuts) Increased effort required by turtles to source high quality food in areas away from disturbance Reduced foraging habitat utilised within the home range	Possible	Moderate	High	Vessels operating in waters shallower than 5 m (Go Slow Wildlife Zones) will travel at a maximum speed of six knots. Areas of Go Slow operations are in place and will be regularly reviewed based on changing depth conditions. Barge speeds are typically less than 10 knots. Some ferries designed to reduce the risk of boat strike through use of jet propulsion and improved hull design. Training requirement for workforce regarding risk of marine megafauna to avoid interactions with those species. Maritime Safety Queensland requirements for reduced vessel speeds near craning operations and wharves. A vessel must not approach a turtle within 50 m whilst underway or 150 m if moving faster than planing speed. If a turtle approaches an underway vessel closer than 50 m, the master must put their gears in neutral and move away when safe at a speed of no more than 4 knots. Relatively short marine transport distance from the mainland to Curtis Island Procedures for visual monitoring and reporting of turtles.	Unlikely	Moderate	Medium
Boat strike from shipping activities and ferries in Port Curtis during operations	Collision between LNG cargo ship and marine turtles or ferry and marine turtles	Ship speed, number of ships using accessing LNG facilities, abundance of turtles around shipping routes, depth of channel, number of ferries operating post-construction.	**Potential Impacts:** Increased incidence of boat strike from LNG cargo ships transiting through Port Curtis to or from the LNG facilities. Turtles may be deterred from foraging in the areas of seagrass adjacent to the Port Curtis shipping channels due to the additional presence of LNG cargo ships. As turtles have a high degree of site fidelity, the net effect of increased vessel activity may be a reduction in the foraging area or continued foraging throughout the home range, with an increased risk of boat strike Increased incidence of collision between turtles and ferries during operations **Potential consequences:** Death or injury from propeller strike Displacement of turtles from foraging areas. Reduced foraging habitat utilised within the home range	Unlikely	Moderate	Medium	All vessels will utilise predefined and regular routes and will only alter this route for marine safety reasons. Establish procedures for visual monitoring and reporting of turtles. Some dedicated navigation channels for LNG carriers, where practical. Controlled vessel speeds within the Port of Gladstone. Training requirement for workforce regarding risk of marine megafauna to avoid interactions with those species.	Rare	Minor	Low
Boat strike from shipping activities in Great Barrier Reef Marine Park and lagoon	Collision between LNG cargo ship and marine turtles	Ship speed, abundance of turtles along oceanic shipping routes, proximity of shipping routes to key reef habitats, migratory pathways and nesting beaches.	**Potential Impacts:** Increased incidence of boat strike from LNG cargo ships transiting through the Great Barrier Reef Marine Park and lagoon. Displacement of turtles from sections of their offshore reef habitat to adjacent areas. Disruption of migratory pathways and routes. **Potential consequences:** Death or injury from propeller or hull strike Reduced access to nesting sites. Disrupted mating behaviour Displacement of turtles from key habitat areas.	Unlikely	Minor	Low	Vessels utilise predefined shipping routes and will only alter this route for marine safety reasons.	Unlikely	Minor	Low

3.2.2 Lighting

Lighting risks are associated with LNG facilities' contribution to the overall sky glow, as there is no direct line of sight from any of the three LNG facilities to any turtle nesting beach (*Table 5*). Lighting risks are well managed through the use of technology, and include use of low pressure sodium lights, screening, directional lighting and timer switches. Low pressure sodium lights minimise the light frequencies which are disruptive to turtles. While the effectiveness of low pressure sodium lights varies among turtle species, they are recognised as an important management tool in minimising impacts of lighting on nesting beaches (Salm *et al*. 2000; Salmon 2006). Flaring is expected to be infrequent and for some types of flaring, the timing of flaring can be controlled to occur during the day or at night outside of periods of turtle nesting and hatching activity. LNG ships will comprise up to 14% of the ships utilising the Port of Gladstone at full production, and will generally navigate straight into port upon arrival in Gladstone, avoiding the need to anchor offshore. This significantly minimises the potential impacts of lighting from ships while at sea on marine turtles.

Table 5: Risk Assessment Table Considering the Likelihood and Consequence of Artificial Lighting Impacting on Marine Turtles Arising from Development and Operation of the LNG Facilities

Activity with Potential to Cause Harm	Hazard	Factors Important in Determining Risk	Potential Impact(s) and Consequences to Sea Turtle	Likelihood (Population)	Consequences (Population)	Inherent Risk	Approved Mitigation and Management (Already Being Implemented)	Likelihood (Population)	Consequences (Population)	Residual Risk
Sky glow from LNG facilities during construction and operations.	Increase in the existing sky glow of the Gladstone Region when viewed from turtle nesting beaches	Design, height, orientation and shading of lighting. Frequency, duration and timing of gas flaring. Height of natural barriers between light sources and nesting beaches.	**Potential Impacts:** Repulsion of females from nesting sites Females staying offshore away from nesting beaches Disorientation of nesting female turtles when in the water or on the beach Disorientation of turtle hatchlings emerging from their nests Suppression of natural cues for hatchlings and nesting females Disruption of offshore dispersal by hatchlings **Potential Consequences:** Reduced nesting attempts and nesting success Nesting attempts occur at non-nesting beaches, leading to reduced success Increased mortality of emerging hatchlings from predation as a result of increased lighting and visibility of hatchlings to predators Increased mortality of emerging hatchlings due to predation due to hatchling s moving towards unnatural light sources away from the sea Increased mortality of emerging hatchlings due to desiccation or injury from a failure to reach the water in a short amount of time. Increased mortality of dispersing hatchlings due to predation as they are attracted to inshore habitats by light pollution	Possible	Moderate	High	Use low pressure sodium lights to reduce contribution to night time glow. Use of motion detecting sensors and light timers to reduce contribution to night time glow. All LNG sites are well screened by Curtis Island topography. Restricting the height of lights and applying shrouds to downcast the lights and control their direction. Reducing the amount of reflective surfaces where practical, to reduce contribution to night time glow. Flares are located as low as practicable to the ground and in accordance with approval conditions. Lighting at LNG facilities to be as low as reasonably practical and in accordance with existing approval conditions. APLNG has a ground flare.	Unlikely	Moderate	Medium
Light from LNG ships operating offshore from nesting beaches. Light from navigation aids established to assist LNG ships navigate at night.	Creation of new artificial light sources when viewed from turtle nesting beaches and adjacent waters.	Design, height, intensity, orientation and shading of lighting on LNG cargo ships and on new navigation aids. Duration of stay for LNG vessels anchored offshore awaiting their opportunity to load. Location of shipping route and anchorages in relation to turtle nesting areas and adjacent turtle habitats. Location of lighting on jetties or new navigation beacons leading offshore.	**Potential Impacts** Gravid female turtles stay away from nesting beaches Disorientation of nesting female turtles when in the water or on the beach Disorientation of turtle hatchlings emerging from their nests Suppression of natural cues for hatchlings and nesting females **Potential Consequences** Reduced nesting attempts and nesting success. Nesting attempts on non-nesting beaches Increased mortality of emerging hatchlings due to predation by increased lighting and visibility of hatchlings to predators Increased mortality of emerging hatchlings due to predation due to hatchling s moving towards unnatural light sources away from the sea. Suppression of natural cues for hatchlings and nesting females Increased predator presence around lit navigation aids and anchored ships where hatchlings may congregate.	Possible	Moderate	High	Level of shipping activity to be small on an operational basis (up to 14% of total ships through the Port of Gladstone at full production). LNG ships will generally move straight into port, avoiding anchoring offshore. Lights and navigation beacons are required for navigational safety.	Unlikely	Moderate	Medium

3.2.3 Dredging and Piling

Dredging and piling risks are well managed by existing controls and are at their highest during construction, much of which is currently well underway or completed (*Table 6*). Detailed environmental management plans are in place to manage the environmental impacts of dredging and piling activities.

Table 6: Risk Assessment Table Considering the Likelihood and Consequence of Dredging and Piling Impacting on Marine Turtles Arising from Development and Operation of the LNG Facilities

Activity With Potential to Cause Harm	Hazard	Factors Important in Determining Risk	Potential Impact(s) and Consequences to Sea Turtle	Likelihood (Population)	Consequences (Population)	Inherent Risk	Approved Mitigation and Management (Already Being Implemented)	Likelihood (Population)	Consequences (Population)	Residual Risk
Capital and maintenance dredging of berth areas and immediate approach channels using a cutter suction dredge or trailer suction hopper dredge.	Dredge head operating in close proximity to foraging turtles. Habitat loss through direct disturbance to seagrass. Habitat loss through a temporary increase in light attenuation and smothering of seagrass foraging areas. Increased levels of underwater noise from dredging plant. Increased turbidity causing a decline in water quality.	Location of dredging in relation to turtle habitats. Type of dredging equipment used. Sediment characteristics and dredging methods used to minimise impacts on water quality.	**Potential Impacts:** Interaction between turtle and dredge head (cutter suction dredge). Temporary loss of seagrass biomass, diversity and nutritional quality for foraging turtles. Avoidance behaviour from turtles to avoid underwater noise associated with dredging. Avoidance behaviour from turtles to avoid areas of poor water quality. Disruption to the behaviour of turtles engaging in mating or nesting throughout the Gladstone Region. **Potential impacts:** Death or significant injury resulting from interaction with dredge head. Turtles move elsewhere to seek foraging habitat or forage on seagrass beds of a poor nutritional quality. Health effects from poor nutritional quality of seagrass. Turtle moves outside of its home range and is displaced from foraging habitats. Reduced reproductive success for marine turtles in the area.	Unlikely	Moderate	Medium	Where trailer suction dredging is carried out, during times when the drag head is not in contact with the seabed, and pumps are in operation, pump speed shall be reduced and drag head water jets must be activated to minimise the risk of turtle capture. Trailer suction hopper dredge vessel fitted with turtle exclusion device. Before beginning dumping activities, the Dredge Contractor must check, using binoculars from a high observation platform on the vessel, for cetaceans, turtles and dugongs within the monitoring zone (300 m). If individuals of marine species specified above are sighted in the monitoring zone, dredging and dumping activities must not occur in the monitoring zone until 20 minutes after the last marine species is observed to leave the monitoring zone or the dredge is to move to another area of the dredge/disposal site to maintain a minimum distance of 300 m between the vessel and any turtle. Halt dredging if water quality guidelines at sensitive environmental receptors are exceeded.	Rare	Minor	Low
Installation of piles into the seabed during construction of the berth facilities	Creation of underwater noise in pulses due to piling. General disturbance to the seabed, and construction activity in areas where turtles may be found. Creation of new turtle habitat (piles and rock walls) to which turtles may be attracted.	Proximity of turtle foraging habitat to piling activity. Number and type of piles to be driven. Substrate into which piles are to be driven (rock substrates may create higher levels of noise) Sensitivity of turtles to underwater noise pulses. Duration and methods employed for piling. Significance of avoidance behaviour in turtle ecology. Timing of piling activity, in relation to the visibility of marine fauna (daylight hours).	**Potential impacts:** Exposure to underwater noise above relevant guideline levels for marine fauna if in close proximity to piling activity. Startle response at the commencement of piling. Avoidance of turtle foraging habitat over a prolonged period due to constant disturbance and underwater noise. **Potential consequences:** Temporary loss of hearing sensitivity as a result of underwater noise pulses above guideline levels. Permanent auditory tissue damage as a result of underwater noise pulses above guideline levels. Injury arising from a collision caused by startle response at the commencement of piling. Disturbance of natural behaviour. Turtle moves outside home range and is displaced from foraging habitats. Reduced reproductive success for marine turtles in the area.	Possible	Minor	Medium	Minimise the extent of new works through the detailed design process. Soft start piling procedure, whereby piling is increased gradually for 15 minutes. Pre-start observations for turtles, using marine fauna observers, with a 500 m radius marine turtle observation zone established. Use of pile cap cushions to reduce the intensity of underwater noise generated. Halt piling if turtle is seen by turtle observer within a defined exclusion zone Noise monitoring will be completed during piling and if noise is measured above recommended guidelines for protection of marine fauna, then pile casings or bubble curtains will be implemented to keep noise levels below guideline values. EIS studies completed have guided the development of management plans for piling and indicate that noise levels are highly unlikely to reach the levels required to cause permanent auditory tissue damage to marine turtles. Marine piling only to be conducted during daylight hours. The vast majority of piling has already been completed.	Unlikely	Minor	Low

3.2.4 Indirect disturbance and effects on turtle health

Indirect impacts include the effects of the LNG facilities on top of those impacts already existing within Port Curtis from other industrial activities. In such circumstances, the ecosystem resilience may be lacking and it is therefore beneficial to consider the risks in a cumulative sense. Risks in this category are perhaps the most difficult to control and predict, yet among the most likely to eventuate at some level, due to their association with broader environmental health, rather than tangible aspects under the direct control of construction teams. Mitigation of the risks associated with indirect impacts is best achieved by implementing coordinated management actions across a variety of habitats (*Table 7*).

Table 7: Risk Assessment Table Considering the Likelihood and Consequence of Indirect Disturbance on Marine Turtle Health Arising from Development and Operation of the LNG Facilities

Activity With Potential to Cause Harm	Hazard	Factors Important in Determining Risk	Potential Impact(s) and Consequences to Sea Turtle	Likelihood (Population)	Consequences (Population)	Inherent Risk	Approved Mitigation and Management (Already Being Implemented)	Likelihood (Population)	Consequences (Population)	Residual Risk
Dredging and increased shipping activities	A general decline in water quality caused by dredging and increased shipping activities. Changes in the community composition of seagrass habitats. Introduction of invasive species from ballast water and hulls of vessels	Duration of dredging activities and the consequent potential for impacts to manifest. The location of shipping activities in relation to key turtle habitats Disposal arrangements for dredged material and their impact on water quality and general environmental health. Tidal flow and velocity Timeframes between dredging campaigns to allow recovery of seagrass species Legal restrictions for displacement of ballast waters. Risk assessment procedures for use of foreign vessels in operations and construction activities (e.g. dredging barges from other regions).	**Potential Impacts:** Loss of the low value foraging grounds for resident turtles located immediately adjacent to the LNG facilities and disturbance of foraging areas offshore from anchoring. Decline in seagrass growth rates and nutritional value. Competition for existing invertebrate species comprising diet of loggerhead, hawksbill and flatback turtles. **Consequences:** Movement of turtle species to seek different food sources Increase in the incidence of disease in resident turtles Reduced survivorship, reproductive output and reproductive success	Possible	Major	High	LNG ships to generally avoid offshore anchoring by steaming directly to the LNG jetty for loading. Use of approved environmental management plans to manage the impacts of dredging and the disposal of dredged material. Dynamic response to activities based on monitoring program, which shows recovery of seagrass following floods in 2011. Halt dredging if Photosynthetic Active Radiation (PAR) triggers are exceeded at sensitive environmental receptors. Monitoring of seagrass impacts by LNG proponents and independent bodies.	Unlikely	Moderate	Medium
Changes in underwater topography as a result of disturbance from dredging.	Increased sedimentation in areas that have been dredged. Alteration of natural habitat through construction	Direction and velocity of tidal flow. Depth of dredging and presence of residual toxins or contaminants. Ecological characteristics of marine fauna in relation to withstanding disturbance and re-establishing. Value of existing habitat to be disturbed pre-construction.	**Potential Impacts:** Reduction in seagrass habitat Increase in contaminant loads residual within seagrass Loss of invertebrate habitat Creation of new artificial habitats which may attract turtles. **Consequences:** Migration of turtle species to seek different food sources Increase in the incidence of disease in resident turtles Toxin or contaminant-associated mortality and morbidity	Possible	Moderate	High	Post-dredging monitoring to be completed to determine effectiveness of management controls. Environmental auditing to ensure compliance with approval conditions.	Unlikely	Moderate	Medium

Activity With Potential to Cause Harm	Hazard	Factors Important in Determining Risk	Potential Impact(s) and Consequences to Sea Turtle	Likelihood (Population)	Consequences (Population)	Inherent Risk	Approved Mitigation and Management (Already Being Implemented)	Likelihood (Population)	Consequences (Population)	Residual Risk
Increasing industrial activity	Decline in turtle health correlated with general decline in environmental health Spillages from site or vessels	Background turtle disease prevalence in Gladstone region. Health of resident and transient turtle populations Presence of opportunistic diseases Degree of environmental disturbance Type of hydrocarbon liquids or chemicals stored. Safety zone for loading vessels to dock to nesting beach Tidal flow and velocity	**Potential Impacts:** Increased mortality and morbidity of turtles Contamination of feeding grounds Contamination of nests **Consequences:** Increased prevalence of current diseases and emergence of new diseases in all turtle species. Disease outbreaks causing population-wide mortality. Reduced population resilience to catastrophic events such as floods. Loss and/or toxicoses of seagrass habitats Nest failure/ toxicoses	Likely	Moderate	High	Implementation of detailed environmental management plans for all aspects of the developments, including: Weekly inspections of designated storage areas for all chemicals with spill clean-up kits. Implement Stormwater management plans Environmental auditing to ensure compliance with approval conditions.	Possible	Minor	Medium
Increased human presence in region as a result of population increases from LNG facility workforce.	Increased human disturbances on and around turtle nesting beaches and other habitats.	Level of access to nesting beaches and surrounds. Level of active management for nesting beaches.	**Potential Impacts:** Disturbance of turtles causing failure to nest Predation of nests by feral pests **Consequences:** Decrease in successful nesting Decreased hatching success	Possible	Minor	Medium	Fund feral animal pest control on Curtis Island in accordance with the Curtis Island Environmental Precinct Land Management Plan 2010, prepared by the Department of Infrastructure and Planning (DIP 2010). Entry into the Environmental Management Precinct of Curtis Island prohibited for staff and contractors while on shift. No pets are allowed to be brought to the island. Pest management activities on site to reduce pest numbers. Human interaction with native fauna is minimised.	Possible	Minor	Medium

3.3 Discussion of Risk Assessment Outcomes

The management actions established prior to development of this LTTMP by LNG proponents for the construction and operation of the LNG facilities have been assessed to have significantly reduced the risk of relevant activities on marine turtles and their habitats. Residual risk levels, following the consideration of existing mitigation actions, have been assessed as either Low or Medium across the range of activities relevant to marine turtle impacts, with risks reduced to levels as low as reasonably practical.

Activities for which the risk is Medium and therefore higher than the lowest possible rating of Low are as follows:

- A short-term increase in vessel activity during construction of LNG facilities;
- An increase in the existing sky glow in the Gladstone region from construction and operation of the LNG facilities when viewed from turtle nesting beaches;
- Lights on LNG cargo ships operating offshore and on new navigational aids adjacent to non-nesting beaches in the Port of Gladstone, located in the direct line of sight to turtle nesting beaches, and
- Changes in the topography, environmental health and water quality of the marine environment arising from increased industrial development, including dredging, shipping and higher human presence.

Generally, these activities are salient components of the new developments and mitigation actions can only be implemented to a certain extent without compromising safety or operational viability. Additionally, the construction-related impacts relating to vessel activity and sky glow can be expected to reduce significantly from late 2013, as the LNG projects start to move to operational phases.

There is potential for some impacts to be cumulative, due to their spatial proximity or compounding effects on certain marine turtle life cycle stages. An assessment of the potential for risks to be cumulative on the various life cycle stages of marine turtles is provided in *Table 8*, based upon the location of the life cycle stages in relation to the risks assessed in *Table 4* to *Table 7*. The assessment suggests that juvenile (coastal stage) and foraging sub-adult and adult turtles living within the Gladstone region have the greatest chance of being exposed to cumulative impacts associated with the LNG projects. This is because they are likely to spend most of their life cycle stage within Port Curtis, where the risk of boat strike and indirect impacts arising from project activities are predicted to be highest. It is therefore important that monitoring activities (such as foraging surveys) target these cohort stages and in particular the risks associated with boat strike and indirect project impacts (see *Section 5*).

Table 8: Assessment of the potential for cumulative impacts for each marine turtle life cycle stage, based upon the risk of boat strike, lighting, dredging and piling, and indirect project impacts

Life Cycle Stage	Boat Strike	Lighting	Dredging and Piling	Indirect Impacts	Potential for Cumulative Impacts*
Egg	Low	Low	Low	Medium	Low
Hatchling	Low	Medium	Low	Low	Low
Juvenile (pelagic stage)	Low	Low	Low	Low	Low
Juvenile (coastal stage)	Medium	Low	Low	Medium	Medium
Foraging Sub-adult or Adult	Medium	Low	Low	Medium	Medium
Nesting Female	Low	Medium	Low	Low	Low
Migratory Male (mating)	Medium	Low	Low	Low	Low
Inter-nesting female	Medium	Low	Low	Low	Low

* Low – 1 risk assessed Medium or higher. Medium – 2 risks assessed Medium or higher. High – 3+ risks assessed Medium or higher.

4.0 MANAGEMENT AND MITIGATION STRATEGIES

This section describes and evaluates the adequacy of existing mitigation actions in reducing the risks to marine turtles, while evaluating the costs and benefits of additional (new) mitigation strategies. In mitigating the risks of environmental impacts, a balance is generally sought between investment in management actions and the associated environmental benefits of such investments. While investment in mitigation actions can theoretically continue indefinitely, the benefits of such actions to the environment can be expected to reach a peak at some point, after which further investment will lead to little or no additional reduction in the overall risk of an environmental impact. For example, modifications to the design to a vessel to reduce the risk of boat strike can be made to a point, beyond which the loss of functionality may be considered unsafe or impractical for the effective navigation of the vessel.

The LNG proponents have taken an approach of seeking to mitigate risks to marine turtles and their habitats arising from the construction and operation of LNG facilities to the greatest extent practical, whereby further investment in mitigation would be disproportionate to the resulting environmental benefits, or would create new environmental risks or safety issues. The approach to mitigating the risks of boat strike, lighting, dredging and piling, and indirect impacts are discussed in detail in the following sections. The predicted impacts of the residual risk are also discussed in the context of the conservation of marine turtle populations in the Gladstone region.

4.1 Boat Strike

The risk of boat strikes on marine turtles is always present when vessels operate within the geographic distribution of turtles. The examination of stranding records provides a useful insight into the relative contribution of boat strike to turtle mortality compared with other anthropogenic risks, recognising that many turtle carcasses may never be found, especially for turtles in oceanic waters.

Biddle and Limpus (2011) provided a detailed account of the number, type and cause of marine turtle strandings in Queensland from 2005 to 2010. Of approximately 800 stranded turtles recorded in Queensland each year, approximately 80 (or 10%) can be attributed to boat strike. Of these, the vast majority (>50%) occur within the Moreton Bay Marine Park, with the Townsville and Great Sandy Straits regions also identified as ‘hot spots’ from time to time. Stranding records for the Gladstone region indicate that the frequency of boat strikes is low to moderate, with 5 boat strikes recorded on turtles in 2003 (Greenland and Limpus 2003). More recent stranding summary reports (e.g. Biddle and Limpus 2011) do not present data on boat strikes for the Gladstone region, making it difficult to determine whether the rate of boat strikes is increasing.

These results suggest that outside of key coastal ‘hot spots’ the risk of boat strike is relatively low. However, boat strike is nevertheless responsible for more turtle deaths across Queensland than other anthropogenic risks such as entanglement, dredging, ghost nets or fishing. The increased industrialisation of the Port of Gladstone brings with it risks of increased incidence of boat strikes on marine turtles and associated impacts on turtle populations. There are also important links between the frequency of boat strike and the general health of marine turtles. Nutritionally-compromised turtles, such as those residing within Port Curtis after a 2011 flood event, are thought to have a reduced ability to avoid predators and vessels and may therefore be more prone to boat strikes than at other times, when foraging areas are not impacted by floods.

Holistically, a range of options are available to reduce the risk of boat strike, but only a small number of these are practical. Vessels can be designed to minimise the risk of injury to turtles from boat strike, by reducing the draft of the vessel through modern hull designs, having rounded edges and using jet propulsion rather than propellers. These design elements do not avoid the impact of blunt trauma caused by collision with the vessel hull, but certainly reduce the risk of boat strike incidents occurring. Such modifications have been partially adopted within the ferry fleet of the LNG proponents, but are not practical for international LNG cargo vessels (which are also not under the direct control of the LNG proponents).

A reduction of vessel speed is the most significant practical mitigation option to reduce the risk of boat strike, with slow speeds (generally < 10 knots) adopted for short distances in areas of key turtle habitats or in shallow water (< 5 metres) where turtles are most vulnerable. Speed limits have been imposed on project construction-related vessels (< 6 knots in waters < 5 m in depth) and a purpose-built facility at Fisherman's Landing Northern Expansion has also been constructed and reduced marine transport distances for ferry and barge transport significantly for one permit holder (APLNG) from approximately 10 km to 3km, reducing the risk of boat strike. Given the widespread distribution of general turtle habitat in Queensland, the adoption of slow speeds across a vast geographic area would not be practical and would probably result in little improvement to the inherent risk of boat strike. While boat strikes are possible in waters deeper than 5 m, the risk is thought to be significantly reduced when compared with shallow areas where turtles may rest or forage.

Turtles are not well adapted to avoid vessels approaching at high speed, especially if they are already afflicted with a buoyancy disorder which prevents them from diving or nutritionally compromised as a result of a flood or similar event affecting the quality of foraging areas. Vessel masters may also have great trouble seeing turtles in the path of vessels due to the clarity and depth of water and the speed of the vessel. Heat-sensitive infra-red cameras have been fitted to part of the ferry fleet operating to Curtis Island to reduce the risk of boat strike on marine mammals (primarily dugong). However, such systems do little to mitigate the risk of boat strikes on turtles, which are cold-blooded. All staff, including vessel operators will participate in an induction and training program on the environmental values of the Gladstone region and in particular its importance to a variety of listed species including marine turtles. This will raise awareness among vessel skippers and crew for the need to be alert for the potential for boat strikes on marine fauna, including turtles.

Dramatically reducing the speed of a vessel, particularly that of a large cargo ship, is generally not possible over a short distance, and taking action to avoid a collision by altering the vessel's path may also bring significant risks to safety, especially for passenger ferries. While underwater cameras may assist vessel masters in sighting turtles in clear oceanic waters offshore from Port Curtis, there would generally be insufficient time to take action to avoid a collision, due to the size of the ship. Their application within the turbid waters of Port Curtis would also not be practical. In this context, there are very few technological applications that can assist in reducing the risk of boat strike on turtles, other than an improvement in vessel design and a reduction in speed in key habitat areas. Vessel speed is generally reduced in any case on approach to jetty facilities for navigation reasons and has the additional benefit in reducing the risk of boat strike in such circumstances.

Mitigation measures to reduce the risk of boat strikes are summarised in *Table 9*. Additional mitigation measures beyond those described are not considered to be practical and would have little additional benefit in reducing the risk of boat strike. Monitoring programs will be established to evaluate the effectiveness of the mitigation measures. It should be noted that for mitigation measures to be completely effective in reducing the risk of boat strike, they would need to apply to all vessel movements in the Gladstone region, not just those related to the LNG facilities.

Table 9: Mitigation Actions to Reduce the Incidence of Boat Strike

Activity	Objective	Strategy or approach to minimise impact	Related plans	Performance targets	Responsible
Increased vessel activity during construction of LNG facilities on Curtis Island	Minimise the risk of boat strike on marine turtles during construction activities	Vessels operating in shallow waters (< 5 metres) will travel at a maximum speed of 6 knots. Areas of Go Slow operations are in place and will be regularly reviewed based on changing depth conditions.	QGC Shipping Activity Management Plan. APLNG Shipping Activity Management Plan. GLNG Shipping Management Plan QGC Significant species management plan – turtles. Coordinator General and SEWPaC vessel speed limits. Consistent with recommendations of the Commonwealth Turtle Recovery Plan for green turtles of the southern GBR.	No deaths or injuries to marine turtles as a direct result of Project activities. All incidents involving fauna management are reported immediately. All personnel trained in fauna management requirements relevant to their area of work. All community enquiries and complaints are followed up, recorded and the results recorded in the Environment Management System.	LNG proponents Vessel masters Maritime Safety Queensland Vessel crew Fauna spotters
		A vessel must not approach a turtle within 50 m whilst underway or 150 m if moving faster than planning speed (QGC)	QGC Shipping Activity Management Plan. Consistent with conditions of GBRMPA Permits for commercial dugong watching.		
		If a turtle approaches an underway vessel closer than 50 m, the master must put their gears in neutral and move away when safe at a speed of no more than 4 knots to a distance of over 100 m	QGC Shipping Activity Management Plan, APLNG Shipping Activity Management Plan. QGC Significant species management plan – turtles. Condition of GBRMPA Permits for commercial dugong watching.		
		Maritime Safety Queensland requirement for reduced vessel speeds near craning operations and wharfs. Passenger ferries to operate at a maximum speed of 25 knots Vessels to comply with standards for Marine Construction Activities within Gladstone Harbour Use of jet powered vessels in the fleet to reduce the risk of boat strike, particularly in waters deeper than 5 m. Use of larger vessels where possible to reduce the number of smaller vessels on the project, with corresponding reduction in the risk of boat strike in waters deeper than 5 m.	Transport Operations Marine Safety Regulation 2004 QLD. Marine Construction Activities within Gladstone Harbour. Gladstone LNG Shipping Activity Management Plan. Notices to Mariners 665 of 2011 Notices to Mariners 1146 of 2012		
		A fauna exclusion zone shall be established around the perimeter of all working vessels (300 m APLNG). If marine turtles are spotted staff will keep observing the marine turtle and inform the vessel operator who take appropriate action to avoid a collision.	Marine Fauna Management Plans. APLNG Operational Environmental Management Plan		
		Vessels to comply with standards for Marine Construction Activities within Gladstone Harbour	Transport and Main Roads Standards for Marine Construction Activities within Gladstone Harbour.		
		Educate workforce regarding risk of marine megafauna to avoid interactions with those species	Report for Western Basin Dredging and Disposal Project Marine Mega fauna and Baseline Impact Assessment. Gladstone LNG Wildlife and Habitat Management Plan. QGC Significant species management plan – turtles. Condition 6 of EPBC Act approvals.		
		If an animal is harmed the skipper will immediately report it to DEHP hotline 1300130372 and the on-site environmental manager. The report will include information on the extent of the injury, the exact location of the animal/incident, and where safe and practical, staying with the animal until advised otherwise by the DEHP officer. Turtle handling and welfare measures should be implemented where practical and safe (e.g. NSW NPWS 2002).	Notification within one day a requirement of any EPBC species including marine turtles is required for all proponents. APLNG Shipping Activity Management Plan. QGC Significant species management plan – turtles.		
		Vessels are to avoid exclusion zones for marine wildlife.	QGC Significant species management plan.		
		All vessels will conduct regular servicing and inspections according to the manufacturer's instructions. This will reduce any unnecessary noise coming	APLNG Shipping Activity Management Plan.		

Activity	Objective	Strategy or approach to minimise impact	Related plans	Performance targets	Responsible
		from the vessel which would otherwise be a deterrent to feeding turtles in areas near operating vessels.			
		All GLNG project related vessels and their crew will remain within the approved navigation passage, abide by the Port of Gladstone published speed restrictions and exclusion zones set out by all relevant authorities at all times, and will contribute to any process to assess improvements to speed management of vessels in Gladstone Harbour.	GLNG Shipping Management Plans.		
		All vessels will have a trained crew member on board at all times who will be able to identify and avoid interaction with large aquatic fauna whilst transiting Port Curtis, including dugongs, turtles, marine mammals and large fish.	GLNG Shipping Management Plans. APLNG Operational Environmental Management Plan.		
		Comply with vessel speed limits established by Port of Gladstone and Maritime Safety Queensland. Operations in the area to be conducted in accordance with MSQ regulations to reduce the risk of oil spill. Oil spill prevention management plans and oil spill kits to be present on all vessels working on the project	Western Basin Dredge Management Plan. Western Basin Flora and Fauna Management Plan.		
Boat strike from shipping activities in Port Curtis and ferries during operations	Minimise the risk of boat strike on turtles during LNG operations	All vessels will utilise predefined and regular routes and will only alter this route for marine safety reasons Dedicated navigation channel for LNG carriers	APLNG Shipping Activity Management Plan. QGC Shipping Activity Management Plan GLNG Operational Shipping Activity Management Plan Phases I and II Bechtel APL shipping Management Plan. Standards for Marine Construction Activities within Gladstone Harbour.	No deaths or injuries to marine turtles as a direct result of Project activities. All incidents involving fauna management are reported immediately. All personnel trained in fauna management requirements relevant to their area of work. Trained MFO's on all vessels and for marine works All community enquiries and complaints are followed up, recorded and the results recorded in the Environment Management System.	
		Establish procedures for visual monitoring and reporting of turtles	APLNG Shipping Activity Management Plan. QGC Shipping Activity Management Plan		
		Controlled vessel speeds within the Port of Gladstone.	Maritime Safety Queensland and Port of Gladstone requirements.		
Boat strike from shipping activities in Great Barrier Reef Marine Park and lagoon	Minimise the risk of boat strike on turtles during LNG operations	All vessels will utilise pre-defined shipping routes and will only alter this route for marine safety reasons	APLNG Shipping Activity Management Plan QGC Shipping Activity Management Plan GLNG Operational Shipping Activity Management Plan Phases I and II	No collisions between LNG cargo ships and marine turtles in oceanic waters of the Great Barrier Reef during LNG facility operations	

4.2 Lighting

There have been substantial developments in the understanding and management of lighting since its effects on marine turtles were first described by McFarlane (1963). The geographic overlapping of turtle nesting habitats and coastal development has become an important management issue in many places around the world, including parts of Queensland and internationally in locations such as Florida (United States). While artificial light sources have a strong influence on the nesting behaviour of adult females and on emerging hatchlings, there are many practical management actions that can be put in place at lighting sources and at nesting beaches to significantly mitigate the impacts.

Sea turtles normally nest on remote beaches, shrouded in darkness and return to their natal site (location of emergence as a hatchling) to nest (Salmon 2006). The selection of a nesting site generally occurs at night and involves consideration of localised features of the beach, including the absence of obstructions such as rocks or reefs, presence of dune vegetation and the profile of the beach (Salmon 2006). The presence of artificial light has the potential to significantly reduce the number of nesting attempts of female adult turtles (Witherington 1992).

Hatchlings generally emerge at night when the sand has cooled, and undertake a rapid crawl directly to the ocean which is mediated visually, crawling away from tall dark objects towards the lower, flatter beach horizon which is often lit by the stars and the moon. Under natural lighting, hatchlings will rarely deviate more than 20^{o} (degrees) from the direction heading straight out to sea (Salmon 2003). Light emitted from developments such as the City of Gladstone, either directly or through sky glow, has the potential to disrupt these natural behaviours and consequently reduce the reproductive success of turtles.

Most of the effective mitigation actions relating to the use of industrial light sources in coastal regions of the Great Barrier Reef occur at the design phase. Significant reductions in the potential impacts of light sources on turtles can be achieved through the type (wavelength) and design aspects of lighting infrastructure, such as the use of shrouds and reductions in the height of light poles. Enhancing the silhouette of a dune can also reduce lighting problems (Limpus 1971b, Witherington and Martin 1996), making the conservation of dune vegetation on the region's nesting beaches an equally important consideration for the ongoing mitigation of impacts.

All three LNG facilities are located on sections of Curtis Island which are visually obstructed from turtle nesting beaches of the Gladstone region, through natural topography (vegetated hills). The terrain between the LNG facilities on Curtis Island and the major nesting beach of southern Curtis Island includes hills over 100 m in altitude, which provide a robust visual barrier preventing any direct light from the LNG facilities reaching the nesting beaches. Therefore, the primary consideration of the impacts of the LNG facilities in relation to light is their contribution to the overall night time sky glow of the Gladstone region when viewed from turtle nesting beaches. This glow is generated by lights from a variety of residential, industrial and infrastructure sources associated with a city of approximately 50,000 people. Mitigating any new contribution from LNG facilities to the existing sky glow, during both construction and operational phases of the projects is an important strategy to mitigate impacts on marine turtles.

Low-pressure sodium lights are a pure yellow source of light and are the least disruptive to turtles among commonly used, commercially available light sources (Witherington and Marin 1996). However, low-pressure sodium lights are not ignored by turtles, and the response varies among species. For example, loggerhead turtles show a different response to low-pressure sodium light than do green turtles (Salmon 2006). However, the use of low-pressure sodium lights ensures that any contribution to the sky glow of the Gladstone region arising from the LNG facilities is of a spectral range that has minimal impact on turtles. Other mitigation measures include the use of motion sensors and timers to reduce the number of lights turned on at any one time and the use of directional lighting, with light fittings covered by shrouds. Photographs showing examples of directional lights in use at the LNG facilities are provided in *Figure 5*.

Figure 5: Photographs demonstrating the use of Low Pressure Sodium and Directional Lights with Shrouds to Reduce Light Scatter at the Curtis Island LNG facilities



Flaring is an activity that will occur infrequently at the LNG facilities, and has the potential to impact on nesting beaches through additional contributions to the sky glow. Light emitted from natural gas flares has peak spectral intensity in the range of 750 to 900 nm (GLNG 2009a), which is much higher than that which is known to affect turtles. Also, the frequency of flaring is such that it may only occur very occasionally at night, as shown in *Table 10*. The LNG proponents have also designed their flares as low as practicable to the ground to reduce the potential for light spill, and in the instance of one proponent, as a ground flare. On this basis, the contribution of flaring to the night time sky glow is predicted to be extremely minimal.

Table 10: Situations in which Gas Flaring is anticipated from the Santos GLNG Project (GLNG 2009a)

Situation	Description
Scheduled Maintenance	Scheduled shut down and start up for maintenance inspection, which occurs every three years and lasts for three hours
Controlled Relief	Due to blocked outlets to the propane compressors (typically approximately 15 minutes in duration). Likelihood of occurrence is rare and may never happen during the lifetime of the facility's operation.
Emergency Shut Down	Rare or may never happen during the lifetime of the project.
Warm Ship Load Out	Load out of LNG to a ship when the ship is warm, occurring probably once in three years. It will take approximately 24 hours to cool the ship down using LNG, much of which will be boiled off and recycled back to the LNG facility for re-liquefaction.

LNG cargo ships which berth at the LNG facilities are required to be lit at night for safety reasons (as are other vessels using Port Curtis including coal ships), and will be directly visible at times from nesting beaches while in transit. As there are no depth restrictions for LNG ships accessing the LNG facilities, it is expected that LNG ships will move directly into the port upon arrival in Gladstone and will not generally be anchored offshore. In this context, the potential risks to turtles from lighting of ships at sea are significantly reduced and confined to the relatively short periods while ships are in transit. Additional navigation beacons may be required as a result of the changes to shipping from the LNG facilities, to guide LNG cargo ships into and out of the Port of Gladstone safely at night. If required, these may provide a further source of direct light at nesting beaches. However, the size and number of lights on ships and navigation beacons is generally small and cannot be mitigated without compromising navigational safety. It should also be noted that responsibility for lighting on LNG ships and on navigation beacons within the Port of Gladstone does not rest with the LNG proponents, and the implementation of additional measures in this context is outside of the direct control of the LNG proponents.

Pendoley Environmental (2012) completed a survey of the ambient night time light levels of the Gladstone region from four turtle nesting beaches in September 2011. The dominant light was a broad band of sky glow originating from the city and the Port of Gladstone and merged with glow from the nearby coal and alumina port facilities. Glow from the Boyne Smelter, Tannum Sands and ships offshore from the nesting islands were also evident. Variations in the presence of tall dunes and vegetation on nesting beaches were noted, and were predicted to result in variations in the success of sea finding for emerging hatchlings.

Mitigation actions in place to reduce the impacts of lighting on marine turtles are summarised in *Table 11*. The success of these measures will be monitored through the long-term monitoring program as outlined in Section 5.

Table 11: Mitigation Actions to Reduce the Incidence of Lighting Impacts

Activity	Objective	Strategy to minimise impact	Related plans	Performance target	Responsible
Construction and operation of LNG facilities contributing to the sky glow of the Gladstone region	Reduce contribution to the existing sky glow of the Gladstone region when viewed from turtle nesting beaches	Use low-pressure sodium lights to reduce contribution to night time glow at wavelengths to which turtles are most sensitive. Use of motion detecting sensors and light detectors to reduce contribution to night time glow. Restricting the height of available light or applying shrouds to control direction Reducing the amount of reflective surfaces through the use of matt paints on surfaces where practical, to reduce contribution to night time glow. Where possible avoid flaring at night or during the turtle nesting to hatching season No decorative lighting to be used. Flares design and constructed as low as practicable to the ground (in one instance as a ground flare). All LNG sites are well screened by Curtis Island topography. Minimise tree clearing and alterations of current topography	APLNG Operational Environmental Management Plan. GLNG Supplementary EIS. Commonwealth Turtle Recovery Plan. EPBC approval condition to minimise light spill. EPBC approval condition to minimise alterations of current topography.	Assessment and monitoring of sky glow indicates no or minimal changes during turtle breeding season. No disruption to marine turtle nesting activities as a result of lighting from the LNG facilities, as determined by control charts on turtle nesting parameters on Curtis Island. No disruption to marine turtle hatchling emergence as a result of lighting from the LNG facilities, as determined by control charts on orientation on Curtis Island.	LNG proponents
		Level of shipping activity to be small on an operational basis. Lighting on shore shall be directed away from the sea or shielded	Gladstone LNG Shipping Management Plan. GLNG Bechtel Wildlife and habitat management plan.	Lighting on vessels meets relevant safety standards while minimising light spill into the water.	LNG proponents Vessel masters
Light from navigation aids established to assist LNG ships navigate safely at night.	Reduce the incidence of light disturbing nesting females and emerging marine turtle hatchlings	Lights are required for navigational safety and need to be visible to mariners.	Maritime Safety Queensland requirements. Australian Maritime Safety Authority requirements.	Minimal number of navigation aids in place to meet relevant safety standards.	Port of Gladstone. Maritime Safety Queensland.

4.3 Dredging and Piling

Dredging and piling involve relatively intensive and direct disturbance of the marine environment during construction periods of the project. Following construction, only occasional maintenance dredging of the berth areas and associated approach channels is likely to be required. At the time of drafting the LTTMP, the vast majority of dredging and piling had been completed.

Marine turtles are known to occur within the general vicinity of the dredging and piling construction works. For example, a total of 522 turtles (mostly green turtles) were observed throughout the Gladstone region during aerial and vessel based surveys of Port Curtis in 2008 and 2009 (GPC 2009), including a small number of individuals within 1 km of the LNG facilities.

The LNG cargo ship berth areas are not located within key foraging areas for marine turtles, with seagrass habitats located further west and south of the berth areas containing dense seagrass habitats and larger numbers of turtles. Some sparse areas of *Halophila* and *Zostera* are present at times in the vicinity of the LNG facilities and thus the presence of foraging turtles can be expected from time to time.

Marine construction activities including dredging involve direct disturbance of habitats and have some level of unavoidable impact, including a short-term and localised deterioration of water quality (increased turbidity and suspended sediments), increased sedimentation on areas adjacent to the dredging footprint, the generation of underwater noise and removal of soft-bottom benthic habitats.

It should be noted that much of the construction activity associated with the LNG facilities is well progressed or completed, and has been carried out under the conditions of existing environmental approvals (including GPC's EPBC Act approval 2009/4904). Detailed environmental management procedures (approved by SEWPaC) have been developed for implementation during construction activities as summarised in *Table 12*. In summary, the measures include:

- Turtle monitoring prior to dumping of dredged material;
- All trailer suction hopper dredge vessels fitted with turtle exclusion devices;
- Reduced pump speed and use of drag head water jets during times when the drag head is not in contact with the seabed and pumps are in operation (trailer suction hopper dredge);
- Soft start piling procedures, with cap cushions to reduce noise intensity, and
- Noise monitoring during piling, with use of casing or bubble curtains to reduce noise if required.

In relation to the direct disturbance of dredging, it is important that interactions between turtles and dredging equipment are minimised and avoided if possible. Dredging accounts for only a small number of known turtle deaths in Queensland, with 1 recorded death in 2007 and 4 in 2006 (Biddle and Limpus 2011). Such records highlight the general effectiveness of environmental management procedures and technology such as turtle deflectors at minimising impacts.

For dredging aspects of the project (managed by the GPC), all trailer suction hopper dredge (TSHD) vessels have turtle exclusion devices fitted. Other operational measures implemented to mitigate the risk of marine turtle injury or death includes a cessation or reduction in pump speed as the dredge head is lifted from the sea floor. Drag head water jets are also activated at this time to minimise the risk of turtle capture.

Table 12: Mitigation Actions to Reduce the Impact of Dredging and Piling

Activity	Objective	Strategy to Minimise Impact	Related Plans	Performance Target	Responsible
Capital and maintenance dredging of berth areas and immediate approach channels using a cutter suction or TSHD dredge.	Minimise potential for interaction between dredge plant and marine turtles	Maintain turtle observations prior to dumping activities. Trailer suction hopper dredge vessel fitted with turtle exclusion device. Reduce pump speed and use of drag head water jets during times when the drag head is not in contact with the seabed and pumps are in operation (trailer suction hopper dredge).	Western Basin Dredging and Disposal (Onshore and Offshore) Project Dredge Management Plan. Flora and Fauna Management Plan, Western Basin Dredging and Disposal (Onshore and Offshore) Project.	No deaths or injuries to marine turtles as a direct result of dredging. All incidents involving fauna management are reported immediately. All community enquiries and complaints are followed up recorded and the results included in the Environment Management System.	Dredging Contractor GPC
Installation of piles into the seabed during construction of the berth facilities	Minimise underwater noise and vibrations within the surrounding water that might affect marine turtles	Soft start piling procedure, whereby piling is increased gradually over a minimum of 15 minutes. Use of pile cap cushions to reduce the intensity of underwater noise generated. Maintain Marine Fauna observer during piling activities. Piling only to be conducted during daylight hours, except in the event of a pile being in an unsafe state at dusk. In these circumstances, work may continue until the individual pile is made safe before piling is ceased for the evening. A fauna exclusion zone shall be established around the perimeter of all working vessels. If marine turtles are spotted staff will keep observing the marine turtle and inform the vessel operator who will take appropriate action to minimise work that may cause significant underwater noise. Cease piling operations if marine fauna come within designated exclusion zones (500 metres if piling has not commenced (300m APLNG); 100 metres if piling has commenced).	APLNG Operational Environmental Management Plan. GLNG Bechtel Wildlife and Habitat Management Plan. QGC EIS and Construction Environmental Control Plans.	No deaths or injuries to marine turtles resulting from piling activities. Soft start piling activities implemented in all cases. Noise monitoring conducted with associated management responses implemented as necessary.	On site supervisor LNG proponents
		Noise monitoring will be completed during piling and if noise is measured above recommended guidelines for protection of marine fauna, then piling cushions, pile casings or bubble curtains will be implemented to keep noise levels below guideline values	APLNG EIS.		

4.4 Indirect disturbance

Indirect forms of disturbance to marine turtles are less obvious than those associated with boat strike, dredging, piling and lighting, but have the potential to cause significant impacts to marine turtle populations in the long term. Port Curtis is already a highly industrialised marine environment and the additional contribution of the LNG facilities to the manifestation of impacts on marine turtles and their habitats is an important consideration for this plan.

Development of the LNG facilities will bring additional pressures on the environmental health of the Gladstone region, caused by a range of factors including an increased local workforce and human presence, additional shipping activity and associated environmental risks, loss of habitat or a change in the value of existing habitat values and an overall industrialisation of the marine environment. Marine turtles have been proposed to be useful indicators of environmental health, in part due to their reliance on a range of environmental variables indicative of a healthy ecosystem.

The careful application of EMPs and management thresholds is an effective approach used to monitor, manage and mitigate environmental impacts of large marine construction projects. Detailed EMPs have been developed and approved for implementation during construction aspects of the project, with monitoring undertaken during works to determine whether declines in environmental values (light and turbidity) are manifested at a level where impacts on sensitive receptors such as coral reefs and seagrass are likely. Relevant details of mitigation strategies are summarised in *Table 13*.

Environmental auditing is conducted to provide assessment of compliance with EMPs and their associated management commitments. These measures serve to verify the effectiveness impact mitigation actions on conserving the overall environmental health of Port Curtis, with resulting benefits to a range of marine species including turtles.

Although an existing industrial port and city, the increased human presence in the Gladstone region resulting from construction and operation of the LNG facilities is of a large magnitude, and has the potential to indirectly impact sensitive marine environments unless carefully managed. The LNG proponents have implemented important management arrangements to minimise the potential for human interaction within sensitive environments, through their onsite work procedures, implementation of buffer zones and by completing feral animal control to break any association between the abundance of feral species with an increasing human presence. They also fund the control of foxes and pigs within the Curtis Island Environmental Management Precinct to reduce predation impacts on turtle nests, in accordance with the Land Management Plan prepared by DIP (2010).

Anchoring of all ships offshore while they await the opportunity to come into port has the potential to damage turtle foraging habitats located east of Curtis and Facing Islands, through direct disturbance from anchors and their associated chains swinging on the sea bed (e.g. Dobbs 2001; Gibson and Smith 1999). Given the LNG proponents have dedicated loading facilities at Curtis Island and a stringent LNG schedule, ships will steam directly to the jetty for loading. This is also assisted as access to the Port of Gladstone for LNG ships will not be limited by tidal variations in depth and LNG ships will generally steam directly inside Port Curtis to their berth areas upon arrival in the Gladstone region. Thus, it is not expected that there will be any significant anchoring disturbance to turtle foraging areas as a result of LNG projects.

Table 13: Mitigation Actions to Reduce the Impact of Activities with the Potential to Cause Indirect Disturbances to Marine Turtles and their Habitats

Activity	Objective	Strategy to Minimise Impact	Related Plans	Performance Target	Responsible
Dredging and increased shipping activities	Minimise indirect impacts to marine turtles and their habitats arising from disturbance of marine environment	Offshore anchoring by LNG ships will generally not be conducted, with ships steaming directly into port upon arrival to the Gladstone region. Use of approved environmental management plans to manage the impacts of dredging and disposal of dredged material. Dynamic response to the management of construction activities and operations based on monitoring program. Halt dredging if approved Photosynthetic Active Radiation PAR triggers or turbidity trigger levels in the Western Basin Dredging and Disposal Project or Narrows Crossing dredging are exceeded at sensitive environmental receptors. Monitoring of seagrass impacts by LNG proponents and independent bodies.	APLNG approval conditions. GLNG approval conditions. Western Basin Dredging and Disposal approval conditions. QGC approval conditions. QGC Significant Species Management Plan. Western Basin Dredging and Disposal (Onshore and Offshore) Project Dredge Management Plan. Flora and Fauna Management Plan, Western Basin Dredging and Disposal (Onshore and Offshore) Project.	No decrease in turtle populations. No increase in the incidence of disease in turtle populations, as determined by monitoring turtle health parameters. No decline in the quantity and quality of turtle habitats.	Dredging contractor GPC LNG proponents
Changes in underwater topography as a result of disturbance from dredging	Minimise and manage impacts arising from changes in the marine environment	Minimisation of dredging footprint. Completion of post-dredging monitoring Environmental auditing by external bodies to ensure compliance	Application of the Environment Management System. LNG Dredge Management Plan- Append G9. LNG EIS Attach B3.	No significant environmental impacts arising from works.	GPC LNG proponents
Increasing industrial activity	Minimise disturbance to marine turtles and their habitats from the LNG facilities' contribution to the industrialisation of the Gladstone region	Implementation of detailed environmental management plans for all aspects of the development, including: Weekly inspections of designated storage areas for all chemicals with spill clean-up kits. Retention cisterns for storm water drainage Dynamic monitoring and auditing	Western Basin Dredging and Disposal Marine Mega fauna Baseline and Impact Assessment. LNG EIS Attach B3. QGC EIS.	No change in the environmental health of Port Curtis, marine turtle populations and their habitats as a result of the project.	LNG proponents
Increased human presence in region as a result of population increases from LNG facility workforce.	Minimise disturbance to sensitive marine turtle habitats	Feral pest control Human interaction minimisation Maintain buffers between LNG facilities and nesting beaches No pets on site	Key area identified in Commonwealth Marine Turtle Recovery Plan. LNG EIS Attach B3. EPBC Act approval conditions.	Interactions between workforce and sensitive marine turtle habitats minimise. Effective management of sensitive environments in the control of the LNG proponents.	LNG proponents On site supervisors
Increased presence of marine debris	No debris discarded to the marine environment.	No marine debris is to be discarded. Each vessel to have a waste management plan	APLNG, GLNG, QGC management plans. International convention for the prevention of pollution from ships, 1973.	No marine pollution incidents.	On site supervisors
Loss of habitat	Minimal loss of seagrass habitat, which is restricted to dredging footprint	Minimise direct losses of seagrass habitat from works Prevent indirect losses of seagrass habitat arising from works	QGC Significant Species Management Plan. Commonwealth Marine Turtle Recovery Plan. Western Basin Dredging and Disposal Dredge Management Plan. Narrows Crossing Dredge Management Plan.	No long-term loss of seagrass habitats, except within dredging footprints.	Dredging contractor GPC LNG proponents

5.0 MONITORING PLAN

5.1 Rationale

A comprehensive monitoring program is an essential component of the LTTMP, given the importance of the health and stability of marine turtle populations within the Gladstone region as they respond to increasing anthropogenic stressors associated with high density port activities and development. The EPBC Act approval conditions also require that comprehensive baseline information on marine turtle populations be collected and that monitoring projects be capable of achieving a statistical power of 0.8.

The primary objectives of this LTTMP with respect to monitoring are to:

1. Quantify the indicators of turtle population status at the start, throughout and at the conclusion of the 10 year life of the management plan through the development of independent monitoring programs and integrating with existing programs.

2. Have the adaptive ability to identify early and mitigate activities which may cause harm to marine turtle populations, based on the findings of monitoring.

3. Provide rigorous scientific information to assist in the sustainable management of marine turtle populations and their habitats within the Gladstone region.

The life history of marine turtles is complex (see *Section 2.2*), with the ecology of life cycle stages variable among species and also subject to different levels of project risk. For example, foraging adult turtles in Port Curtis are more susceptible to impacts from piling noise and boat strike than are juvenile pelagic loggerhead turtles in the Great Barrier Reef lagoon. There are hundreds of environmental parameters that could potentially be monitored across all life cycle stages of all species to assist in gaining a better understanding of marine turtle populations in the Gladstone region and their response to project-related activities. However, for monitoring to be practical and effective in determining the impacts of project-related activities, it should be targeted to a variety of carefully selected marine turtle parameters of relevance to the project activities and in particular, those with the highest risk of impacting marine turtle populations. For these reasons, the majority of monitoring activities have been established within Port Curtis and at Curtis Island, where environmental risks from boat strike, lighting, piling and dredging are likely to be the highest.

There are some extensive baseline data in place relevant to the LTTMP and these will provide a useful indicator of the environmental condition prior to construction of the LNG facilities. One example is the monitoring of many turtle parameters at the Curtis Island index nesting beach since 1969, which represents a unique and long-term baseline data set which has shown relatively minor year-to-year variation, increasing the power to detect future changes which may be project-related. Other data, while not true baseline, have been collected in recent years after the commencement of construction works in mid 2010.

As identified during the gap analysis stage of the LTTMP's development, there are some parameters for which baseline data is limited but where there remains value in collecting long-term data in the future for detection of potential changes to marine turtle populations. It is noteworthy that much of the existing baseline data for the Gladstone region is unpublished, and thus has not been presented in detail in this LTTMP. In this context, the first annual summary report will provide a detailed account of the existing baseline data, with which future monitoring results will be compared. At the time of writing, the GPC was also in the final stages of completing detailed gap analysis on marine turtles in the Gladstone region as part of the ERMP (GPC in prep.). This will provide a valuable source of additional information. . Key findings of the review, including any implications for the monitoring plan arising from the results of the gap analysis, will be presented in the first annual report submitted following publication of the GPC gap analysis.

Two key considerations for any monitoring program which aims to detect change is the statistical power that is required (to detect a change) and the level of change that is considered to be 'significant'.

Both of these variables have an influence on the statistical merits of a monitoring program and the likelihood that monitoring objectives will be achieved. It is generally accepted that statistical power should be 0.8 or greater, meaning that there is an 80% or greater chance of detecting a change of a given magnitude when one actually occurs. For long-term monitoring programs involving repeated measures of environmental variables over time, deciding upon a reasonable level of change indicative of an environmental impact is just as important as the corresponding power to detect this change. The EPBC Act approval conditions specify that a power of 0.8 should be achieved (or an alternative power approved by the Minister), with the level of change that is to be detected at this power not specified. This is because in practice, the biologically-relevant level of change will vary among environmental parameters and is therefore best determined based upon monitoring objectives, existing baseline data and knowledge of the potential project risks. For example, detecting a change of 5% at a power of 0.8 would require much more intensive sampling than detecting a change of 50% at a power of 0.8. In this context, the statistical power on its own has little meaning without directly relating this to the level of change that is to be achieved at this power.

The statistical method used to detect a significant level of change is also important in achieving monitoring objectives. Monitoring should be responsive so that changes, if detected, can be identified early and lead to further investigation of the potential causes, and if necessary, the implementation of additional mitigation measures, prior to any long term impact occurring. High replication of data increases statistical power and the ability to detect change, but can also take many years to achieve, particularly for long-lived, slow growing taxa such as marine turtles. In this context, a balance must be sought between obtaining the highest possible level of statistical power and monitoring environmental parameters for which biologically-relevant changes can be readily identified. While an early warning mechanism for detected change is desirable, it is also important to minimise 'false triggers' which indicate a change when one doesn't really exist (also known as Type I error).

Time-series control charts offer a robust approach to understanding trends in parameters over time by showing deviations beyond those that would normally be expected, by plotting a measure through time with reference to its expected value (Anderson and Thompson 2004). Control charts provide a basis for identifying potential environmental impacts quickly, triggering an early warning if a change is detected which can then be subject to further investigation. Control charts have been applied for many decades to the monitoring of a range of stochastic processes, including manufacturing and financial risk. More recently, their application to environmental monitoring has become relatively common, due to the responsive manner in which data can be analysed and deviations can be identified from what would normally be expected. Such an approach is well suited to monitoring several parameters relevant to marine turtles over time, such as the number of turtle standings, number of nesting females utilising a beach or the proportion of hatchlings showing signs of disorientation when dispersing down a beach towards to the ocean. Control charts were adopted for the Gorgon LTTMP in Western Australia (Chevron 2012) and have been applied as a useful means of monitoring a variety of ecological parameters before, during or after some form of development (e.g. Schipper *et al*. 1997; Manly and Mackenzie 2000; GPC 2011b).

Comparison of environmental variables with their long-term baseline mean provides a basis for determining whether turtle populations may be deviating from their long-term trend and signifies the need for early investigation of the possible causes. In a normal distribution, 68% of observations lie within one standard deviation of the mean, approximating a 80% power metric. If several indicators are monitored (e.g. nesting track counts, number of nesting females, hatchling emergence), then it is reasonable to assume that something has changed should a number of these show a change beyond one standard deviation from the mean. Such an approach also provides an early warning of change, rather than necessitating the need to collect large volumes of data over a long period of time to obtain sufficient statistical power. Indeed, establishing a suitable baseline data set to account for the inherent variability in measures of marine turtle populations could be expected to take 9 years for nesting flatback turtles, and decades for green turtles (C. Limpus pers. comm.). Accordingly, the control chart approach, targeting multiple environmental parameters relevant to marine turtles, including those for which there are existing long term data sources available, will be the primary mechanism for assessing change at a power of 0.8 in this LTTMP. This will be followed by the implementation of proactive review process and management triggers in the event that a change is detected.

Where control charts aren't relevant to the particular environmental parameters of interest, then alternative approaches will be used. For example, detecting statistical significance is not always possible when assessing the health of marine turtles, as certain diseases, even if recorded in low numbers, may be an early warning sign that a marine turtle population is starting to show signs of environmental stress. As such, some of the monitoring parameters will be subject to qualitative assessment, using the expertise of veterinarians or independent scientific experts to determine the level of environmental risk. To determine if a project-related activity is having an impact on the marine turtles of the Gladstone region, a change is considered to be significant if a measurable variation in the long-term baseline is detected, beyond which might otherwise be expected in the absence of the LNG facilities.

The monitoring plan has been developed in consultation with some highly experienced researchers in the field of turtle biology, with the primary purpose of outlining the objectives and general approach to each monitoring task and linking this with project-related risks most relevant to marine turtles. Implementation of the monitoring plan will be undertaken by suitably qualified turtle researchers, and the monitoring tasks have been described to provide an appropriate amount of discretion from turtle experts in the application of suitable research techniques and procedures. Given the long-term duration of the monitoring plan, it is likely that some improvements in research methods and technology may arise during the currency of the LTTMP. The LNG proponents will seek to partner with suitably qualified turtle researchers to implement the monitoring plan in a manner that maximises links with existing projects in the Gladstone region, and provides sound scientific outcomes from the research. It is anticipated that results of the monitoring program will be published in the peer-reviewed scientific literature and/or otherwise made available to researchers and the public through a peer-review process to further the conservation and management of marine turtle species in the Gladstone region.

The following sections provide an outline of:

- Existing monitoring programs and where available, a brief summary of baseline data;
- Gaps in marine turtle knowledge relevant to project risks, and
- A monitoring plan, providing details of the environmental parameters to be measured and the analytical methods to be applied, in order to comply with the EPBC Act approval conditions.

5.2 Existing Monitoring Programs

The Gladstone region hosts a range of industrial facilities, including an aluminium refinery and smelter, chemical plants, a power station, cement production facility, expanding coal handling terminals and soon, LNG facilities. The majority of these industrial facilities use Port Curtis to some extent, contributing a variety of stressors to the resident and transient marine fauna and flora. The monitoring program is not intended to provide an exhaustive list of information on the Gladstone ecosystem, or make the LNG proponents responsible for collating the effects of all of Gladstone's industries on the marine environment. Rather, monitoring activities for the LTTMP have been developed to target the environmental parameters of highest risk to marine turtles due to the activities of the LNG facilities.

The proposed monitoring program is designed to be complementary with the aims of GPC's Port Curtis and Port Alma Ecosystem Research and Monitoring Program (ERMP; GPC 2011c).

The ERMP has been designed to:

- Be a flagship program for future industry developments;
- Assist in minimising environmental impacts, and maintenance of a functioning ecosystem;
- Develop improved understanding of the drivers of ecosystem condition and population trends for key biota and habitats, and

- Monitor the effects of project-related activities including, but not limited to:
  - Dredge vessel movement,
  - Pile driving,
  - Construction dredging,
  - Bund wall construction during dredging,
  - Construction of the bund wall,
  - Filling of reclamation area,
  - Develop an environmental risk management approach to provide evidence based adaptive management,
  - Develop long-term data for population trends for key biota and habitats.

There are currently also several industry-funded, independent, government and tertiary monitoring programs operating in the Gladstone region that would provide significant baseline information to which the LNG proponents can value-add through integration. Where gaps exist, the contribution of additional monitoring program components will result in a cost-effective holistic monitoring program capable of accurately detecting the effects of the LNG facilities on the Gladstone region ecosystem.

Monitoring of the prevalence of boat strike-related injuries and mortality, noise disturbance caused by piling and dredging, baseline effects of lighting prior to the LNG facilities becoming operational, seagrass meadow composition, abundance and distribution, extensive water quality measures, and marine turtle movement, nesting and population composition are currently occurring to some extent in the Gladstone region, and in many cases funded by the LNG proponents as part of their broader environmental program. Where relevant to the LTTMP, these existing monitoring programs are described in the following sections along with new additional monitoring projects which have been adopted.

5.2.1 Boat Strike

The DEHP utilises reporting from members of the public, their Queensland Parks and Wildlife Service counterparts and other partner organisations to record marine turtle strandings along the coast of Queensland. Turtle carcasses are generally examined and the likely cause of death is assigned as anthropogenic, natural or undetermined, with records maintained on the StrandNet database including species, date and location information. These data are used to develop a comprehensive summary of the frequency, spatial distribution and causes of stranding and mortality of marine turtles across Queensland. Annual reports of all strandings are prepared and published by DEHP (e.g. Biddle and Limpus 2011). Anthropogenic causes of death are identified where possible, and for boat strike are generally indicated by the presence of propeller injuries on the carcass or other signs of blunt trauma. Importantly, detailed necropsies identifying the cause of death of stranded turtle carcasses are not always completed, due to a lack of available resources to facilitate the collection of this information, particularly for such a large number of stranded animals across the Queensland coast. Accordingly, there is rarely any subsequent analysis of the circumstances of the vessel collision that has led to the boat strike mortality, such as the presence of pre-existing illness in a marine turtle.

5.2.2 Piling and Dredging

Under GPC's EPBC Act approval 2009/4904, Condition 33 requires GPC to monitor the effects of noise created by pile driving and other disturbances on marine megafauna, as part of the ERMP. The effects of dredging on water quality within Port Curtis during the construction phases of the projects have also received considerable attention and consequently, studies of water quality changes caused by dredging and the effects of this on seagrass meadows have been comprehensively conducted. At the time of drafting the LTTMP, no injuries to marine turtles had been identified due to dredging works, with approved environmental management procedures being effective at minimising risks. New monitoring initiatives are not proposed in this LTTMP to assess the direct impacts of piling and dredging, as existing programs are in place and have been approved.

5.2.3 Lighting

There have been relatively few historical light studies in the Gladstone region. The Queensland Turtle Conservation Program study of Hummock Hill Island examined the effects of light spill on turtle nesting behaviour based on track direction over a brief period of time in 2006 (Hodge *et al*. 2006). Since this report, an independent study of the existing ambient night time light levels has been completed by Pendoley Environmental (2012) on behalf of the GPC, with the objective of determining changes to the night time light horizon as perceived by marine turtles over time. This study monitored the night sky light conditions during the new moon in September 2011 at two nesting beaches on Curtis Island and two on Facing Island, using a sky camera and filter system. The study found that a broad band of sky glow was visible from the Boyne Smelter and the Boyne Island and Tannum Sands residential areas, with a large number of vessels anchored offshore also visible from nesting beaches. The potential impacts of the existing baseline sky glow on turtles were predicted, although no data have been collected to verify these predictions.

5.2.4 General Indirect Impacts

Marine turtles are proposed sentinel indicators of environmental health (Aguirre and Lutz 2004), with changes in the health status of marine turtles correlated with environmental stressors (Flint *et al*. 2010). Therefore indirect influences of marine turtle health and biology also offer measurable parameters that act as barometers of Gladstone's ecosystem health. As such, their inclusion in marine turtle monitoring programs has a double benefit and in the case of this LTTMP, is an important component of targeting monitoring activities to the areas of highest cumulative risk.

Seagrass health. There are several ongoing monitoring programs in place within Port Curtis to record seagrass composition, distribution and biomass, by a range of government, volunteer and industry stakeholders. These programs provide vital information on a primary resource for green turtles and a refuge resource for several of the invertebrate species that comprise part of the loggerhead turtle's diet. Further, they account for natural events to place the stressors of industry into context. An existing study by GISERA (2011) is also studying seagrass habitats in the vicinity of the LNG facilities and developing a seagrass process model to better understand the links between seagrasses and threatened marine species.

Water quality. Several industry, government department, tertiary institutes and independent investigators are examining a range of water quality parameters for the Gladstone Harbour. Commonly, these parameters include salinity, pH, alkalinity, turbidity and sedimentation. Trigger level safeguards have been implemented for the construction and maintenance phases of dredging, for which dredging is considered to be the primary contributor to any negative impact on water quality (GPC 2011b). As such, collectively these studies have the capacity to provide a dynamic comprehensive analysis of the state of Gladstone Harbour's waterways. Like the seagrass health monitoring studies, these ongoing data can account for natural events to place the stressors of industry into context.

Turtle biology, disease and population health. The biology of marine turtles is intermittently measured throughout Port Curtis. Investigations by the DEHP and their collaborators have resulted in both published and unpublished data on the four primary species that inhabit the Gladstone region. Nesting on surrounding islands and the important monitoring of flatback turtle nesting on Curtis Island are documented, providing a baseline knowledge of how marine turtles interact within this region. Current investigations include: 1. A study by GISERA (2011) that will combine seagrass meadow surveys with determining the movements of marine turtles (and dugongs) through the deployment of acoustic tags on turtles. This study aims to gain a greater understanding of marine turtle movements within Port Curtis so that water traffic can be directed to minimise damage to key seagrass habitats and minimise the risk of boat strike injury to turtles. 2. Turtle nesting monitoring on Curtis Island by DEHP to quantify the number of species and individuals utilising these habitats (see Limpus *et al*. 2006). 3. Marine strandings reported to the DEHP through their StrandNet program by wildlife officers and members of the public (e.g. DEHP 2012c). To a lesser extent, some information is known about the habitat utilisation of some of the turtle species that are found within the Gladstone region. However, very little is known about the cohort composition of populations within the Gladstone region, as studies to date have focussed on nesting females.

Turtle disease and population health is an important component of any marine turtle monitoring program, yet very little monitoring of these has been conducted with scientific rigour within the Gladstone region. Baseline studies exist on the health of green turtles in Shoalwater and Moreton Bays that comprehensively define parameters required for the diagnosis of disease (Flint *et al*. 2010). Australian guides are available on how to assess stranded marine turtles and perform necropsies to determine the cause of mortality (Flint *et al*. 2009), and reviews have been performed on how to conduct a marine turtle disease investigation using Australia as an illustrative example (Flint 2012). Within the Gladstone region, these tools have only been applied to a single investigation by The University of Queensland that was commissioned by the GPC after an unusual mortality event of marine turtles and dugongs which occurred after state-wide flooding in late 2010 and early 2011. This report, which linked with a toxicological analysis of tissues, found several disease conditions that were likely to be the result of natural events and industry stressors (Eden *et al*. 2011). Opportunistic disease investigations have also been performed on cohabitant species such as fish and dugongs (e.g. DEEDI 2011).

5.3 Gaps in Existing Monitoring

To rigorously monitor the impacts of the LNG facilities on the Gladstone region's marine turtles, some additions to the existing monitoring programs outlined in Section 5.2 have been developed. Integrating existing programs and addressing knowledge gaps will create a holistic approach to detect any positive or negative effects of the LNG facilities and fulfil the aims of the LTTMP and the EPBC Act approval conditions.

This additional monitoring includes detailed forensic diagnosis of human-related causes of turtle death, examination of the effects of the LNG facilities on turtle nesting and hatchling orientation, health surveillance of the marine turtle populations (when completing physical health assessments under existing ERMP program) and satellite tracking of inter-nesting female flatback turtles to determine habitat use for reassessment of project risks.

5.3.1 Boat Strike

Identification of boat strike as a cause of death is generally restricted to being listed as a 'yes' or 'no' in the DEHP annual stranding reports (Biddle and Limpus 2011). It is rare, especially in the Gladstone region that any further veterinary examination of a carcass is undertaken to determine the circumstances of the boat strike and relate the injuries to the type of vessel which may have resulted in the death (e.g. ferry, cargo ship, recreational speed boat). With the variety of recreational and commercial vessels using Port Curtis, it would be advantageous for the LNG proponents to identify whether vessels associated with their facilities are responsible for this human-related cause of mortality. While the results of necropsy techniques are not always absolute, the injuries inflicted on marine wildlife from boat strike can be related back to vessels (e.g. Rommel *et al.* 2007). Boat strike injuries on stranded turtles in the Gladstone region will be investigated, based upon the examination of several traits, including:

- The length, depth and spacing of propeller cuts, which provide insight into the minimum diameter, shape and pitch of the propeller that has struck the turtle;
- Location of the stranding in relation to known vessel routes, considering currents likely to move the carcass, and
- Veterinary examination of the injury to determine whether the boat strike occurred prior to or after death (a floating turtle which has died from other causes may be subsequently struck by a vessel).

Determining the number of boat strikes on marine turtles that may be attributable to the LNG projects will provide a mechanism to validate or reassess the risk assessment and review mitigation strategies. Given that the number of boat strikes on marine turtles in the Gladstone region is low to moderate, and year to year variance is likely to be high, this gap in current monitoring will initially be addressed in a qualitative manner, using a weight of evidence approach to the analysis of stranding data and necropsy results, rather than a statistical approach. This will always be prone to some level of difficulty given that there are many other vessel users in the Gladstone region.

5.3.2 Lighting

The effect of establishing the LNG facilities on Curtis Island on the nesting behaviour of adult turtles and on the dispersal behaviour of turtle hatchlings from their nest site to the ocean is unknown. As there is no direct line of sight between turtle nesting beaches and the LNG facilities, the contribution of the LNG facilities to the ambient night time sky glow is the primary means by which impacts are likely to be manifested, as determined by the environmental risk assessment (see Section 4). The influence of lighting associated with LNG facility jetties, infrastructure, offshore vessels and gas flaring equipment on the ambient night time sky glow has not been measured and compared with the baseline sky glow. While a small number of LNG ships travelling through the Great Barrier Reef lagoon also have the potential to disrupt nesting turtles and hatchlings, such impacts were assessed as low in the environmental risk assessment and are considered to be a lower priority for monitoring, compared with the night time sky glow. However, the orientation of hatchling dispersal in relation to the direct route of access from nest sites to the ocean is a current knowledge gap that forms part of future monitoring activities. This will provide important data to test some of the predicted impacts of Pendoley Environmental (2012) in their baseline sky glow assessment. This assessment will assist in determining the relative contribution of LNG facilities to night time sky glow when compared with existing lighting sources in the Gladstone region.

5.3.3 General Indirect Impacts

Of the areas examined for the development of this plan, the greatest deficits in current monitoring and/or availability of data exist in the general indirect impacts category.

Turtle biology, disease and population health. Surveillance of the health of each cohort (i.e. foraging juveniles and adult loggerhead, green, flatback and hawksbill turtles, and nesting and hatchling emergence of flatback, green and loggerhead turtles) has not been comprehensively conducted. Surveillance of the health of marine turtles will utilise their role as sentinel indicators of environmental health and directly address the aims of this 10 year monitoring program by assessing the highest risk cohort of marine turtle populations (see Section 4). Important measures requiring data for this type of surveillance which are missing include body condition, prevalence of sub-clinical and clinical diseases, causes of morbidity and mortality, zoonotic potential of identified diseases given the proximity to a growing city, emerging diseases, and the ability to support stranding networks (e.g. StrandNet) that are charged with recording this type of data for state and federal management programs. Green turtles will be targeted within Port Curtis, as these individuals are likely to be reliant upon the environmental health of foraging grounds in the Gladstone region which may be adversely affected by the LNG developments. The health of nesting turtles will not be assessed, as this is likely to be more indicative of the environmental health of their distant foraging areas than the local environment of the Gladstone region.

5.4 Monitoring Plan

Given the known gaps in existing monitoring programs of relevance to the long-term conservation of marine turtles in the Gladstone region, additional monitoring measures will be implemented. Integration with the existing monitoring programs, where possible, will eliminate the need for replication of studies and value-add to the work already being completed. The LNG proponents will therefore use their best endeavours to expand the existing programs where relevant to address identified monitoring gaps. The additional monitoring will provide a comprehensive program capable of identifying, and responding to (if required), any negative effects that the construction and operation of the LNG facilities may have on marine turtles and their habitats within the Gladstone region. Monitoring activities will be conducted and reviewed by turtle experts to achieve a high level of scientific rigour and in many cases will supplement or expand existing research projects to also address the objectives of this monitoring plan. The LNG proponents are confident that there is sufficient expertise available to complete the proposed monitoring, with turtle specialists known to be employed at a range of institutions, including James Cook University, Central Queensland University, the University of Queensland and DEHP. Following approval of the LTTMP, the LNG proponents will seek to enter into research agreements with relevant turtle experts to deliver the monitoring commitments within the plan.

DEHP will be consulted regarding the protocols it has established for the collection and storage of turtle research data. The LNG proponents will require turtle researchers implementing the LTTMP to apply the DEHP research protocols in order to maximise the benefits of the data collected to the Queensland Government's long-term turtle research programs. Details of how and where turtle samples will be stored will be outlined in the first annual report.

The LTTMP monitoring component is based on environmental risk and will include detailed examination of anthropogenic-related causes of mortality, ongoing measurement of sky glow at strategic times during nesting and hatchling emergence, necropsy examination of stranded turtle carcasses, health surveillance of marine turtle populations, monitoring of the orientation of hatchling dispersal on beaches and a range of turtle nesting parameters on Curtis Island and at a control nesting site of Avoid Island, within the Broad Sound Islands National Park, north of Shoalwater Bay (*Figure 6*). Projects are summarised in *Table 14*, with specific objectives, the status of baseline data, statistical analysis techniques and environmental variables to be monitored outlined in the following sections.

The LNG proponents acknowledge the contribution of Dr Mark Hamann of James Cook University, who is a turtle research specialist based in Townsville. Dr Hamann completed an independent review of an early draft of the LTTMP and provided several suggestions to refine the monitoring plan to achieve the objectives of the EPBC Act approval conditions (Appendix C). The LNG proponents also acknowledge helpful comments provided on a later draft by Associate Professor Colin Limpus from the DEHP. The monitoring plan will be regularly reviewed to maintain its relevance to emerging information and to address relevant knowledge gaps in the environmental health of the Gladstone region, as described in Section 6 of this plan.

The LTTMP monitoring plan was revised in early 2024 for the final two years of implementation (2024 and 2025). Changes to the monitoring plan were informed by advice from Associate Professor Colin Limpus of the Queensland Department of Environment, Science and Innovation (DESI). Revision of the monitoring plan was considered necessary to reflect increased knowledge of marine turtle ecology for the Gladstone region, and therefore, changed priorities for addressing knowledge gaps since the LTTMP's development in 2014. Proposed changes to the LTTMP (v6) were submitted to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) for approval in April 2024. The revised monitoring plan will continue to meet the LTTMP's objectives and improve scientific outcomes for marine turtle conservation.

A summary of key changes to the LTTMP monitoring plan for 2024 and 2025 is as follows, with further details in *Table 14*:

- **Amended task**: The final full season nesting census at Curtis Island and Avoid Island (Year 10) is replaced with a standard nesting census at Curtis Island and Wild Duck Island. This change reflects the significant additional knowledge that has been gained of flatback rookery function in the past 10 years, with a full season census no longer a high priority. Key nesting parameters for measuring rookery performance have been collected in sufficient detail during the standard census period, with few additional benefits of a full season census at this time. Wild Duck Island has emerged as a highly significant rookery in the Gladstone region, with approximately four times as many turtles nesting as at Avoid Island. There are five years of continuous monitoring data for Wild Duck Island, which is located in an undeveloped part of the Queensland coastline. The Wild Duck rookery therefore provides a suitable reference point for comparisons of nesting results with those at Curtis Island. Further details are provided in *Table 17*.
- **New task**: Satellite tracking of nesting flatback turtles at Peak Island and Wild Duck Island, to fill knowledge gaps on the inter-nesting habitats of these important Gladstone region rookeries. Further details are provided in *Table 23*.
- **New task**: Desktop modelling of flatback turtle nesting populations at each of the rookeries of the Gladstone region, to provide information on the function of nesting

populations 10 years after construction of the LNG facilities. Further details are provided in *Table 17*.

- **New task**: Desktop assessment of the foraging habitats and associated home range characteristics of flatback turtles, using data from satellite tracking studies of inter-nesting habitat. This task will explore a current knowledge gap in the understanding of flatback turtle ecology. Further details are provided in *Table 23*.

The LTTMP monitoring plan, as revised in 2024, was successfully implemented. A summary of the findings of all monitoring activities from the 10+ year program was prepared and submitted to the Department of Climate Change, Energy, the Environment and Water in early 2026 (see Section 6). While no further monitoring beyond 2025 is required to satisfy EPBC Act approval conditions, the details of each monitoring activity are described in the following sections and have been retained within the plan for historical context.

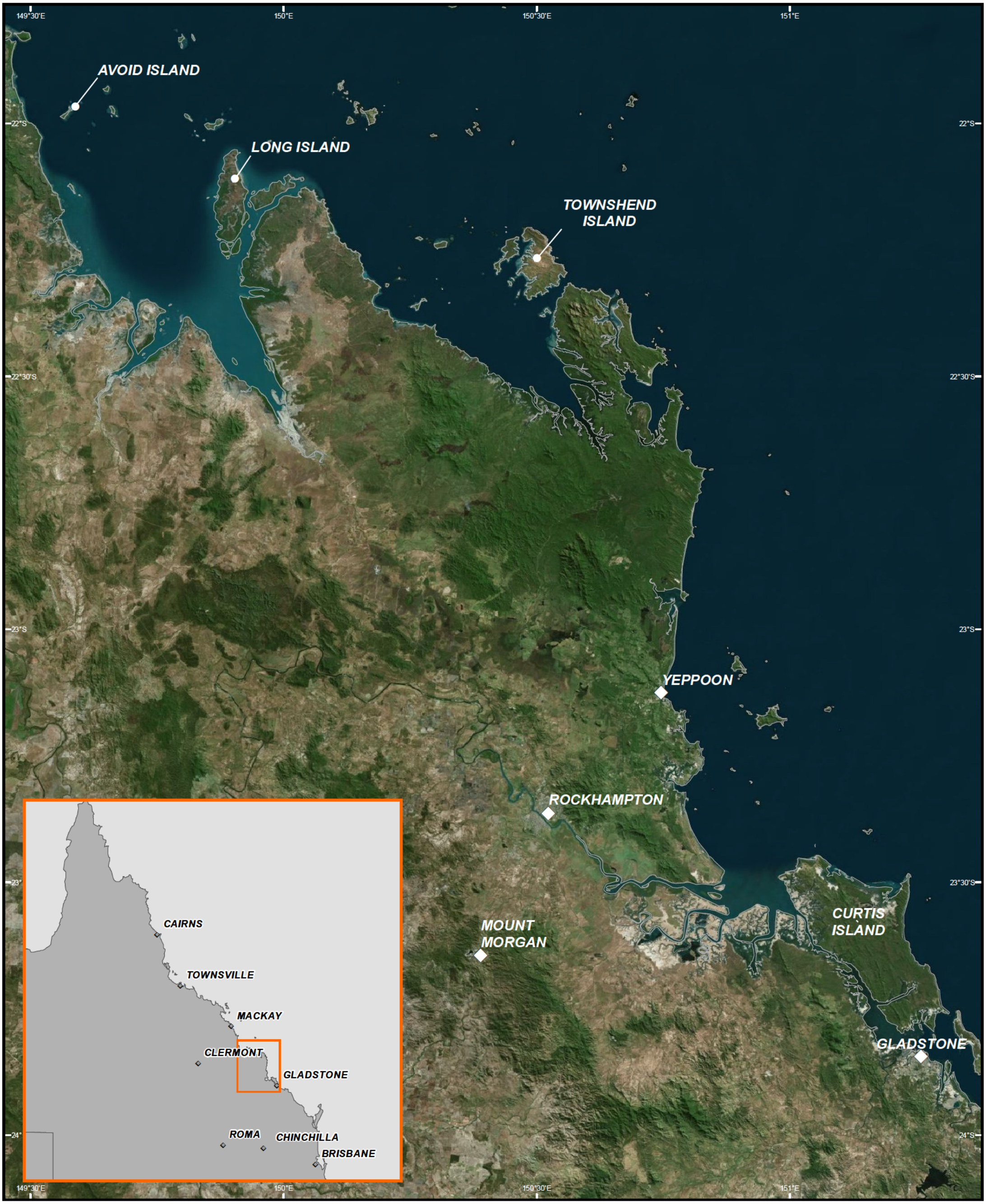


Figure 6. Area Map Showing Avoid Island and the Gladstone Region

N

0 10 20 30 40

Kilometers

Map Projection: GDA 94 SCALE: 1:750,000 (A3)

DATA SOURCE: Towns, Coastline - GA

Legend

◇ Town/City

QGC
A BG Group business

DATE: 30/06/15 **CREATED BY:** hibberde

MAP NO: M_41188_01

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Table 14: Summary of Monitoring Activities

Monitoring Activity	Existing or New Project	Comment	Frequency of Monitoring	New monitoring tasks
Monitoring of nesting turtles on Curtis Island and Avoid Island (control site). **Monitoring of nesting turtles on Curtis Island and Wild Duck Island (Year 10).**	Existing GPC project.	LNG funding the continuation of existing long-term monitoring program. First five years of monitoring at Curtis Island and Avoid Island, including one full season census. Final year of monitoring at Curtis Island and Wild Duck Island (standard census of four weeks field work). Desktop modelling of flatback turtle nesting population size for Curtis Island, Peak Island and Avoid Island in Year 10.	Four weeks annually (Nov/Dec) for a minimum of five years and in Year 10. Whole of season monitoring in one year.	Whole of season monitoring in one year (Curtis Island and Avoid Island). Monitoring at Wild Duck Island in Year 10.
Monitoring ambient night time sky glow following commissioning of LNG Facilities	Existing project (ERMP)	Compare with baseline study completed in 2011.	At milestones in the projects development and every two years thereafter for 10 years.	Enhancement of ERMP commitment. Links with new hatchling disorientation study.
Monitoring hatchling emergence tracks in the sand for signs of disorientation	Enhancement to the ERMP commitment. (Good baseline data from James Cook University study and ERMP 2013-2014 survey.)	Four weeks field work at Curtis Island during hatching period, across the lunar cycle. Some monitoring currently done by volunteers as part of DEHP coordinated program.	Once a year for a minimum of five years (for a period of four weeks, across the lunar cycle).	Increase in ERMP by LNG proponents.
Turtle tracking - foraging	Existing project (GISERA and ERMP)	LNG-funded radio tracking of turtles to determine foraging home ranges.	Minimum of three years, increased to five years as determined from results of initial monitoring.	Existing task outlined in ERMP for megafauna generally, and not specific to turtles. Satellite tagging aspects new.

Monitoring Activity	Existing or New Project	Comment	Frequency of Monitoring	New monitoring tasks
Turtle tracking – flatback inter-nesting	Enhancement to existing ERMP project	Satellite tracking of 10 flatback turtle females during inter-nesting period to determine habitat use and adjust risk assessment accordingly. Monitoring will be conducted off Curtis Island and the control site at Avoid Island. In Year 10, satellite tracking of nesting flatback turtles will be conducted to describe inter-nesting habitat at Peak Island (20 turtles) and Wild Duck Island (20 turtles). Desktop assessment of foraging habitat characteristics and home range sizes of flatback turtles, using all data in Year 10.	Annually for three years as determined from results of initial monitoring (Curtis Island and Avoid Island). One year of monitoring at Peak Island and Wild Duck Island (Year 10).	Increase in the commitment of ERMP monitoring from five turtles per year to 10. Tracking off Avoid Island, Peak Island and Wild Duck Island is a new task.
Detailed necropsy of turtle carcasses showing signs of boat strike to determine type of vessel	New project building on existing DEHP stranding program.	This would involve sending up to 10 turtle carcasses a year to a qualified veterinarian for assessment, for up to 10 years.	Ongoing, dependent on the provision of carcasses with boat strike injuries.	The systematic necropsy of up to 10 turtles a year is a new task. DEHP undertakes occasional necropsies currently, where resources permit.
Necropsies of dead stranded turtles in Gladstone region to determine cause of death and identify increases in the prevalence of disease.	New project building on existing DEHP stranding program.	Up to a maximum of 30 per year to a qualified veterinarian for assessment (additional to boat strike numbers above), for up to 10 years.	Ongoing as suitable carcasses become available. Coordinated through DEHP as appropriate.	The systematic necropsy of up to 30 turtles a year is a new task. DEHP undertakes occasional necropsies currently, where resources permit
Assessment of seagrass health	Existing project (ERMP) and WBDDP.	LNG funding of ongoing assessment of seagrass health.	Once per year for a minimum of five years (ERMP). Minimum of three years (GISERA).	No new commitments.

Monitoring Activity	Existing or New Project	Comment	Frequency of Monitoring	New monitoring tasks
Health surveillance of live turtles	Enhancement to existing DEHP projects.	Supplement with additional health assessment techniques as an early warning of disease emergence.	Undertaken annually for a period up to 10 years, unless the monitoring objectives have been met prior.	Health assessment aspects are new tasks.

5.4.1 Boat Strike

To improve the identification of anthropogenic causes of turtle mortality such as boat strike to the level required to determine if vessels associated with the LNG facilities are responsible for this human-related cause of mortality, forensic investigation and interpretation of boat strike wounds on marine turtle carcasses will be funded by the LNG proponents and implemented in partnership with DEHP. Such assessments will be completed by independent veterinarians and collated through the DEHP StrandNet system to contribute to state-wide management of marine turtles. Interpretation of the results will consider historic and state-wide data required to assess whether occurrences of industry-related boat strike has increased since the commencement of construction works or operations at the LNG facilities and if there are deviations from the trends identified in other regions of Queensland. Importantly, the results will allow the predictions of the risk assessment to be tested with real data, and reassessed if results indicate that impacts are higher than originally expected.

Forensic examination of turtle carcasses will focus on determining the type of vessel involved in the collision. Such investigations do not always provide definitive results, but will be useful in evaluating whether there is an increase in shipping-related boat strikes coinciding with development of the LNG facilities and their operations. Without this data it will be difficult to determine conclusively whether operations are having an insignificant effect on boat strike-related causes of mortality in Gladstone's marine turtle populations. The data will not be analysed with control charts, as numbers are expected to be low and hence, variation high. Rather, this monitoring will aim to identify project-related boat strikes on turtles and evaluate whether the results are consistent with those predicted in the environmental risk assessment. A qualitative assessment of data and the results of turtle necropsies will therefore form the basis of the monitoring project, based upon a weight of evidence assessment approach. Details of this monitoring project are provided in *Table 15*.

Table 15: Details of Monitoring Project – Forensic Examination of Boat Strike Injuries

Objectives	**Provide data on boat strike-related causes of mortality in marine turtles of the Gladstone region.** **Identify the number of boat strikes that are attributable to vessels associated with LNG projects (e.g. ferries, barges and LNG ships).** **Provide real data to test the predictions of the risk assessment.** **Address EPBC Act approval conditions - III c, d (Section 1.1).**
Methods	Use of forensic analysis of boat strike-related mortalities of turtles by a suitably qualified veterinarian to determine the likelihood that boat strikes are attributable to vessels involved in the LNG projects. Methods will be applied based upon expertise in forensic necropsies of marine turtles, using a similar approach as that described by Rommel *et al.* (2007) for manatee. Key questions to be addressed during the necropsy process are: was the turtle alive when struck by a vessel, are there any signs that the turtle was affected by floating disease which may have increased its risk to boat strike, was the turtle otherwise healthy at the time of the boat strike, what type of propeller or vessel hull design could be responsible for the injuries? The project will link in with the existing DEHP marine animal stranding program, to maximise value of information collected and application to future management.

Baseline	Existing DEHP stranding records (which are deficient in analysis of boat strike injuries) – 10+ years. Established techniques to determine the type and size of vessel involved in boat strike injuries based on wound measurements, shape and direction.
Baseline results	Small number of turtle deaths attributable to boat strikes each year in Gladstone region (e.g. 5 in 2003; Greenland and Limpus 2003). More recent unpublished data are available from DEHP's Strandnet database. Published DEHP annual summary reports since 2005 do not provide data on boat strikes for the Gladstone region.
Funding and administration	New project, enhancing DEHP's existing marine animal stranding program. Funding to be provided by LNG proponents to examine up to 10 boat strike-related carcasses per year for each year of the monitoring program.
Environmental variables to be monitored	Injuries on turtle carcasses; length, depth and spacing of propeller cuts; location of stranding in relation to local currents and commercial vessel routes and schedules.
Statistical analysis	Veterinary expertise required. Data can be presented to Power > 0.8 if sufficient replicates are obtained throughout the monitoring program to determine if commercial vessel or recreational vessels are responsible for mortality and changing proportion with activity (unlikely due to low numbers predicted). Analysis will therefore largely be qualitative, and used to verify the assumptions of the environmental risk assessment (that boat strike risk is Medium). The effectiveness of mitigation measures will be reassessed based upon the results of the monitoring project.

5.4.2 Lighting

With respect to lighting, the primary project-related affect necessitating monitoring is the contribution of the LNG facilities on Curtis Island to total sky glow and their associated impact on nesting female turtles and on the dispersal of hatchlings from their nesting sites to the ocean. The objective of this monitoring component will be to detect if any changes in overall light intensity (sky glow) occur as the LNG facilities begin operations and determine whether any increases in sky glow are important in influencing the behaviour of nesting adult turtles and dispersal of hatchlings to the ocean during the nesting season.

A baseline study conducted by Pendoley Environmental (2012) on behalf of the GPC provides a useful reference point for future monitoring, recognising that this study took place approximately 12 months after the commencement of some construction works.

The study measured light intensity at four key nesting sites on Curtis and Facing Islands using a specialised 360° temporally regulated cumulative photometer, or 'Sky Cam'. Pendoley Environmental (2012) found sky glow from the city and port of Gladstone were the primary contributors to artificial light on Curtis Island nesting beaches. Repeating this study for several nights across a lunar cycle during peak nesting seasons on the four sites studied on Curtis and Facing Islands from the year LNG facility operations begins, and then every second year throughout the 10 year plan will allow for any increases in sky glow to be detected and importantly, linked back to the LNG facility and the results of nesting and hatchling dispersal monitoring. Gladstone is a growing city with several infrastructure projects around Port Curtis in stages of expansion. Hence, the timing of sky glow assessments will be closely linked with project milestones to assist in determining the contribution of LNG facility impacts from those of other activities or industries. Details of this monitoring project are provided in *Table 16*.

Table 16: Details of Monitoring Project – Night Time Sky Glow Assessment at Turtle Nesting Beaches

Objective	**Provide data on the night time sky glow of the Gladstone region, with a view to assessing an increase caused by the establishment of the LNG facilities.** **Provide data to guide interpretation of monitoring results for female nesting turtles and for the dispersal of hatchlings from their nesting sites to the ocean.** **Address EPBC Act conditions III a, b, c, d (Section 1.1)**

Methods	Biannual monitoring of night time sky glow at four key turtle nesting sites on Curtis and Facing Islands during the 4 week nesting and hatchling season by use of cumulative Sky Cam. Relate to results of monitoring of nesting flatback turtles and hatchling dispersion (conduct monitoring on the same nights).
Baseline	Existing data for one year (2011) prior to the commencement of LNG facility operations. Global data available by use of geographical positioning systems overlaying known turtle nesting sites in Australia (as per Kamrowski *et al.* 2012).
Baseline results	Post-dusk to pre-dawn light emissions measured in September 2011. Inferences to effect on nesting and hatchling orientation speculated based on known intensity effects derived from the broader literature (Pendoley Environmental 2012). Sky glow generated from Boyne Island smelter, and residential areas at Tannum Sands and Boyne Island. A large number of lit ships also visible offshore (anchored). Light pollution for Eastern Australian flatback nesting sites identified to pose a high risk when compared with other Australian nesting regions (Kamrowski *et al.* 2012).
Funding and administration	Continue biannual monitoring for 10 years to establish comprehensive baselines and quantify changes in the light regime. Continuation of existing ERMP project.
Environmental variables to be monitored	Cumulative light emission during post-dusk to pre-dawn period of new moon; changes with activities (gas flares, offshore vessels, vessels moored at the LNG plants), climatic data (cloud cover, reflection), topographical cue alteration (tree lines, sand dunes, silhouettes).
Statistical analysis	Data processed as per Pendoley Environmental (2012). Temporal values compared by analysis of variance (ANOVA). Provide data at Power >0.8.

In addition, a continuation of long term studies coordinated by DEHP on the nesting turtles at Curtis Island will be funded to determine if increased lighting is having an effect on the orientation of nesting female turtles and on hatchlings dispersing from their nesting sites to the ocean (during the same nights as sky glow assessments). A long-term baseline dataset going back to 1969 provides a highly effective baseline for monitoring nesting female turtles. This involves monitoring of several parameters during the two week peak period of the nesting season. Six years of full season monitoring was also completed in the 1990s, with the results of full season and two week monitoring showing a very strong correlation. Monitoring will also be conducted at the flatback nesting beach of Avoid Island, within the Broad Sound Islands National Park (located approximately 80 km south-east of Hay Point),Avoid Island which will serve as a control site.

Avoid Island is an important flatback turtle rookery of eastern Australia (Limpus *et al.* 2002), with several hundred females nesting annually. Unpublished data relating to nesting flatback turtles indicates that Wild Duck Island, Curtis Island and the Woongara Coast have similar nesting patterns, which differ from that of the nearby Peak Island, which appears to be in a gradual state of decline (C. Limpus, pers. comm.). Thus, monitoring nesting flatback turtles at Avoid Island (rather than the geographically closer Peak Island) will assist in determining whether any future declines detected in nesting success parameters at Curtis Island are part of a region-wide phenomenon, or are potentially related to the LNG facilities. Avoid Island is located north of Shoalwater Bay in a largely undeveloped part of the Central Queensland coast. In Year 10, a final standard nesting census will be completed at Curtis Island and Wild Duck Island, near Shoalwater Bay.

The behaviour of nesting female turtles will be measured in the several ways. For each night during the peak nesting season (4 weeks), adult turtles will be monitored as they land on the beach, individually identified and their tracks assessed once they leave the beach to measure the angle of entry and orientation from water to nest (if nesting successful) for comparison with the direction of any artificial light. Full season monitoring will also be completed once at approximately Year 5 (Curtis Island and Avoid Island), to provide a detailed account of the entire nesting season, and examine the number of clutches laid per female (which can only be determined from full season monitoring). The full season monitoring will also provide data to support comparisons with previous full season monitoring assessments of the 1990's and will provide information on how representative the 4 week annual monitoring results are of the entire nesting season. For each night during hatchling emergence (14 days), the path of hatchlings from nests to the water will be

measured for direction and angle of incidence for comparison with the direction of artificial light and the direct line of access to the beach. This analysis will be conducted yearly for the first five years, and related to the results of the sky glow monitoring.

For each of these monitoring components, the control chart approach will be used to determine whether multiple environmental parameters indicate a significant change requiring further investigation. The approach will yield sufficient replicates (approximately 50 nesting adults and potentially thousands of emerging hatchlings) to produce statistically-sound observations when compared with the long-term DEHP datasets and provide further data to assess the potential issues raised by Hodge *et al.* (2006) relating to the disorientation of turtles when on nesting beaches of the Gladstone region. Details of the turtle nesting monitoring project are provided in *Table 17*, with details of the hatchling monitoring provided in *Table 18*.

Monitoring of the dispersal of hatchlings at sea in response to light from LNG ships is not proposed, as LNG ships will generally move straight into Port Curtis upon arrival in Gladstone, avoiding the need for anchoring offshore. Such operational factors will significantly reduce the potential for impacts from lighting associated with LNG ships on dispersing turtle hatchlings. Once ships are moored at the LNG facilities, their lighting may make a small contribution to the overall sky glow. The magnitude of such influences will depend on the number of ships moored at any given time, the duration of their stay and the operational and safety requirements for lighting once a ship is moored. The potential contribution of lighting on moored ships to the overall sky glow will be monitored as part of the night time sky glow assessments.

Table 17: Details of Monitoring Project – Turtle Nesting Beaches

Objective	**Provide data on nesting flatback turtles from Curtis Islands and Avoid Island (control site) to allow the development of control charts and predictive demographic models, to detect any change in the long-term trend. Conduct final standard nesting census at Curtis Island and Wild Duck Island in Year 10.** **Address EPBC Act Conditions III a, b, c, d (Section 1.1).**
Methods	Annual monitoring of nesting turtles – saturation flipper tagging and PIT tagging during four week period at Curtis Island and Avoid Island (control site) index beaches. Conduct one whole of nesting season tagging census around Year 5 (mid-point of the LTTMP's implementation), by applying the same techniques as four week monitoring for the entire nesting season and assessing the number of clutches laid per female.
Baseline	Existing data for 2 week periods since 1969 and 6 years of whole season monitoring in the 1990s as held by DEHP on Curtis Island. Similar data exists for Avoid Island, collected by John Parmenter of Central Queensland University (CQU). The program will expand the period of data collection (to four weeks) and continue to lower variance and increase power. Control charts will be developed to monitor change.
Baseline results	Mean of 55 (±12 SD, n=18) flatback turtle nestings per 2 week period on Curtis Island. Mean of 56 (± 15 SD, n=6) flatback turtle nestings over full season on Curtis Island. Approximately 50 eggs per clutch Re-nesting interval of 16 days with a remigration interval of 2.7 years Not all data published, although a summary of findings is in preparation (GPC in prep). LNG proponents will work with DEHP and Central Queensland University to undertake further analysis of baseline data, which will be presented in first annual report.
Funding and administration	Continue annual monitoring for a minimum of 5 years (plus a final census in Year 10) to determine changes in response to baselines. Existing DEHP project, with some coordination oversight by ERMP. Work closely with DEHP and Central Queensland University to enhance existing projects, where possible.
Environmental variables to be monitored	All nesting (predominantly flatback) turtles during extended Index period to have morphometric data collected and be individually identified. Nesting success to be recorded. Track angles from ocean to nest and nest to ocean to be calculated. Number of nesting females, mean clutch size and frequency, failed nesting attempts, hatchling emergence, and hatchling failure to be measured. Where nesting fails, information on the inferred reason for the failure is to be recorded. Clutches laid per female to be monitored during whole of nesting season census at approximately Year 5.
Statistical analysis	Control charts depicting trends. Regression analysis of track angle deviation from perpendicular. Provide data at Power >0.8 Desktop modelling of flatback turtle nesting population size for each of the key rookeries in the Gladstone region, in Year 10.

Table 18: Details of Monitoring Project – Hatchling Disorientation and Dispersal

Objective	**Provide data on hatchling disorientation caused by sky glow or lights offshore, post commencement of LNG facility operations.** **Address EPBC Act Conditions III a, b, c, d (Section 1.1).**
Methods	Monitoring will be completed for a period of four weeks, with data collected at various stages across the lunar cycle. Weather disruptions during the four weeks of field work may prevent the collection of data on each night of the lunar cycle. Up to four weeks of field work at Curtis Island during hatching period, annually for a minimum period of five years. Monitor hatchling emergence tracks in the sand for signs of disorientation. Monitor sites of high light intensity for aggregation of post emergence hatchlings. In the years when sky glow monitoring is being completed, hatchling disorientation and dispersal monitoring will be conducted on the same nights as sky glow monitoring, so that the results of hatchling dispersal can be directly linked with quantitative data from the sky glow assessment. Sky glow results will also be compared with those of a previous study (Pendoley Environmental 2012).
Baseline	New project (supplement of existing James Cook University project).
Baseline results	James Cook University collects baseline data, which is currently unpublished (C. Limpus pers. comm.). The LNG proponents will work with James Cook University to review baseline data and contribute to further collaborative studies. From other studies, it has been identified that short wavelengths, diffuse lumination, lack of topographical cues and natural light intensity influence hatchling orientation.
Funding and administration	Annual monitoring in Years 1-5, with the need for continuation reviewed thereafter, based on the results of hatchling dispersal and sky glow monitoring. New Project, with potential to enhance existing James Cook University study and establish links.
Environmental variables to be monitored	Light intensity, light wavelength, vegetation topography, hatchling numbers, hatchling orientation with respect to the line of direct access to the ocean and light sources, predator prevalence around high light intensity, hatchling mortality.
Statistical analysis	Angle of variance from direct line of access to the ocean and from light sources determined. Comparison to known angles. Statistical unit individual based on predetermined angle considered to be affecting orientation (using environmental variables as trigger points). Regression analysis. Provide data at Power >0.8 The results of the hatchling disorientation project will be related to the results of the night time sky glow assessment, to determine whether any disorientation detected may be related to light produced by the LNG facilities.

5.4.3 General indirect impacts

Of the areas examined for the development of this plan, the greatest deficits in baseline information exist in the general indirect impacts category. Accordingly, analytical techniques will be focussed on detecting signs of environmental stress and, where possible, relating these to project activities assessed to pose the greatest risk to marine turtles and their habitats.

Turtle habitat use and home range

Acoustic tracking arrays will be placed within Port Curtis in the vicinity of the LNG facilities and used along with satellite tags to track tagged green turtles to determine patterns of habitat use and the size of home ranges.

This will provide important qualitative information to assist in evaluating the accuracy of the risk assessment, in terms of the location of marine turtles and their distribution in the areas surrounding the LNG facilities. The duration of monitoring and number of tagged turtles will be determined following a review of initial data, in order to provide statistically-robust information on habitat use and home range size. Details of this monitoring project are provided in *Table 19*.

Table 19: Details of Monitoring Project – Turtle Tracking to Determine Habitat Use

Objective	**Determine habitat use of a representative sub-sample of green turtles within Gladstone Harbour.** **Addresses EPBC Act Conditions III a, c.**
Methods	Use of acoustic tracking arrays placed on green turtles and satellite tags to geospatially determine seagrass bed and habitat use. Initially, five turtles will be tagged simultaneously with acoustic tags and GPS satellite tags as a means of calibrating the accuracy of the acoustic system. The results of this initial monitoring will be reviewed and the number of turtles tagged with both acoustic and GPS satellite tags increased if required to provide statistically–robust data. The monitoring activity will detect deviation caused by commercial activities and time spent in areas of high commercial traffic/potential for environmental stress. The number of turtles to be tracked with acoustic tags will be determined based upon statistical analysis of preliminary data. In the event that acoustic monitoring is found to be ineffective in achieving the monitoring objectives, then GPS satellite tags will be used exclusively. In addition, 20 green turtles will be tracked with satellite tags over a two-year period in 2019 and 2020, conducted typically in winter and spring. Tagging will include turtles from a range of sizes, with a focus on small and medium sized turtles using small satellite tags to minimise disruption to their behaviour or movement.
Baseline	Existing project (GISERA - funded by APLNG/CSIRO) with pending results. Implemented with the assistance of DEHP and James Cook University turtle specialists, which will provide links with other tracking studies in the area.
Baseline results	To be presented by GISERA at conclusion of Phase 1 of study (2014).
Funding and administration	Annual monitoring divided into phases. Commence activities in 2012. Conclude in 2014. Funded by GISERA. Undertaken by researchers of CSIRO and DEHP. Monitoring activity to be extended beyond 2014 for up to 10 years if the results of first three years of monitoring are inconclusive in determining habitat use. Monitoring post 2014 will focus on satellite tagging and determining habitat use in areas of Port Curtis where LNG activities are based. The need for monitoring post 2014 was determined in consultation with scientific experts and the Department of the Environment.
Environmental variables to be monitored	Foraging turtle habitat use, dugong habitat use, seagrass survey, seagrass health, commercial vessel usage of area, integrated modelling of measured parameters and habitat use by turtles of different sizes.
Statistical analysis	Geospatial modelling. p

Seagrass Health Assessments

Given the importance of seagrass health to that of foraging green turtle populations (which are the cohort of highest cumulative risk), the extensive existing seagrass monitoring will be continued. This will aim to identify changes in the distribution and quality of seagrass habitats as a foraging ground for green turtles (and other species from time to time). Details of this monitoring project are provided in *Table 20*.

Table 20: Details of Monitoring Project – Assessment of Seagrass Health

Objective	**Provide data on the species composition, distribution, biomass and cover of seagrass beds throughout Port Curtis.** **Address EPBC Act Conditions III b, c, d.**
Methods	Seagrass surveys at permanent study sites. New sites relevant to LNG facilities to be added as part of the ERMP and GISERA projects, as described in GPC (2011c) and GISERA (2011).
Baseline	Existing project by DEEDI (2005-2011), with ERMP and GISERA data to commence from 2012.
Baseline results	Seagrass surveys in Gladstone Port since 2005 (some sites) by DEEDI. Studies indicate stable species composition and recovery of habitats post 2011 flooding.
Funding and administration	Existing project by ERMP examining seagrasses once per year for a minimum of 5 years. Existing project by GISERA to develop a seagrass model for Port Curtis and collect data once per year for a minimum of three years.
Environmental variables to be monitored	Seagrass composition, seagrass biomass, canopy height, algae and epiphyte cover. Contaminant (organic or inorganic) levels in seagrass roots and sediment to be measured if indicated.
Statistical analysis	One-way ANOVA. Control charts. Power > 0.8.

Turtle Biology, Disease and Population Health

The objective of this component of monitoring is to directly measure the health of marine turtles within the Gladstone region and utilise advanced diagnostic tools to determine the prevalence of any negative health effects. Integration with the annual surveys conducted by DEHP and their collaborators through programs such as the GISERA and ERMP provide a significant existing platform to conduct these investigations. These monitoring programs (health surveillance and necropsy examination) will provide direct evidence of any influence that industrial activities are having on marine turtle health.

Surveillance of the health of foraging juveniles and adult turtles will be conducted every year (where possible) and immediately after any adverse natural or anthropogenic event throughout the 10 year monitoring program. The project will be focussed on foraging green turtles within Port Curtis, as these are the cohorts most likely to be impacted by the LNG projects. This will be achieved by health surveillance that will follow the protocols outlined by Flint (2012) and utilise findings by Flint *et al.* (2010) for Queensland and Eden *et al.* (2011) for the Gladstone region as baselines from which to compare findings.

Turtles will be caught for examination using standard procedures developed by DEHP, which may include the capture of turtles while basking on land or using turtle rodeo techniques. Both of these methods have previously been applied successfully within the Boyne Estuary of Gladstone (Gaus *et al.* 2012). The use of tunnel nets is an alternative capture method which may be applied at the discretion of turtle researchers and relevant State approval agencies which administer scientific purposes permits and animal ethics approvals for the research. Monitoring will be integrated with the existing GISERA, DEHP and ERMP programs.

Health assessment of turtles will include, but not be limited to, an assessment of physical abnormalities (injuries or growths), body condition, haematology and blood biochemistry, biopsy of lesions, assessment of breeding condition (laparoscopy) and neurological status. Locations for the assessment will focus on the Pelican Banks area to the east of the LNG sites and possibly the Boyne River Estuary, which are also long term seagrass monitoring sites and are subject to existing ERMP studies. Depending what is found on physical examination, abnormalities will have secondary diagnostics such as microbiology and pathology conducted to ensure an accurate diagnosis of cause of disease.

Further, if indicated from environmental cues such as seagrass health, water quality or population trends, all data will have appropriate diagnostics conducted including screening for pathogens and systemic abnormalities. Given their proportionally higher abundance, it is anticipated that sampling numbers will be dominated by green turtles.

The LNG proponents acknowledge advice provided by Associate Professor Colin Limpus from DEHP on the number of turtles required to be sampled to obtain sufficient data to detect changes in the population status, based on extensive experience in similar studies (200 turtles sampled annually will provide sufficient information on population structure, with 50-100 turtles sampled annually sufficient for determination of length/weight relationships). Thus, the project will aim to sample 200 turtles annually with details of this monitoring project provided in *Table 21*. However, it is recognised that sampling may not be able to be conducted in some years, due to factors outside of the control of the LNG Proponents (e.g. COVID-19 pandemic, crocodile sighting). However, monitoring will be conducted over a period of approximately 10 years and target the capture of approximately 200 turtles per year (i.e., capture of approximately 2,000 turtles over the life of the LTTMP).

Table 21: Details of monitoring project – health assessment of turtles within Port Curtis

Objective	**Provide data on the health status of live turtles in Port Curtis to monitor for declining population health as a consequence of LNG facility operations.** **Address EPBC Act Conditions III a, b, c (Section 1.1).**
Methods	Health assessment of turtles captured during capture-mark-recapture population surveys, using suitable capture methods as advised by research scientists, such as turtle rodeo, collecting turtles while basking on land and tunnel netting. Collection of basking turtles and land and turtle rodeo techniques are suitable for shallow waters and have been applied successfully within the Boyne River Estuary of Gladstone (Gaus *et al*. 2012). Tunnel netting may also be suitable in areas where water is turbid. All capture techniques will be selected by qualified turtle researchers and subject to the assessment and granting of relevant state permits and approvals, such as animal ethics approval and a scientific purposes permit. Assessment includes a physical examination, body condition, haematology and blood biochemistry (including pollutant load), biopsy of lesions, assessment of breeding condition in females (laparoscopy) and neurological status.
Baseline	Significant enhancement to existing DEHP and ERMP projects involving capture-mark-recapture program and assessment of age classes. Foraging areas in the vicinity of the LNG projects will be selected, and will include the Pelican Banks and Boyne River Estuary (which are existing seagrass monitoring sites of GPC). Algal foraging areas will also be considered for monitoring in consultation with turtle researchers. Turtle capture methods may include rodeo, tunnel netting and capture of animals while basking. Gaus *et al*. (2012) successfully sampled 9 turtles using the rodeo method and 31 turtles that were basking on land in the Boyne Estuary.
Baseline results	30 year dataset for South-east Queensland (some limited data for Gladstone). Health assessment through DEHP investigations, notes animals of poor condition. A 2011 study of the Gladstone region (post-flooding) provides a baseline for clinical health, disease processes and potential environmental links for such diseases. Long-term seagrass health data are available from GPC at selected sites, which will assist in relating the results of turtle health assessment with the health of foraging areas.
Funding and administration	Existing DEHP and ERMP project assessing population biology, with additional financial support provided by LNG proponents to perform health surveillance. Every year (if possible) for 10 years; and following catastrophic natural events (e.g. floods) and if any diseases of significance are identified. Each year in the annual report, an assessment of the progress of the monitoring activities in achieving their objectives will be presented.
Environmental variables to be monitored	Live turtle health (physical examination, body condition, haematology and blood biochemistry, biopsy of lesions, and neurological status), in conjunction with existing programs that assess juvenile recruitment, sex ratios, age class structure, breeding rates of adults, growth rates, annual survivorship by age class, and condition status. If required, water quality and seagrass health will be integrated into assessment.
Statistical analysis	Power >0.8 based on one-way ANOVA of healthy and unhealthy animals. Control charts derived from long term data. Individual disease processes will require veterinary expertise to interpret significance of disease as it relates to epidemiology and LNG facility activities, presented as confidence intervals.

For dead turtles that strand within the Gladstone region of suitable condition to allow tissue sampling, a necropsy examination will be facilitated and funded by the LNG proponents through collaboration with DEHP. Necropsies will only be performed by trained personnel as identified by DEHP. Necropsy examination will follow the protocols outlined by Flint *et al.* (2009).

This approach will allow for identification of potential anthropogenic influences on turtle survivorship including fishing activities and environmental degradation, as well as serve as an important early warning indicator as to the effects of other measured parameters on marine turtle health such as natural causes of death.

Identification of industrial-related disease syndromes in multiple carcasses will act as trigger point from which expert advice would be sought. The benefits of this monitoring project are that zoonoses and emerging diseases can be identified in their early stages and it will target the life cycle cohorts at highest cumulative risk from project-related activities. Details of this monitoring project are provided in *Table 22*.

Table 22: Details of Monitoring Project – Identifying Causes of Marine Turtle Strandings

Objective	**To provide data on cause of death and identify increases in the prevalence of disease.** **Addresses EPBC Act Conditions III b, c, d (Section 1.1).**
Methods	Perform comprehensive necropsy examinations on stranded turtles as per established techniques to determine cause of death, the prevalence of disease, baseline and ongoing contaminant levels in tissues during the 10 years of monitoring.
Baseline	Data on turtle condition for over 30 years. Data on turtle causes of mortality in SE Queensland in the 1990's and from 2006 to present. Data on Gladstone region post catastrophic natural event (effect of environmental stressors) in 2011.
Baseline results	Shifts in disease prevalence noted with environmental stressors. Turtles are delayed indicators of changes in environmental health. Multifactorial events result in some disease proliferation (e.g. spirorchiidiasis, secondary microbial pathogens and fibropapillomatosis) over others (e.g. gastrointestinal and buoyancy disorders).
Funding and administration	Supplement existing DEHP stranding program by funding detailed necropsies by qualified personnel for suitable carcasses. Up to a maximum of 30 per year to a suitably qualified veterinarian for assessment (additional to boat strike numbers above). Samples to be sent for analysis immediately after collection.
Environmental variables to be monitored	Causes of sea turtle mortality, spatial and temporal trends, and responses to localised events and activities. In addition, other collaborative project information can be utilised to link necropsy findings with environmental factors to assess LNG facilities activity as a risk factor. Obtain baseline information on the concentration of contaminants within turtle tissues, for use as a comparison in the event of a spill or similar contamination event. Determine how the concentration of contaminants changes over time through ongoing monitoring.
Statistical analysis	Power >0.8 based on one-way ANOVA of natural and LNG facility-related causes. Individual causes of mortality will require veterinary expertise to interpret significance of death and implication as it relates to the activities of LNG facilities, presented as confidence intervals.

Habitat Utilisation by Inter-Nesting Flatback Turtles

There is no baseline data available on the habitat used by flatback turtles during their inter-nesting period. Turtles are likely to move into Port Curtis and utilise marine environments in close proximity to nesting beaches during the inter-nesting period. As inter-nesting turtles are a particularly important cohort to the conservation of flatback turtles in the Gladstone region, and their existing exposure to LNG facility risks is not fully understood, satellite tracking of 10 nesting flatback turtles will be conducted for the first 3 years of the LTTMP. Monitoring of inter-nesting flatback turtles will also be completed at the Avoid Island control site. This will provide data on the habitat use of inter-nesting flatback turtles, and allow risks associated with boat strike and indirect impacts to be further evaluated. Details of this monitoring project are provided in *Table 23*. LNG ships will generally move straight into port upon arrival at the Port of Gladstone, minimising the potential for impacts from ship lighting. The potential contribution of ship lighting to the overall sky glow will be monitored (see *Table 16*).

Table 23: Details of Monitoring Project – Habitat Use By Inter-Nesting Flatback Turtles

Objective	**Determine habitat use by inter-nesting flatback turtles.** **Address EPBC Act Condition III a.**
Methods	Three years of annual satellite tracking of at least ten (10) flatback turtle females off Curtis Island, and at least ten (10) flatback turtle females at the Avoid Island control site. Satellite tags will have time depth recorders and GPS, and will provide data on habitat use during the inter-nesting period. The risk assessment will be adjusted as necessary on the basis of the results. Analysis of the results will assess the interaction between inter-nesting females and the dredged channels/ship movements. In Year 10, one year of satellite tracking of 20 flatback turtle females off Peak Island and 20 flatback turtle females off Wild Duck Island.
Baseline	Enhancement of existing ERMP Project, for which five (5) turtles are tracked per year. Will build upon previous study of inter-nesting flatback turtles and their diving behaviour adjacent to Curtis Island by Sperling *et al*. (2010).
Baseline results	Sperling *et al*. (2010) found 57% of dive time spent on the seabed inactive, with mean dive time 80 (+/- 12) minutes. Only 10% of time was spent at or near the surface. Maximum dive depth of 29 m, reflecting bathymetry of the region.
Funding and administration	Annually (or as determined from results of initial monitoring). Funded by LNG Proponents.
Environmental variables to be monitored	Inter-nesting flatback turtle habitat use, range (in relation to navigation channels) and adjacent areas, time spent in each habitat type, re-nesting interval, time spent at various depth profiles and climatic data. Foraging habitat characteristics and migration routes.
Statistical analysis	Geospatial modelling. Results will be qualitative and assist in reassessment of project risks. Desktop assessment of foraging habitat characteristics and home range sizes of flatback turtles in Year 10.

5.5 Management Response Triggers

In the event that significant changes (as described below) in marine turtles or their habitats are detected by the monitoring program through time, the following management response triggers will be considered for implementation, as appropriate:

5.5.1 One Standard Deviation Of Change

1. For results where multiple environmental parameters (more than one independent biological variable) have deviated by more than 1 standard deviation from their long-term mean (approximating an 80% power metric), the results will be referred to an independent scientific expert or a panel comprised of multiple scientific experts for advice on the possible mechanisms for the change and whether they may be project-related or associated with a region-wide event such as a flood.

2. In the event that the change is considered by an independent scientific review to be real and reasonably likely to be related to impacts caused by the LNG facilities, the existing mitigation actions and monitoring steps will be reviewed by the LNG proponents, based upon the advice received from the independent scientific expert or the panel comprised of multiple independent scientific experts.

3. A report containing the monitoring results, the advice of the independent scientific expert review and the results of the review of mitigation actions and monitoring program will be submitted to the Department of the Environment for its information within 14 days of the report being finalised.

5.5.2 Two standard Deviations Of Change

1. Where trends for multiple parameters deviate more than two (2) standard deviations from their long term mean (approximating a 95% metric power), the LNG proponents will undertake consultation as soon as reasonably practical with an independent scientific expert or panel comprised of multiple scientific experts.

2. In the event that the change is considered by the independent scientific review to be real and reasonably likely to be related to impacts caused by the LNG facilities, any practical mitigation measures to reduce project-related risks to marine turtles will be identified and implemented. Further targeted monitoring actions may also be undertaken, at the recommendation of the scientific expert/s, to assist in determining whether the change is properly characterised as being related to impacts caused by the LNG facilities.

3. Where a change is considered on expert review to be likely to be related to impacts caused by the LNG facilities, a report identifying the initial trends, a summary of the outcomes of the review of mitigation and monitoring measures and a description of any proposed actions will be provided to the Department of the Environment within 14 days of the report being finalised.

The implementation of recommended management responses will commence immediately following a review or report indicating that changes to marine turtles or their habitat are an impact in response to project-related activities. The Department of the Environment will be immediately notified when a management threshold is triggered or when any incident involving marine turtles occurs as a result of project activities.

5.5.3 Mitigation Actions

In the event that a management response is required , additional mitigation actions will be developed to address the project-related activity contributing to the detected impact. Scientific experts will guide this part of the management process. Some examples of potential management responses (to address hypothetical scenarios) are as follows:

- Review of the LNG Proponents' respective Shipping Management Plans, to identify additional opportunities to modify operations to reduce environmental risk to marine turtles and their habitats (e.g. in response to high levels of project-related boat strikes or disturbance of foraging habitat).

- Review of the LNG Proponents' respective Plans of Operations, to identify alternative operational practices that will reduce environmental risk to marine turtles (e.g. changes to lighting practices in the event of a high project contribution to the night time sky glow).

- Increase monitoring of potential project-related discharges to the marine environment (e.g. in the event that contamination of turtle tissues that could be caused by project-related activities is detected) with a view to identifying and eliminating the source of contamination.

These examples are intended only to provide some context around the process of implementing management response triggers. In addition to scientific experts, the LNG Proponents will engage with relevant stakeholders in the development and implementation of mitigation actions.

6.0 MANAGEMENT, FUNDING, AUDITING AND REVIEWS

Monitoring aspects of this LTTMP will be implemented by the three LNG proponents in partnership where agreement is able to be reached, with funding arrangements generally shared equally or as otherwise agreed among the LNG proponents. Each proponent will annually report its annual contribution to implementation of the LTTMP in its Annual Environmental Return that is published following each anniversary of the approval of the LTTMP. Each LNG proponent will be responsible for implementing the management and mitigation measures outlined at their respective LNG facility under their existing approvals. In relation to dredging aspects of the project, the mitigation and management measures will be implemented by GPC through its completion of dredging on behalf of the LNG proponents, as GPC is responsible for all dredging works and has separate approvals in place.

As noted in the EPBC Act approval conditions relating to the LTTMP, it is preferred to have a coordinated approach to the management of marine turtles across the Gladstone region. The proponents already fund many of the planned monitoring activities through the ERMP 10 year monitoring program, administered by GPC and established to monitor potential impacts of the Western Basin Dredging Project on Port Curtis and Port Alma. A similar framework will be established for the coordination and implementation of the monitoring programs in this LTTMP, utilising suitably qualified independent experts. This may involve the ERMP or some other suitably structured organisation, to provide for an appropriate level of independence.

The coordinating organisation will be responsible for implementing the following key tasks:

- Procuring and managing the implementation of all scientific monitoring activities associated with the LTTMP;
- Commissioning an annual review report on the effectiveness of the management measures outlined in the LTTMP, with any additional measures adopted in the event that an impact has been detected. This shall be prepared in consultation with the LNG proponents and the independent scientific expert/s and provided to the Department of the Environment within 60 days of the anniversary of the approval of this plan, and
- Coordinating access to a suitably qualified, independent scientific experts, who will be engaged to provide advice on the likely causal factors and effective management responses in the event that an impact on marine turtles is detected during the implementation of this plan.

The LNG proponents will provide an annual review report on the effectiveness of the management measures and operating controls directed at avoiding impacts on marine turtle species, as required by the EPBC Act approval conditions. The annual report will not include reporting on GPC's activities in relation to the management of dredging, which is outside of the scope of this plan. Preparation of the review report will be jointly funded by equal contributions from the three LNG proponents, with the review report structured generally as follows:

- Description of mitigation measures and operating controls implemented;
- Overview of monitoring results and implications for marine turtle species and their habitats, and
- Evaluation of the need for improvements to the conduct of operations and activities, based on the results of monitoring. If an impact on any marine turtle species is identified management measures and operating controls to mitigate impacts will be outlined.

The review report will be provided to the Department of the Environment within 60 days of each anniversary of the approval of the plan.

In the event that an impact is identified on any marine turtle species during the implementation of the plan, a report will be submitted to the Department of the Environment within 30 days of detecting the impact, outlining recommendations for improved management measures and operating controls.

An audit of performance against commitments outlined in the plan will also be completed and submitted to the Department of the Environment for its information. A biannual (minor) review of the LTTMP will be conducted by the LNG proponents to evaluate the performance of the LTTMP against its objectives and the EPBC Act approval conditions. A major review will be conducted after five years, at the mid-point of the plan's currency. Each of these periodic reviews will be submitted to the Department of the Environment for its information. Following completion of ten years implementation of the LTTMP, a report will be submitted to the Department of the Environment comprising: a) tables and/or diagrams summarising the data collected for all monitoring projects, b) all findings from the monitoring projects and any management responses, and c) the report of an independent peer-review of: the monitoring projects; all findings and management responses; a statistical analysis of the robustness of the data and findings of the monitoring projects; and recommendations regarding any further monitoring required to satisfy the EPBC approval conditions in respect of the LTTMP. Should there be clear scientific evidence that a continuation of some monitoring activities is necessary beyond the 10 year life of the plan to satisfy the EPBC Approval conditions regarding the LTTMP, then such findings will be reported and future monitoring activities considered at that time, in consultation with the Department of the Environment.

Performance measures to be assessed and considered at periods of review will include:

- Mitigation measures implemented;
- Monitoring plan implemented;
- Monitoring results interpreted, peer-reviewed and reported at required frequency;
- Any impacts associated with LNG projects on marine turtles and their habitats assessed and described;
- Plan amended (under the guidance of independent peer review) to provide additional protection to marine turtles and their habitats, in the event that an impact on marine turtles and/or their habitats is detected;
- Approved amendments to the plan to improve the protection of marine turtles and their habitats implemented, and
- Compliance with EPBC Act approval conditions.

In early 2026, the LNG Proponents submitted the final report summarising all findings of the 10+ year monitoring plan, and an accompanying report of an independent peer-review of the LTTMP to the Department of Climate Change, Energy, the Environment and Water. Annual Reports describing the findings of monitoring activities and assessing the effectiveness of mitigation measures were also submitted to the Department in August of each year from 2016 to 2025 inclusive (total of 10 Annual Reports).

The final report and independent peer-review confirmed that the LTTMP had been implemented effectively and satisfied the relevant conditions of approval under the EPBC Act. Mitigation measures outlined within the LTTMP to avoid and/or reduce impacts of the projects on marine turtles and their habitats will continue to be implemented by the LNG Proponents.

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APPENDIX A – ASSESSMENT OF COMPLIANCE WITH EPBC APPROVAL CONDITIONS

EPBC Condition Number			EPBC Condition	Description of compliance and reference to sections of LTTMP
GLNG 2008/4057	QCG 2008/4402	APLNG 2009/4977		
34	34	52	*Within six months of this approval, the proponent must:* *Contribute an initial amount of $150,000 towards preparation of a long term marine turtle management plan; and* *Participate in industry wide discussions with the Gladstone Ports Corporation and other port users (including LNG proponents) with a view to establishing a long term marine turtle management plan and future funding requirements for the plan.*	Compliance achieved. Details of expenditure are provided in the annual reports of LNG proponents. Industry-wide discussions occurred with the Gladstone Ports Corporation, with a view to establishing a long term turtle management plan. Refer to Section 1.
35	35	53	*If terms of the long term marine turtle management cannot be agreed on an industry wide basis (within the Port of Gladstone) within six months of this approval, then the proponent must prepare a long term marine turtle management plan in consultation with other LNG proponents who have confirmed an intention to establish an LNG Facility on Curtis Island.*	Compliance achieved. Refer to all sections of this Long Term Turtle Management Plan.
36a	36a	54a	*The plan (in either case referred to above), must include:* *A program to establish comprehensive baseline information on populations of marine turtles that utilise the beaches and nearby waters of Curtis and Facing Island (including the Green Turtle Chelonia mydas, the Loggerhead Turtle Caretta caretta, and the Flatback Turtle Natator depressus);*	Compliance achieved. Significant baseline monitoring has been completed for a range of relevant environmental parameters. Additional monitoring is also proposed. Refer to Section 2, Section 5 and Appendix B.
36b	36b	54b	*A monitoring program to measure and detect changes to the marine turtle populations over a period of at least 10 years from commencement of the program. Monitoring methods must have the ability to detect changes at a statistical power of 0.8, or an alternative statistical power as determined in writing by the Minister;*	Compliance achieved. A detailed monitoring program has been developed, targeted at the environmental parameters most relevant to measuring and detecting a change to marine turtle populations and their habitats. Monitoring methods have the ability to detect changes at a statistical power of 0.8. Refer to Section 5 and Section 6.
36c	36c	54c	*The identification of significant activities relating to the construction and operation of LNG facilities (or in the case of an industry wide plan, activities within the Port of Gladstone) with the potential to cause adverse impacts on marine turtles;*	Compliance achieved. Significant activities with the potential to cause adverse impacts on marine turtles are discussed in detail, referring to relevant literature where appropriate. Refer to Section 3.
36d	36d	54d	*Management measures including operating controls and design features to help manage and avoid adverse impacts to marine turtles shown to be adversely impacted by LNG operations (or in the case of an industry wide plan, activities conducted within the Port of Gladstone). In relation to the LNG operations, management measures will include any reasonable and practicable measures found necessary or desirable to minimise disturbance to marine turtles from gas flaring, and from lighting of the LNG plant and ships moored at the loading berth (except where the adoption of measures would be in contravention of health and safety legislative requirements).*	Compliance achieved. Reasonable and practical management measures including operating controls and design features have been described in detail. Refer to Section 3 and Section 4.

EPBC Condition Number			EPBC Condition	Description of compliance and reference to sections of LTTMP
GLNG 2008/4057	**QCG** 2008/4402	**APLNG** 2009/4977		
36e	36e	54e	*Identification of annual contributions by the proponent, other LNG proponents who have confirmed an intention to establish an LNG facility on Curtis Island and, in the case of an industry wide plan, contributions by other port users.*	Compliance achieved. The LNG proponents will fund mitigation measures relating to their own operations and site to comply with this plan. The LNG proponents will share the funding of ongoing monitoring programs through the ERMP structure and by jointly funding equally monitoring and reporting measures additional to those of ERMP. Annual independent auditing and reporting will be funded jointly by the three LNG proponents, with costs shared equally. Expenditure will be reported by the LNG proponents in their annual reports. Refer to Section 6.
37	37	55	*The Long Term Marine Turtle Management Plan must be submitted for the approval of the Minister at least 3 months before the planned date of the commissioning of the first LNG train. The approved Plan must be implemented.*	Compliance achieved. The planned date of the commissioning of the first LNG train is late 2014 (QGC). The submission of this plan for assessment in Q1 2013 meets the requirements of this approval condition.
38	38	56	*Within 60 days of each anniversary of the approval of the plan the proponent must provide a review report ("the Report") of the effectiveness of the management measures and operating controls directed at avoiding impacts on the marine turtle species. Note: the review report may be provided by the Gladstone Ports Corporation or another entity on behalf of the proponent.*	Compliance achieved. The monitoring plan outlines an annual reporting requirement which is consistent with this condition. Refer to Section 5.
39	39	57	*If an impact on any of the marine turtle species is identified, the report must recommend improvements to the conduct of those operations and activities which are found to have a causal connection with the identified impact. The Minister may require improvements to be implemented. Note: To avoid doubt, if a condition of another approval held by the proponent requires a Turtle Management Plan, the proponent may simultaneously meet the relevant requirements of both conditions by submitting a single plan. The plan may also be prepared and implemented in consultation with the Gladstone Ports Corporation or other bodies.*	Compliance achieved. The monitoring plan outlines management response triggers which will require the input of independent scientific experts and the reassessment of mitigation action and monitoring activities, in the event that a potential impact on marine turtles is identified. Refer to Section 5.

APPENDIX B – RESULTS OF THE GAP ANALYSIS

Gladstone Marine Turtle Studies

Study Description	Summary of content and owner (where relevant)	Important points	Value to LTTMP	Reference
Marine Strandings update - September 2012	Provides information on marine megafauna strandings in Queensland (Queensland Government - DEHP).	Brief table includes Gladstone strandings compared with the rest of Queensland since 2009. Significant decrease in turtle strandings since 2011 (when there was a flood event).	Very High	Department of Environment and Heritage Protection (2012) Marine strandings until 30 September 2012
Chelonia mydas - Species Profile and Threats Database (SPRAT Profile)	Provides summary information for the species including distribution, nesting, feeding, threats and legal information (Commonwealth Government – SEWPaC).	Curtis and Facing Islands are identified as important nesting and inter-nesting habitats in Queensland. Light disturbance is covered. Provides information on the population in the southern Great Barrier Reef.	Very High	Department of Sustainability, Environment, Water, Population and Communities (2012). *Chelonia mydas* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Tue, 6 Nov 2012 01:23:57 +1100
Natator depressus - Species Profile and Threats Database (SPRAT Profile)	Provides summary information for the species including distribution, nesting, feeding, threats and legal information (Commonwealth Government – SEWPaC).	Outlines lifecycle including important nesting areas. Identifies key threats, outlines major studies and management strategies to be taken into account. Curtis island as a key nesting beach. Effects of lighting are discussed.	Very High	Department of Sustainability, Environment, Water, Population and Communities (2012). Natator depressus in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from:http://www.environment.gov.au/sprat. Accessed Tue, 6 Nov 2012 01:01:55 +1100
Report for Marine megafauna and acoustic monitoring - autumn survey	Provides information on EPBC listed species and their presence in the Gladstone region. Marine megafauna fauna survey of Port of Gladstone in 2011 recording marine fauna including turtle observations. Provides comparisons over previous surveys. Provides information on direct and indirect impacts (Gladstone Ports Corporation).	Recent survey identifying sightings in the area, provides information on direct and indirect impacts in relation to projects in the area.	Very High	GHD (2011) Gladstone Ports Corporation: Report for Marine Mega fauna and Acoustic Survey - Autumn Survey. Prepared by GHD on behalf of Gladstone Ports Corporation. November 2011.
Report for Marine megafauna and acoustic monitoring - summer survey	Provides information on EPBC listed species and their presence in the Gladstone region. Marine megafauna fauna survey of Port of Gladstone in 2011 recording marine fauna including turtles. Provides comparisons with previous surveys. Provides information on direct and indirect impacts on marine megafauna (Gladstone Ports Corporation).	Recent survey identifying sightings in the area.	Very High	GHD (2011) Report for Marine Mega fauna and Acoustic Monitoring - Summer Survey. Prepared by GHD on behalf of Gladstone Ports Corporation. June 2011.
Gladstone Ports Corporation Report for Western Basin Dredging and Disposal Project Marine Ecology Assessment	Provides an overview of the marine ecological values of the Western Basin Project area. In relation to turtles, it identifies seagrass habitat and macroinvertebrate communities which may be important foraging habitat for various turtle species. It also records incidental observations of marine megafauna in the study area (Gladstone Ports Corporation).	Turtles had a high presence within the Western Basin study area, indicating a potential foraging habitat for turtles.	Very High	GHD 2009 Report for Western Basin Dredging and Disposal Project, Marine Ecology Assessment, report for Gladstone Port Corporation (http://www.westernbasinportdevelopment.com.au/media/pdf/EIS%20Appendix%20Q.pdf
GPC 2011-2012 Annual Report Managing Our Environment	Provides information on outcomes of 2011-2012 Environmental Management System (Gladstone Ports Corporation).	Provides information on turtle monitoring program for 2011-2012 nesting census.	Very High	Gladstone Ports Corporation (2012) 2011 -2012 Annual Report Sustainability Managing Our Environment. http://annualreport.gpcl.com.au/managing-our-environment
Queensland Turtle Conservation Project: Hummock Hill island Nesting Turtle Study, 2006	Identifies low density turtle nesting on Hummock Hill Island and discusses management issues (Queensland Government – DEHP).	Low density nesting on Hummock Hill Island. Predators (dingoes and goannas) were observed in the area. Turtles described as disorientated from the Queensland Alumina refinery lights approximately 18 km north of the site. Indicates turtles in the area may be disorientated by light horizons tens of km's away. Light spillage from large ships also discussed in terms of the light horizon.	Very High	Hodge, W. J., Limpus, C.J., Smissen, P. Queensland Turtle Conservation Project: Hummock Hill Island Nesting Turtle Study

Study Description	Summary of content and owner (where relevant)	Important points	Value to LTTMP	Reference
A biological review of Australian marine turtles - Green turtle *Chelonia mydas*	General species information including nesting, distribution and potential impacts for green turtle	Identifies nesting habitats in the Great Barrier Reef. Identifies key impacts and foraging foods.	Very High	Limpus (2008). A Biological Review of Australian Marine Turtles. 2 Green turtle, *Chelonia mydas.*
A biological review of Australian marine turtles - Flatback Turtle *Natator depressus*	General species information including nesting, distribution and potential impacts for flatback turtles.	Curtis Island is an index beach for this species. Provides nesting information for Southern Queensland. Identifies key impacts on species.	Very High	Limpus (2008). A Biological Review of Australian Marine Turtles. 5 Flatback Turtle *Natator depressus*
Queensland Turtle Conservation Project Curtis Island and Woongarra Coast Flatback Turtle Studies, 2005-2006.	Provides information on the Curtis Island Population and the number of nesting females at the location (Queensland Government – DEHP).	Provides important information on the nesting population as Curtis Island is an Index beach for the eastern Australia turtle population for the 2005 survey. Data exists for other years but is not reported in this document.	Very High	Limpus, C.J., McLaren, M, McLaren G and Knuckey, B. (2006) Queensland Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtle Studies, 2005-2006, Environmental Protection Agency, Brisbane.
Queensland Turtle Conservation Project - Curtis Island Marine Turtle Nesting Study 1999-2000	Provides information on the Curtis Island Population and the number of nesting females at the location for the 1999 survey period (Gladstone Ports Corporation).	Provides information on the commencement of monitoring and information about the density of nesting activities.	Very High	Limpus, C.J, Gilmore., K. And Barrett, P. (2000) Queensland Turtle Conservation Project Curtis Island Marine Turtle Nesting Study: 1999-2000. Report to Gladstone Port Authority and Queensland Parks and Wildlife Service
Project Order - Towards an integrated study of the Gladstone marine system.	Identifies turtle and seagrass research program for Gladstone region (APLNG).	Identifies current and future monitoring in the Gladstone region. Provides a very useful insight into the scale and type of monitoring programs already committed to by LNG proponents.	Very High	Gas Industry Social and Environmental Research Alliance (2011) Project Order Proforma 2011 - Towards and integrated study of the Gladstone Marine System.
Queensland Curtis LNG Significant Species Management Plan	Provides Information on management plans for EPBC species. Includes information on turtle ecology, distribution, preferred habitats and potential distribution within the Narrows crossing (QGC).	Good turtle profiles and information on distribution within the Narrows crossing. Provides information on prior management and mitigation measures in the area .	Very High	Queensland Curtis LNG (2011) Significant Species Management Plan QCLNG Export Pipeline - Narrows Crossing Project
GLNG Dugong and Turtle Management Plan	Provides information on marine turtles including nesting and foraging. Includes specific information for Port Curtis and a management plan for the Santos GLNG project.	Information on turtle species in Port Curtis and previous management examples in the region.	Very High	URS (2009) Turtle and Dugong Management Plan. Report prepared for GLNG
DEHP Strand Net annual stranding reports	Provides information on the distribution of species and GPS coordinates of turtle strandings for each year up to 2011 (Queensland Government – DEHP).	Combining this information with distribution data will provide a useful overview of what is present and what proportion of animals is susceptible to strandings (i.e., cohort of interest for management plans).	High	Biddle, T.M., & Limpus, C.J. (2011) Marine wildlife stranding and mortality database annual reports 2005–2010. Marine Turtles. Conservation Technical and Data Report 2010 (1). 1–124.
Health Assessment of Green Turtles in South and Central Queensland Following Extreme Weather Impacts on Coastal Habitat during 2011	Identifies the health of green turtle populations in Queensland after 2011 floods with studies in Moreton Bay, Shoal water Bay and Gladstone.	Turtle populations in Gladstone (Boyne River) were in the poorest condition with malnutrition the most likely cause of ill health. Turtle populations of the Pelican Banks were also in poor condition due to malnutrition.	High	Colin J. Limpus, Duncan J. Limpus, Michael Savige and Damon Shearer (2012). Health assessment of green turtles in South and Central Queensland following extreme weather impacts on coastal habitat during 2011. Conservation Technical and Data Report 2011 (4): 1-13.
Port of Gladstone Western Basin Strategic Dredging and Disposal QLD (EPBC 2009/4904) Annual Environmental Report	Provides an overview of marine monitoring activities for 2011 and identifies monitoring projects as required by the project (Gladstone Ports Corporation).	Identifies ERMP research program for Western Basin including ambient light study, turtle nesting studies, monitoring of index beaches Peak Island and Curtis Island, light impact research, regional survey of turtle nesting, turtle foraging studies. Identifies areas where turtles were recorded in the study. Provides seagrass data information for 2011. Useful overview of monitoring activities that have been committed to.	High	CQC Consulting (2011) Port of Gladstone Western basin Strategic Dredging and Disposal Project, QLD (EPBC 2009/4904) Annual Environmental Performance Report

Study Description	Summary of content and owner (where relevant)	Important points	Value to LTTMP	Reference
Lepidochelys olivacea - Species Profile and Threats Database (SPRAT Profile)	Provides summary information for the species including distribution, nesting, feeding, threats and legal information (Commonwealth Government – SEWPaC).	No concentrated nesting in Australia. Low density nesting recorded in Northern Australia. Diet mostly molluscs. Identifies key risks.	High	Department of Sustainability, Environment, Water, Population and Communities (2012). Lepidochelys olivacea in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from:http://www.environment.gov.au/sprat. Accessed Tue, 6 Nov 2012 01:25:06 +1100
Caretta Caretta - Species Profile and Threats Database (SPRAT Profile)	Provides summary information for the species including distribution, nesting, feeding, threats and legal information (Commonwealth Government – SEWPaC).	Does not identify nesting in Gladstone. Outlines lifecycle and describes an extensive foraging area at Heron Island. Identifies major threats including fishing, coastal development, light pollution and boat strike, and outlines management plans.	High	Department of Sustainability, Environment, Water, Population and Communities (2012).Caretta caretta in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from:http://www.environment.gov.au/sprat. Accessed Tue, 6 Nov 2012 01:23:02 +1100
Dermochelys coriacea - Species Profile and Threats Database (SPRAT Profile)	Provides summary information for the species including distribution, nesting, feeding, threats and legal information (Commonwealth Government – SEWPaC).	No major nesting in Queensland. No leatherbacks recorded nesting in Queensland since 1996.	High	Department of Sustainability, Environment, Water, Population and Communities (2012). *Dermochelys coriacea* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from:http://www.environment.gov.au/sprat. Accessed Tue, 6 Nov 2012 01:25:06 +1100
Eretmochelys imbricata - Species Profile and Threats Database (SPRAT Profile)	Provides summary information for the species including distribution, nesting, feeding, threats and legal information (Commonwealth Government – SEWPaC).	Outlines life cycle. No nesting in Gladstone. Lighting and coastal development risks, fishing and pollution are discussed.	High	Department of Sustainability, Environment, Water, Population and Communities (2012). *Eretmochelys imbricata* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from:http://www.environment.gov.au/sprat. Accessed Tue, 6 Nov 2012 01:25:06 +1100
Incorporating marine turtle habitats into the marine protected area design for the Great Barrier Reef Marine Park, Queensland, Australia.	Provides requirements to design a sea turtle conservation program in an area of high conservation importance.	Gives parameters required for successful turtle nesting and foraging within a marine protected area using the Great Barrier Reef as an illustrative example.	High	Dobbs, K., Fernandez, L., Slegers, S., Jago, B., Thompson, L. J., Hall, J., Day, J. Incorporating marine turtle habitats into the marine protected area design for the Great Barrier Reef Marine Park, Queensland, Australia. Pacific Conservation Biology 2003;13:293-302
Recovery Plan for Marine Turtles in Australia	Provides information about turtle populations within Australia. Identifies threats, management and monitoring techniques (Commonwealth Government – DotEE).	Identifies recovery actions for turtle species including management of direct and indirect threats including lighting, boat strike, vehicle collisions and oils spills.	High	Department of the Environment and Energy (2017). Recovery Plan for Marine Turtles in Australia (2017-2027). Commonwealth of Australia.
Port of Gladstone Western Basin Strategic Dredging and Disposal Project EIS Supplemental Information	Provides information on environmental values in project area (Gladstone Ports Corporation).	Good information on animal interactions with vessels and identifying compulsory speed limits.	High	Gladstone Ports Corporation (2010) Port of Gladstone Western Basin Dredging and Disposal Project EIS Supplementary Information Document
A biological review of Australian marine turtles - Loggerhead Turtle *Caretta caretta*	General species information including nesting, distribution and potential threats for the loggerhead turtle.	Does not identify nesting in Gladstone. Outlines lifecycle, extensive foraging area on Heron Island . Identifies major threats including fishing, coastal development, light pollution, boat strike and outlines management plans.	High	Limpus (2008). A Biological Review of Australian Marine Turtles. Loggerhead turtle, *Caretta caretta* (Linneaus)
A biological review of Australian marine turtles - 3. HAWKSBILL TURTLE, *Eretmochelys imbricata* (Linnaeus)	General species information including nesting, distribution and potential threats for the hawksbill turtle.	No nesting in Gladstone. Identifies potential threats to the species.	High	Limpus (2008). A Biological Review of Australian Marine Turtles. 3. HAWKSBILL TURTLE, *Eretmochelys imbricata* (Linnaeus)
A biological review of Australian marine turtles - Olive Ridley Turtle *Lepidochelys olivacea*	General species information including nesting, distribution and potential threats for the olive ridley turtle.	No nesting in southern Queensland. Foraging in the Great Barrier Reef Marine Park.	High	Limpus (2008). A Biological Review of Australian Marine Turtles. 4 Olive Ridley Turtle *Lepidochelys olivacea*

Study Description	Summary of content and owner (where relevant)	Important points	Value to LTTMP	Reference
A biological review of Australian marine turtles - LEATHERBACK TURTLE, *Ermochelys coriacea* (Vandelli)	General species information including nesting, distribution and potential threats for the leatherback turtle.	Outlines life cycle. No nesting in Gladstone. Risks for the species are discussed.	High	Limpus (2008). A Biological Review of Australian Marine Turtles. 6 LEATHERBACK TURTLE, *Ermochelys coriacea* (Vandelli)
Australian Hawksbill Turtle Population Dynamics Project	Provides Information of Australian Hawksbill Turtle ecology and results of surveys (Japan Bekko Association).	Chapter 4 provides relevant information about the distribution an abundance of marine turtle nesting in northern and eastern Australia with specific information for Curtis and Facing islands. This includes aerial and ground surveys. Includes distribution maps for all six species found in Australia.	High	Limpus, C.J. and Miller, J.D. (2008) Australian Hawksbill Turtle Population Dynamics Project. A report prepared for the Japan Bekko Association.
Queensland Curtis LNG Environmental Impact Statement - Marine Ecology Report	Provides an overview of marine environmental factors in the Gladstone region. Provides information on turtle numbers in Gladstone and potential impacts from the development (QGC).	Provides a good map of turtle nesting sites and a table on turtle nesting activity for Gladstone. Identifies impacts of shipping activities.	High	Queensland Curtis LNG (2009) Environmental Impact Statement Volume 5, Chapter 8 Marine Ecology
Australia Pacific LNG Project Appendix I - Marine Mammal and Turtle Management Plan	Provides an overview of turtles in the Gladstone region. Identifies direct and indirect impacts (APLNG).	Describes previous management measures for the area and identifies legislative framework for the LNG facility.	High	Worley Parsons (2010) Australia Pacific LNG Project Appendix I - Marine Mammal and Turtles Management Plan. LNG Facility.
Description of techniques for the forensic analysis of boat strike injuries on carcasses of manatees in Florida, and relating this to the types of vessels responsible for the injury.	Illustrative description of forensic examination techniques and implications for boat strikes on manatee in Florida.	Information on the types of vessels responsible for boat strike injuries can be obtained through forensic examination of manatee carcasses. A similar approach to the examination of turtle carcasses is appropriate (though not discussed by the authors).	High	– Rommel SA, Costidis AM, Pitchford TD (2007). Forensic methods for characterizing watercraft from watercraft-induced wounds on the Florida Manatee (*Trichechus manatus latirostris*). Marine Mammal Science 23(1): 110-132.
Study of the diving behaviour of inter-nesting flatback turtles at Curtis Island.	Provides information on the time spent by flatback turtles at various depths during the inter-nesting period.	Majority (57%) of dive time spent on the sea bed inactive, with mean dive time 80 (+/- 12)_minutes, Only 10% of time spent at or near the surface. Maximum dive depth 29 m.	High	Sperling JB, Grigg GC, Limpus CJ (2010). Diving behaviour in two distinct populations of gravid flatback turtles, *Natator depressus*. Australian Zoologist 35: 291-306.
Australia Pacific LNG project EIS - Marine Ecology Technical Report Transmission Pipeline	Identifies that six turtles are found in Australia and describes their conservation status under IUCN, EPBC and NC Act. Provides general information about turtles and an overview of Curtis island nesting activities and foraging (APLNG).	Flatback turtle nesting is described with a medium density rookery noted. Sporadic green and loggerhead turtle nesting described. Foraging items for species are outlined and the nesting density for species are described.	Moderate	Australia Pacific LNG (2010) Australian Pacific LNG Project Volume 5: Attachments, Attachment 19: Marine Ecology Technical Report - Transmission Pipeline
Australia Pacific LNG APLNG Shipping Activity Management Plan (Submission for EPBC Act Approval)	Identifies potential impacts to marine fauna and flora (seagrass) from shipping (APLNG).	Identifies previously used management activities in the Gladstone region.	Moderate	Bechtel (2011) Australia Pacific LNG Project - APLNG Shipping Activity Management Plan (Submission for EPBC Act Approval). Prepared by Bechtel OG&C and Affiliates on behalf of Australia Pacific LNG Pty Ltd.
Environmental Impact Statement Arrow LNG Plant. Chapter 19 Marine and Estuarine Ecology	Provides general habitat information for Port Curtis. In relation to turtles it provides specific information about Gladstone turtle populations. Includes a description of nesting habitats and a good map of densities (Arrow Energy).	Provides a useful summary of turtle values and a map of population densities.	Moderate	Coffey Environments (2012) Environmental Impact Statement Arrow LNG Plant. Chapter 19 Marine and Estuarine Ecology
Study of the impacts of light from the Arrow LNG facility on Curtis Island (in preparation).	Pendoley Environmental is currently completing a study of the lighting considerations for the proposed Arrow LNG facility on Curtis Island (Arrow). It is expected to include predicted light impacts at Facing Island (east and west side), South End and Connors Bluff and descriptions of the night time ambient light regime.	Results not yet available. Arrow site is in direct line of sight to turtle nesting beaches, unlike the other proponents. Nevertheless, is likely to have some relevance to the LTTMP when complete.	Moderate	Pendoley Environmental (in prep.). Assessment of the night time ambient light regime and predicted impacts of the proposed Arrow LNG facility on Curtis Island (note publication not sighted by project team – pers. comm. Michael Lammp).
Environmental Impact Statement Arrow LNG Plant. Chapter 32 Cumulative Impacts	Identifies potential cumulative impacts on environmental values in the Gladstone region (Arrow Energy).	Identifies speed reductions and increased vigilance as the main mitigation measures. Identifies a direct view from LNG Facility to nesting sites at the south end.	Moderate	Coffey Environments (2012) Environmental Impact Statement Arrow LNG Plant. Chapter 32 Cumulative Impacts

Study Description	Summary of content and owner (where relevant)	Important points	Value to LTTMP	Reference
Fitzroy River Estuary Development Proposals - A review of issues	Identifies nesting turtles in the Gladstone region and potential impacts on turtles including disorientation by lighting (Fitzroy Basin Authority).	Identifies light pillage of vessels as a potential issue on Peak Island turtle population. Identifies key threats and foraging foods.	Moderate	Eberhand, R. (2012) Fitzroy River Estuary Development Proposals- A review of issues. Prepared for Fitzroy Basin Association
Briefing- Western Basin Dredging and Disposal Project Environmental Impacts	Provides an overview of results associated with environmental monitoring of the Western Basin dredging (Gladstone Ports Corporation).	Provides information on strandings in the Gladstone region compared with other parts of Queensland.	Moderate	GPC (2011) Briefing: Western Basin Dredging and Disposal Project - Environmental Impacts. 26 October 2011
QGC Shipping Activity Management Plan - Construction Phase	Outlines shipping management plans and identifies potential impacts to marine fauna and flora (seagrass; QGC).	Provides a map for turtle nesting beaches and previously used management activities in the area.	Moderate	QGC (2011) Shipping Activity Management Plan - Construction Phase QCLNG Project
Australia Pacific LNG- Environmental Impact Statement Supplementary	Provides information about the environmental values of the area and addresses questions and comments in response to the EIS (APLNG).	Not much new information - addressing comments.	Low	Australia Pacific LNG (2010) Australian Pacific LNG Project Supplemental information to the EIS Marine Ecology Pipeline. http://www.aplng.com.au/pdf/eis/supp/PipelineMarineEcology.pdf
Queensland Coastal Plan - Annex 7 Turtle nesting areas	General information about nesting of leatherback, hawksbill, green turtle and olive ridley turtles (Queensland Government – DEHP).	Provides guidelines and actions for Capricornia Cays National Park including modification of light sources and revegetation of foredune area.	Low	DERM (2012) Queensland Coastal Plan Annex 7
Environmental Impact Statement Fishermans Landing Northern Expansion - Chapter 11 Nature Conservation	Identifies environmental values in the study area and potential impacts and mitigation measures (Gladstone Ports Corporation).	Identifies turtle observations in the area and previous mitigation measures.	Low	Gladstone Ports Corporation (2009) Environmental Impact Statement Fishermans Landing Northern Expansion
GLNG Project - Environmental Impact Statement Supplement	Provides information on environmental values in the project area (GLNG).	Provides information on turtle and dugong management (covered as a different reference).	Low	GLNG (2009) GLNG Project Environmental Impacts Statement Supplement. Report Prepared for GLNG
QGC Environmental Impact Statement Supplement	Provides further information on environmental values in project area (QGC).	Primarily addresses comments. Not much new information on turtles.	Low	Queensland Curtis LNG (2009) Environmental Impact Statement Supplemental Report
Queensland Curtis LNG Environmental Impact Statement EPBC Act Assessment Report	Provides information on EPBC Protected Species in the Project area (QGC).	Provides information on turtles in the area. This is more thoroughly covered in the Marine Ecology Report.	Low	Queensland Curtis LNG (2009) Environmental Impact Statement Volume 13, EPBC Act Assessment Report
Queensland Curtis LNG Environmental Impact Statement - Assessment of the Environmental Impacts of the Swing Basin and Channel Construction	Provides information on existing environmental factors, impacts of the swing basin and channel and management procedures for construction for QCLNG (QGC).	Provides information on turtles in the area. This is more thoroughly covered in the Marine Ecology Report.	Low	Queensland Curtis LNG (2009) Environmental Impact Statement Volume 6, Environmental Assessment of Swing Basin and channel construction
GLNG Marine Ecology Technical Report (URS)	Marine ecological assessment of Port Curtis conducted by URS. There were no turtle sightings and limited information about turtles provided. Information about seagrass habitat is outlined (GLNG).	Information about seagrass habitat.	Low	URS (2009) GLNG Marine Ecology Technical Report. Prepared for GLNG Ltd.
Port Curtis Ecosystem Health Report 2008-2010	Provides an overall health assessment for Port Curtis in a report card style (PCIMP).	The only information on turtles is the importance of seagrass as a food source.	Very Low	PCIMP (2011) Port Curtis Integrated Monitoring Program Port Curtis Ecosystem Health Report 2008-2010. Available from: http://www.pcimp.com.au/PDFs/PCIMP%20Report%202008-2010.pdf Accessed Tue, 6 Nov 2012 01:01:55 +1100
Queensland Curtis LNG Environmental Impact Statement – Appendix 5.6 Reptiles and Amphibians Report	Provides a very brief outline of turtles in the survey area (QGC).	Very brief information on turtles.	Very Low	Queensland Curtis LNG (2009) Environmental Impact Statement Volume 5, Appendix 5.6 LNG Facility Reptiles and Amphibian Report

APPENDIX C – REPORT FROM INDEPENDENT EXTERNAL REVIEWER – DR MARK HAMANN