



# **Prelude Floating LNG Project EIS Supplement-Response to Submissions**

**Shell Development (Australia) Proprietary Limited  
EPBC 2008/4146**



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# 1 INTRODUCTION

This supplement to the Prelude Floating Liquefied Natural Gas (LNG) Project Draft Environmental Impact Statement (Draft EIS) presents Shell Development (Australia) Proprietary Limited's (Shell's) consideration and response to the submissions received during the public consultation period for the Prelude Floating LNG Project Draft EIS.

The Draft EIS and this supplement collectively make up the Prelude Floating LNG Project Final Environmental Impact Statement (Final EIS) for the proposed Prelude Floating LNG Project and are provided to the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) for its assessment under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the EPBC Act, DEWHA makes recommendations on the Project to the Commonwealth Environment Minister who makes a final decision on the environmental approval of the Project.

The Draft EIS and supplement were prepared by Shell as the proponent and operator of the proposed Prelude Floating LNG Project. The Draft EIS was available for public comment for 30 business days between October 12th and November 20th 2009. This Supplement is also published as required under the EPBC Act.

## 1.1 SUPPLEMENT-RESPONSE TO SUBMISSIONS

Three submissions were received during the public review period, all from individuals. These being from:

1. Rudi H.Overmars, Victoria
2. Ari Chakrabarti, Western Australia
3. Simon Dean, Malaysia

Comments were also received from DEWHA on the 4th December 2009.

Copies of these submissions are included in Appendix A, and the comments are addressed in detail in Section 2 in this supplement.





## 2 RESPONSE TO SUBMISSIONS RECEIVED

Shell has reviewed the four submissions received for the Draft EIS and prepared responses to the issues and questions raised in accordance with the requirements of the EPBC Act. The four submissions raised 19 individual issues. A cross-reference table is provided in Appendix B which details where the response in this supplement can be found for the issues raised in the submissions. The following section details Shell's responses to the four submissions received.

### 2.1 ERRATA

Reference Number	Submission Party	Issue Raised
1	Rudi H.Overmars	<ul style="list-style-type: none"> <li>Table 6.30 page 169. Reservoir CO<sub>2</sub> Should be 966,000 instead of 966</li> <li>Page 285 mV is millivolt. not megavolt.</li> </ul>

Thank you for reporting these two errors. A corrected Table 6.30 from the Draft EIS is provided below.

**Table 6.30** Annual CO<sub>2</sub> equivalent Emissions from the Prelude FLNG Project

Tonnes per year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> e	%
Reservoir CO <sub>2</sub>	966,000	370	0	973,728	42.4
Fuel combustion	1,259,664	114	2.4	1,262,688	54.9
Flaring	57,792	101	2	60,480	2.6
Fugitive	0	101	0	2,016	0.1
Total	2,283,456	686	4.4	2,298,912	100

### 2.2 HYDRODYNAMIC MODELLING OF LIQUID DISCHARGES

#### 2.2.1 Generation of bromoform from cooling water

Reference Number	Submission Party	Issue Raised
2	Rudi H.Overmars	Page 160 <i>chlorine</i> . It is well known that free residual chlorine in waste water can result in the formation of toxic, carcinogenic chlorinated organic compounds. This is accepted because the benefits of chlorination far exceed the small potential problems these chlorinated compounds can cause. However I cannot understand how bromium containing organic compounds such as bromoform are formed as a result of chlorination. Is this via natural occurring bromium compounds in sea water?



Both bromine and bromoform (CHBr<sub>3</sub>) occur naturally in seawater. Bromoform, a trihalomethane, is also produced as a byproduct of the chlorination process used to prevent marine growth in the FLNG cooling water system (see Section 4.7.8 of the Draft EIS). Bromoform is formed when three of the four hydrogen atoms of methane (CH<sub>4</sub>), found in naturally occurring organic matter within the water column, are replaced by bromine atoms. Bromine is relatively abundant in seawater with a concentration typically around 85 ppm. The modelling of chlorine by-products presented in Section 6.7.5 of the Draft EIS observed a maximum concentrations for bromoform of 4.9 µg/l which is several magnitudes of order lower than known toxic concentrations.

### 2.2.2 Hydrodynamic modelling

Reference Number	Submission Party	Issue Raised
19	DEWHA	<p><b>Discharge of waste</b></p> <p><i>Discharge of cooling water</i></p> <p>..... Thus we recommend the proponent undertake hydrographical modelling to determine the flow and dispersal characteristics of discharged heated sodium hypochlorite treated water, and whether this poses a harm risk to the marine environment. Measures will also need to be taken to ensure that seawater intakes do not pose a significant risk to marine fauna.....</p> <p><i>Food waste and putrescibles</i></p> <p>.....It is likely the discharge of these materials will increase nutrient levels in the waters around the facility. We recommend the proponent assesses the potential impacts that enhanced nutrient levels may pose the marine environment, and (if necessary) how these may be mitigated.....</p>

Section 6.7 of the Draft EIS describes the hydrodynamic modelling of liquid discharges from the FLNG Facility undertaken for the Draft EIS. The range of modelling undertaken is also summarised in Table 6.20 of the Draft EIS, which is presented below. “The hydrodynamic model chosen to assess the impacts of the FLNG facility on the physical marine environment is the Generalized Environmental Modelling System for Surface Waters (GEMSS®) using a nested grid covering a region of approximately 30 by 30 km, with finer resolution around the discharge locations (Figure 6.9) (ERM, 2009a)” (Section 6.7.4 of the Draft EIS, p156). A copy of the modelling report (ERM, 2009a) was also provided to DEWHA on 23 July 2009 along with the Draft EIS.

Results of the modelling of the cooling water discharge are presented on pages 160-161 of the Draft EIS. Modelling included assessment of free residual chlorine levels, chlorine by-products and temperature dispersion. The cooling water plume temperature is modelled as being within the required 3°C of the surrounding ocean water temperature within 15-20 m of the discharge point, comfortably meeting the World

Table 6.20 Summary of Modelled Impacts

Waste Stream	Constituents
PFW	• BTEX, NPD and PAH compounds
	• Residual MEG within the PFW that is not recovered through the MEG regeneration unit
	• MEG brine from the MEG regeneration unit
Cooling water	• Temperature
	• Chlorine
	• Dissolved oxygen (DO)
Wastewater (sewage/ grey water/drainage)	• Total Suspended Solids
	• Coliforms
	• Oil and grease
Implications associated with the combined effects of wastewater discharged and discharge of cooling water (deep water extraction)	• Nutrients
	• Oxygen demand
	• Chlorophyll-a
	• DO

Bank guideline of achieving this temperature within 100 m. The risk assessment presented in the Draft EIS concluded *“Given the very localised temperature changes compared to the size of the receiving environment and the very low concentrations of chlorine and chlorine by-products, the magnitude of impact from the discharge of cooling water is low and impacts are unlikely, the significance of impact is therefore assessed to be minor.”*

Mitigation measures to ensure that seawater intakes do not pose a significant risk to marine fauna presented in the Draft EIS included:

- *“Automatic biocide dosing, quality control and feedback systems will be incorporated into the FLNG facility design”*
- *“Screens will be installed on the cooling water riser inlets and inlet current speeds will be low (estimated at 0.5 m/s) to prevent the ingress of large marine fauna into the cooling water system”*

Results of the modelling of the wastewater discharge (sewage, putrescibles, greywater and deck drainage) as well as the combined discharges of wastewater and cooling water are presented on pages 161-163 of the Draft EIS. The cooling water discharge was included in the assessment of nutrients as the FLNG’s cooling water system transfers a large quantity of waters from 150m below the Prelude Facility to near the ocean surface. Deeper water typically contains higher nutrients and lower Dissolved Oxygen (DO) concentrations than surface waters.

To investigate if the addition of nutrients was likely to result in increased phytoplankton growth in surface waters, modelling of the impact on nutrients and oxygen demand levels on chlorophyll concentrations was undertaken. Based on the results of this investigation, the Draft EIS concluded *“The modelled maximum concentration of chlorophyll-a is lower than the clear water default trigger value (0.5 µg/l) and the modelled maximum DO difference is only 3% of the average value. Furthermore, the area of impact is very small, within 100 m of the discharge. Small plumes develop at each of the four discharge pipes and at the aft surface, where waves and currents quickly disperse and dilute the plumes. As such, potential impacts are assessed to be minor.”*

## 2.3 GREEN HOUSE GAS RELATED SUBMISSIONS

### 2.3.1 Name of other LNG facilities used for benchmarking

Reference Number	Submission Party	Issue Raised
4	Ari Chakrabarti	In EIS for recent LNG projects in Australia, benchmarked comparison has been presented, and it shows specific names of each project. For Prelude project, similar comparison should be presented also.

Figure 6.18 of the Draft EIS was presented to enable comparison of Prelude’s Green House Gas (GHG) intensity with similar projects (benchmarking). This was also a requirement as stipulated in DEWHA’s Prelude EIS guidelines (See Appendix A of the Draft EIS). A copy of Figure 6.18 from the Draft EIS is also presented below.

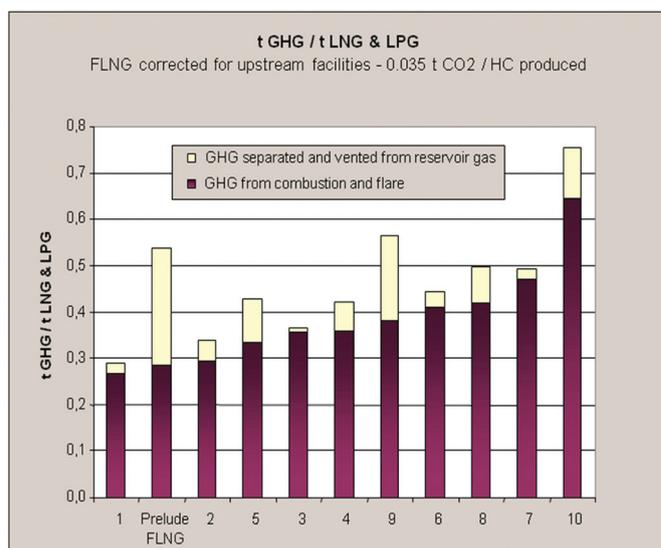
As stated in Section 6.8.2 of the Draft EIS: *“Figure 6.18 presents a comparison of GHG intensity for a group of 10 existing world scale LNG facilities benchmarked against the Prelude FLNG facility. These ten LNG Plants account for about 70% of current total global LNG capacity ie about 140 mtpa LNG production.”*



Benchmarking is a process which enables comparison of a chosen performance metric (GHG intensity in this case) between different projects. Each participant is able to see how they compare to their peers whilst their own specific performance is kept confidential from the other participants. Shell is not able to publicly name the 10 other facilities included in the GHG intensity comparison presented in Figure 6.18 of the Draft EIS, as they are confidential. Prelude’s GHG intensity can still be compared and ranked without the inclusion of facility names.

As shown in Figure 6.18 and discussed in detail in Section 6.8.2 of the Draft EIS, the FLNG liquefaction process is energy efficient but Prelude’s higher reservoir CO<sub>2</sub> levels contribute to its GHG footprint. See also the response to Submission Reference Number 7 presented in Section 2.3.5 of this document for further discussion of Prelude’s GHG intensity compared to other proposed LNG projects.

**Figure 6.18** GHG Intensity Comparison



### 2.3.2 Calculations of GHG intensity of LNG facilities for benchmarking

Reference Number	Submission Party	Issue Raised
3	Ari Chakrabarti	Draft EIS Figure 6.18 shows comparison of GHG intensity for a group of 10 existing world scale LNG facilities benchmarked against the Prelude FLNG facility. However, it is not clear how the figures of 10 existing facilities have been estimated. The detailed calculation basis, including amount of subtracted as upstream operation, should be elaborated.

The data used in Figure 6.18 of the Draft EIS was based on results of a benchmarking study undertaken by Shell Global Solutions International using their proprietary methodology which was designed to ensure a “like-for-like” comparison. For calculating the CO<sub>2</sub> emissions from each participant, the following data is requested:

- feedgas and fuelgas composition(s);
- fuelgas and liquid fuel usage by gas turbines, boilers, furnaces, incinerators and engines;
- amount of gas flared and vented;
- flare efficiency;
- condensate sales by road, ship and rail;
- condensate storage quantity and tank type (floating roof, internal roof, fixed roof); and
- for methane losses – the number of flanges, valves, seals, pumps, relief valves, sampling points.

The upstream GHG intensity for Prelude was derived from the energy usage of more than 100 Shell upstream facilities across the globe over a number of years. It is an average figure only and was subtracted from the overall FLNG GHG intensity result to allow a direct comparison between the Prelude FLNG Facility and onshore LNG plants (which excluded the upstream energy usage).

### 2.3.3 Prelude fuel consumption emissions

Reference Number	Submission Party	Issue Raised
5	Ari Chakrabarti	EIS for recent LNG projects in Australia presents detailed basis of GHG emission, however, Prelude EIS does not show the basis of 1,260 ktpa in Table 4.6. Detailed estimate basis, such as CO <sub>2</sub> emission from steam boilers, steam consumption of various turbines, and so on, should be presented

The description of the Prelude FLNG liquefaction process in the Draft EIS has been written to enable any potential environmental impacts to be assessed and at a level sufficient for understanding by the general public.

Section 4.7.11 of the Draft EIS describes the utility systems on the Prelude FLNG facility. The major source of fuel combustion emissions are the six steam boilers running on low pressure fuel gas. These boilers generate high pressure steam used to drive compressors used in the liquefaction process and turbines to generate electricity for the process and facility, as well as low pressure steam for process heat. The compressors and turbines running off the steam generated by the boilers do not themselves generate any additional GHG emissions.

GHG emissions are presented and discussed in more detail in Section 6.8 of the Draft EIS. For assessing the environmental impacts of GHG emissions, it is the total emission volumes which are of interest rather than individual processes or sources. Nevertheless, Table 6.30 shows the contribution from reservoir CO<sub>2</sub>, combustion, flaring and fugitive sources.

The data presented in the Draft EIS enables the environmental impacts to be determined and managed, as described in Section 6.8 of the Draft EIS, and also meets the requirements of an EIS as outlined in DEWHA's Prelude EIS Guidelines. The request for more detailed information on CO<sub>2</sub> emissions and energy usage at an equipment level goes beyond what is required for consideration of the environmental impact of the project and would require disclosure of Shell proprietary information.

### 2.3.4 Use of steam boilers

Reference Number	Submission Party	Issue Raised
6	Ari Chakrabarti	It is commonly recognized in LNG industry that thermal efficiency of steam turbine driven will be lower than that of gas turbine driven.

The selection of the power generation and compressor driver type for the Prelude FLNG Project was subject to numerous studies and value engineering. Compared to a traditional onshore facility, a remotely located floating facility has some unique challenges which affect equipment selection. Whilst efficiency is an important consideration for any LNG plant, reliability is more critical for FLNG as the floating facility will be permanently moored offshore for ~25 years and have limited space and capacity on board for undertaking major maintenance or repair campaigns. The choice of steam for driving compressors and power generation turbines, whilst not as energy efficient as a combined cycle gas turboalternator or direct drive aeroderivative gas turbines, was selected because it offers:

- proven high reliability in a marine setting (steam boilers have been used on LNG ships for many decades);
- simpler operations and maintenance;
- reduced rotating equipment count (reduced complexity);
- use of low pressure fuelgas, which reduces the energy required to compress end flash gas for fuelgas;
- fuel gas composition flexibility which is important as FLNG is being developed as a generic solution to be deployed globally; and
- avoids the need for very large variable speed electric motor drivers or the use of fired equipment in the liquefaction module on FLNG.



Nonetheless, the Prelude FLNG liquefaction process is an energy efficient process compared to that used at many land-based LNG plants (see Section 2.3.5 of this document for further details). The efficiency gains offered by FLNG are detailed in Section 4.4.2 of the Draft EIS.

Reference Number	Submission Party	Issue Raised
11	Simon Dean	The selection of steam boilers for main power generation over a combined cycle gas turbine and waste heat recovery system means that you have to comply with World Bank EHS requirements of 320 mg/m <sup>3</sup> NO <sub>x</sub> concentration in the exhaust stream. A combined cycle gas turbine system would have a lower limit of 25 ppmv (equivalent to 47 mg/m <sup>3</sup> at 25C). Therefore, the selection of steam boilers for main power generation as opposed to combined cycle gas turbines is not the best available technology for minimisation of NO <sub>x</sub> emissions.

The choice of steam boilers for power requirements is discussed above. As outlined above, equipment selection is a multifaceted issue which typically involves trade-off between competing requirements. The Submission Party correctly highlights that steam boilers produce more NO<sub>x</sub> emissions than gas turbines. This is due to the simple burner arrangement of boilers compared to a gas turbine. However, Prelude will install Dry Low NO<sub>x</sub> burners in its steam boilers to minimize NO<sub>x</sub> emissions.

Oxides of nitrogen emissions can be of concern for three reasons:

- human health effects, including those associated with photochemical smog;
- generation of photochemical smog or acid rain in air sheds with high levels of nitrogen oxides; and
- Nitrous oxide (N<sub>2</sub>O), an oxide of nitrogen, is a greenhouse gas with a very high GHG warming potential of about 300 times that of CO<sub>2</sub>.

The Prelude FLNG facility will comply with Australian occupational health and safety requirements. This will be detailed and assessed as part of the approval process required from the National Offshore Petroleum Safety Authority (NOPSA), as discussed in Section 2.4.3 of the Draft EIS, and is outside the scope of this EIS.

It should also be noted that given Prelude's remote offshore location, health impacts on external parties from NO<sub>x</sub> emissions are not possible (also see Section 6.8.4 of the Draft EIS). The lack of other cumulative sources of NO<sub>x</sub> emissions within the region also protects against the potential for photochemical smog or acid rain generation.

For the Prelude Project, the greatest issue with NO<sub>x</sub> emissions concerns the contribution of N<sub>2</sub>O to Preludes' total GHG emissions. Prelude's GHG emissions, including N<sub>2</sub>O emissions, are discussed in section 6.8 of the Draft EIS. As detailed in Section 4.4.2 and 6.8 of the Draft EIS and Section 2.3.1 and 2.3.5 of this document, the overall GHG efficiency of the Prelude liquefaction process is better than many other existing or proposed LNG plants which use combined cycle gas turbine systems.

### 2.3.5 Prelude's GHG Intensity compared to other LNG facilities

Reference Number	Submission Party	Issue Raised
7	Ari Chakrabarti	<p>From the referrals of recent LNG projects in Australia, the emission rates (tGHG/tLNG&amp;LPG) are indicated as below.</p> <ul style="list-style-type: none"> <li>• North West Shelf Train 4 (2000) 0.44</li> <li>• Darwin (2002) 0.46</li> <li>• Gorgon (2004) 0.35</li> <li>• Pluto (2007) 0.33</li> <li>• Gladstone (2009) 0.35</li> <li>• Curtis Island (2009) 0.26</li> <li>• Prelude (2009) 0.33</li> </ul> <p>Compared to Curtis Island design, Prelude should have a lot of possibilities to improve emission rate and thermal efficiency</p>

There is indeed a wide range of reported GHG intensities for the various projects, with some of the variation caused by differences in the calculation basis. Therefore, to ensure a 'like-for-like' comparison, Shell chose to compare in a consistent manner Prelude FLNG's forecast emissions to the actual emissions from 10 existing LNG facilities that account for 70% of current world LNG capacity (see Figure 6.18 of Draft EIS and Section 2.3.2 of this document for further discussion).

To explore emission rates and efficiencies across an integrated project we use the proposed Queensland Curtis LNG project, discussed as Curtis Island (2009) in the above submission. From the Queensland Curtis LNG EIS we can derive the following comparison table covering both upstream and downstream components of LNG production.

CO <sub>2</sub> e source	Queensland Curtis LNG	Prelude FLNG
	CO <sub>2</sub> e tonnes per year	
Upstream	2,400,906*	1,325,184
Pipeline	39,479	
LNG Facility	2,856,914	
Reservoir CO <sub>2</sub> emissions	0	973,728
Production (LNG+LPG)	12,000,000	4,000,000
GHG Intensity (tGHG/tLNG+LPG)		
Full project excluding reservoir CO <sub>2</sub>	0.44	0.33
Full project including reservoir CO <sub>2</sub>	0.44	0.57

\* Corrected for a total of three trains of 4 MTPA capacity

Queensland Curtis LNG, like Prelude FLNG, has an efficient liquefaction process (0.26 and 0.29 tGHG/tLNG+LPG respectively). However, when upstream emissions are taken into account, the GHG intensity of the Curtis LNG development increases to 0.44 tGHG/tLNG+LPG<sup>1</sup>. By comparison, Prelude is located directly over the gas field and its combined upstream and downstream GHG intensity is 0.33 tGHG/tLNG+LPG if the contribution of reservoir CO<sub>2</sub> emissions is excluded. When Prelude's reservoir CO<sub>2</sub> emissions are included, Prelude's overall GHG intensity increases to 0.57 tGHG/tLNG+LPG.

<sup>1</sup> Queensland Curtis LNG will use coal seam methane as its feedstock. Coal seam methane gas does not contain CO<sub>2</sub> and does not produce LPG or condensate. Coal seam methane projects extract methane gas from coal seams at very low pressures and this gas needs to be compressed, and in the case of Curtis LNG piped a considerable distance to the LNG plant on the coast, before it is suitable for use in a liquefaction process.



Reference Number	Submission Party	Issue Raised
12	Simon Dean	The Pluto LNG GHG Abatement Program (copy attached) contains a graph (Figure 6) that shows the Tonnes of GHG per tonne of LNG produced. A rough calculation for Prelude indicates that the development will emit ~0.43 Tc CO <sub>2</sub> per Tc LNG (equivalent). This is hardly best in class so how does this compare to an onshore LNG facility?

Prelude FLNG’s GHG intensity is discussed in Section 6.8.2 of the Draft EIS and a comparison with current operating onshore LNG Plants is presented in Figure 6.18 (see also response to submission Reference Number 7 above). The Prelude FLNG facility is energy efficient in comparison to many land-based LNG plants but its overall GHG emissions are impacted by Prelude’s high reservoir CO<sub>2</sub> levels.

It is unclear how the Submission Party arrived at a GHG intensity for Prelude FLNG of ~0.43 tGHG/tLNG. Figure 6.18 in the Draft EIS shows Prelude’s GHG intensity for the LNG plant is 0.29 tGHG/tLNG&LPG (excluding upstream fuel usage and reservoir CO<sub>2</sub> emissions) and 0.54 tGHG/tLNG&LPG if the reservoir CO<sub>2</sub> emissions are included.

### 2.3.6 Carbon Pollution Reduction Scheme

Reference Number	Submission Party	Issue Raised
13	DEWHA	With regards to the discussion about the Carbon Pollution Reduction Scheme (CPRS), it was noted that your referral initially raised the possibility of using geosequestration as a method to reduce carbon emissions. Your draft EIS document also noted on page 100 that geosequestration may be considered at a later stage in the life of the project but provided no further commitment to this. Given the current uncertainty regarding the CPRS, the Department considers that Shell needs to outline further options to offset or mitigate green house emissions which will be implemented throughout the operation life of the facility

Shell has a global strategy on management of CO<sub>2</sub> that recognises what we call the three hard truths:

- Global energy demand is accelerating;
- Easy oil and gas supply will struggle to keep pace; and
- Climate stress makes dealing with CO<sub>2</sub> imperative.

Shell’s response to this for their global operations is to:

- Maximise efficiency of operations (*Prelude has a high thermal efficiency as described in the Draft EIS Sections 4.4.2 and 6.8.3 and Section 2.3.5 of this document*);
- Seek to use CO<sub>2</sub> capture and storage (*Prelude is investigating geosequestration – see below*);
- Leverage technology (*Prelude will use floating LNG which is a leading edge combination of their LNG, Offshore and LNG shipping technologies*); and
- Produce low CO<sub>2</sub> sources of energy (*Power stations using gas from LNG as a fuel emit half the CO<sub>2</sub> compared to coal*).

Shell advocates that a “cap & trade” system for large stationary sources of CO<sub>2</sub> emissions can create a global CO<sub>2</sub> market which will be the most effective means to incentivise industry to reduce their carbon footprint. Given the global concerns on climate change, we consider that by the time the Prelude FLNG Project commences operations in 2016, some type of system will be in place in Australia that puts a value on carbon emissions. Therefore, we view the current delays and uncertainties on the CPRS, or any alternative, as temporary and not significant enough to warrant any change in strategy for the Prelude FLNG Project.

Shell believes carbon capture and storage will be a key technology to combat climate change. For the Prelude FLNG Project, Shell is continuing to investigate possible means to geosequester Prelude’s reservoir CO<sub>2</sub> (See section 4.4.2 of the Draft EIS,

pages 53–56). However, whilst resolution of the significant technical and economic challenges involved with geosequestration for Prelude (described on pages 54-55 of the Draft EIS) is underway, it is not possible to guarantee that they can all be overcome. On this basis, Shell is not able to make a commitment on geosequestration of reservoir CO<sub>2</sub> for the Prelude FLNG Project. Geosequestration of reservoir CO<sub>2</sub> will only be undertaken if it can be demonstrated both within Shell and to external regulators, and within project timeframes, that geosequestration is technically and commercially viable.

At a project level, Shell’s HSSE Control Framework (see Section 2.8 of the Draft EIS) requires the development and maintenance of a Greenhouse Gas Management Plan. Prelude’s Greenhouse Gas Management Plan (see Section 7.7 of the Draft EIS) will present Prelude’s Greenhouse Strategy and an evaluation of energy efficiency and GHG abatement options. The plan will also capture Prelude’s obligations under the Energy Efficiency Opportunities and National Greenhouse and Energy Reporting Acts (see Section 2.3.3 of the Draft EIS).

Given the above, the basis upon which Shell has developed the Draft EIS and seeks environmental approval for the Prelude FLNG Project is as follows:

- The reservoir CO<sub>2</sub> will be safely discharged up the flare stack after its separation from the feedgas;
- Maximising energy efficiency and reducing emissions wherever practicable through design choices and good operation;
- Supporting the proposed Australian Carbon Pollution Reduction Scheme (CPRS) and meeting all obligations under the Scheme; and
- Undertaking further studies during design to further minimize flaring, optimize process availability and reliability and investigate geosequestration.

The Draft EIS concluded that GHG emissions from the Prelude FLNG Project will contribute on a cumulative basis to global GHG emissions but will not have any direct negative environmental impact on receptors, including matters of National Environmental Significance, in the project area of the Browse Basin.

### 2.3.7 Nitrogen

Reference Number	Submission Party	Issue Raised
8	Ari Chakrabarti	Table 6.32 does not show any excess gas from end flash stage being sent to flare. It appears that the assumption is that all the Nitrogen rich gas from the end flash is used as fuel gas. What is the Nitrogen level in the feed gas assumed? Please state Nitrogen in feed gas and what sensitivity of this is allowed in making these emission figures.

As shown in Figure 4.7 of the Draft EIS, the end flash gas generated when the LNG is flashed down to atmospheric pressure is captured and compressed into the LP fuelgas system, rather than vented or flared. This is in line with the ‘no venting and no flaring from routine operations principles’ applied to the Prelude Project as described in Section 4.8.4 of the Draft EIS. Prelude feed gas contains a low concentration of nitrogen (0.6 mol %) so the end flash gas contains a relatively small volume of nitrogen (about 10 vol%), making it suitable as fuelgas.

### 2.3.8 Boil-off gas

Reference Number	Submission Party	Issue Raised
9	Ari Chakrabarti	Section 6.8.3: Reduced boil-off due to shorter product line is included in emission reduction calculation. This is only a temporary effect eventually all the lighter gases and nitrogen will boil-off the storage tank in course of time. What about increased boil-off due to constant sloshing in the storage tanks, has this been taken into account?



Once liquefied, LNG is stored at atmospheric pressure and at its boiling point temperature of  $-161^{\circ}\text{C}$ . With such a huge difference in the temperature of LNG compared to the outside ambient temperature, significant efforts are made to insulate the pipes and tanks in which LNG is stored to limit the amount of heat in-leak (absorption) and hence reduce the rate of boil-off of the LNG product. LNG loading lines, when not in use, are maintained at a cryogenic temperature by recirculating LNG from the LNG storage tanks through the dual line system. This is necessary to avoid repeated thermal expansion and contraction which can damage bellows and pipe supports. Onshore LNG plants typically have several kilometres of such linework which increases the surface area for heat in-leak. Prelude FLNG has an advantage with much shorter rundown lines to storage and export lines for loading onto LNG Carriers. This is not a temporary effect. It will contribute to reduced boil-off over the life of the project.

The main parameter impacting boil-off gas rates of storage tanks is the extent of heat in-leak through the layers of insulation into the LNG tanks, not tank motions. LNG carriers typically have boil-off rates of their LNG cargo of about 0.15% per day. Newer designs are reducing this to 0.1% per day. For onshore LNG storage tanks, the boil-off rate is lower at about 0.05% per day due to more effective tank insulation. For Prelude, the boil-off rate assumed is 0.15% per day and this figure has been taken into account in the fuel gas balance and emissions presented in the Draft EIS.

## 2.4 SHIPPING MOVEMENTS AND SPILLS

### 2.4.1 Shipping visitation

Reference Number	Submission Party	Issue Raised
14	DEWHA	<p><u>Vessel Strike</u></p> <p>When operations commence, around 23 vessels will undertake round journeys to the FLNG facility each month. We consider that this increase in vessel traffic between the proposed facility and the ports of Broome and Darwin could increase the risk of vessel strike on cetaceans because vessels transiting between the Port of Broome and the proposed facility between the months of July to November will intersect the humpback whale migration pathway.</p> <p>The proponent intends to mitigate this risk by developing and implementing “Vessel cetacean interaction procedures” (at 207). These procedures would require drilling, construction and supply contractors engaged by Shell to maintain a watch for cetaceans when transiting, to not knowingly approach within 500m of cetaceans, to take actions to avoid cetaceans located within a distance of 500m from the vessel when safe to do so. The contractors would be required to complete a ‘Whale and Dolphin Sighting Report Sheet’ in the event that cetaceans were sighted.</p> <p>However – given the correlation between higher vessel speeds and the incidence of vessel strike – we recommend the proponent consider limiting vessel speeds for vessels transecting the humpback whale migratory pathway between July and November.</p> <p>We recommend the proponent include the following information and measures in its upcoming referral:</p> <p><i>Vessel operations:</i></p> <ul style="list-style-type: none"> <li>- <i>projected frequency and timing of vessel movements between the Port of Broome and the proposed facility;</i></li> <li>- <i>vessel sizes; and,</i></li> <li>- <i>operational vessel speeds</i></li> </ul>

Operational shipping activity associated with the Prelude Project is discussed in Section 4.8.4 of the Draft EIS. The Submission Party incorrectly calculates that around 23 return journeys per month will be undertaken between the facility and the Maintenance Workshop, located in either Broome or Darwin. The number of vessel journeys from the Port of Broome or Darwin to the FLNG facility is considerably lower, around 3-6 per month as described below. This is a similar level of activity used to support most manned offshore installations.

A significant advantage of FLNG and Floating Production, Storage and Offloading (FPSO) oil/condensate facilities, compared to an onshore development, is that there is no need for export tankers to travel to coastal ports. This removes the need for export tankers to transit coastal whale migration routes, the loading and transport of large volumes of hydrocarbons in coastal environments and the discharge of ballast water in coastal environments. Prelude's weekly LNG carriers, monthly LPG carriers and fortnightly condensate tankers will not transit across the humpback migration path from the FLNG to the Port of Broome. LNG Carriers will return with a full load to LNG receiving terminals overseas, most likely in Asia. LPG and condensate tankers may travel to other ports to complete loading before discharging their cargos overseas or within Australia. However, the Port of Broome has no capacity to accept LNG, LPG or condensate tankers.

The FLNG facility will be supported by 3-4 vessels; two tugs which will be based at the FLNG facility itself and only return to the Maintenance Workshop occasionally for maintenance, and 1-2 supply vessels that will visit the FLNG facility every week or two during operations. In total, it estimated that there will be 3-6 vessel return journeys between the Maintenance Workshop and FLNG facility per month.

The tugs and supply vessels will be similar in design and size to the tugs and supply vessels that service existing offshore installations and commercial ports in Australia. As described in Section 6.3.3 of the Draft EIS, these vessels, as well as the export tankers, are all displacement hull vessels which operate at low speeds, typically less than 20 knots. Thousands of similar displacement hull vessels work and transit the humpback whale migration route to access the Ports of Bunbury, Fremantle, Geraldton, Shark Bay Salt, Exmouth, Onslow, Dampier, Cape Lambert, Port Hedland and Broome on the west coast of Australia, and similarly on the east coast of Australia, with very few incidents of collisions with whales.

Shell has already committed that drilling, construction and supply vessels will maintain a watch for cetaceans when transiting, to not knowingly approach within 500m of cetaceans and to take actions to avoid cetaceans within 500m of the vessel when safe to do so. Given that the small number of vessels transiting between the Prelude FLNG Facility and the Maintenance Workshop are displacement hull vessels that travel at relatively low speeds, there is no reason to limit vessel speeds further at any time of year.

#### 2.4.2 Spills

Reference Number	Submission Party	Issue Raised
10	Ari Chakrabarti	EIS should highlight potential large LNG spill due to FLNG to LNGC or LNGC to LNGC collision and its impact.

Hydrocarbon spills and leaks are discussed in Section 6.9.2 of the Draft EIS. Spills of LNG and LPG, both large and small, are not discussed in detail because they do not present a significant environmental risk to the marine environment. Unlike condensate and diesel, which are discussed in detail in Section 6.9.2 of the Draft EIS, both LNG and LPG are non-toxic liquids which would volatilise quickly (instantly) in the event of a loss of containment. Both LNG and LPG are stored at atmospheric pressure and kept liquid by heavily insulated tanks, with LNG stored at its boiling point of -161°C and LPG at -42°C for propane and -12°C for butane. Given the open ocean location of the Prelude project and the lack of receptors, the non-toxic nature of the liquids and their rapid volatilization upon discharge, environmental impacts of a spill of LNG or LPG would be minimal.



A large spill of LNG or LPG however would pose a significant safety risk to workers on the facility. Considerable work on all the safety aspects of the FLNG Facility, including mitigation and controls of spills, has already been completed and will be further developed during the Prelude Front End Engineering and Design process (see Section 4.3.3 of the Draft EIS). Safety requirements for the Prelude FLNG Project will be addressed in accordance with NOPSAs requirements. Shell also has an extensive history and experience in both the LNG/LPG industry (see Section 1.6 of the Draft EIS) and LNG shipping, through STASCO (Shell International Trading and Shipping Company Limited) which operates one of the largest fleet of oil and gas ships around the world.

The risk of a significant collision between the stationary FLNG facility and a LNG or LPG Carrier, sufficient to cause a breach of an LNG/LPG tank on either the FLNG Facility or the LNG/LPG carrier, is extremely low given:

- the FLNG facility is surrounded by a monitored 500 m exclusion safety zone which vessels cannot enter without permission;
- LNG/LPG Carriers will only approach the FLNG when the weather is suitable and at very low speeds whilst under the control of two tugs as they prepare to berth;
- the FLNG facility is fitted with thrusters to maintain a fixed bearing and position during berthing operations;
- the FLNG facility is fitted with very robust Yokohama fenders to protect both the facility and LNG carriers during berthing;
- both the FLNG facility and LNG/LPG Carriers have double hulls and, for a spill to occur, both hulls on either the FLNG facility or LNG/LPG Carrier as well as the LNG/LPG tank linings would need to be breached;
- The risk of collisions between LNG/LPG Carriers and other vessels, or within channels and turning basins, is lower at Prelude than for a similar onshore LNG Plant located in an existing port supporting higher levels of shipping traffic; and
- only one export tanker of any description will be loaded at the Prelude FLNG facility at any time (Section 4.8.4 of Draft EIS).

In conclusion, LNG and LPG spills are not considered further in the draft EIS for Prelude because:

- The risk of such a spill is very low and the environmental impact would be minimal; and
- There is a lack of external societal receptors near the project location (Broome is 475 km away).

## 2.5 IMPACTS OF FACILITIES ON FAUNA

### 2.5.1 Collision and entanglement

Reference Number	Submission Party	Issue Raised
15	DEWHA	<p><b>Subsea infrastructure collision/entanglement</b></p> <p>The proposed facility extracts hydrocarbon through a subsea infrastructure array which includes anchors, flexible risers, flowlines, riser base manifolds, umbilicals and wellheads. These devices will cover 7,701m<sup>2</sup> of seafloor.</p> <p>These devices may pose a collision and/or entanglement risk to cetaceans and marine turtles. Therefore we recommend that the proponent:</p> <ul style="list-style-type: none"> <li>i) outlines its rationale as to why its subsea infrastructure poses no collision and/or entanglement risk to cetaceans and,</li> <li>ii) devises mitigation measures to minimise harm posed by its subsea infrastructure to marine fauna (i.e. cetaceans and marine turtles) if collision/entanglement is identified as a risk</li> </ul>

The subsea infrastructure listed in Table 6.6 of the Draft EIS and discussed in the above submission is all lying directly flat on or in the seabed and poses no collision or entanglement risk to cetaceans or turtles. The Submission Party's concern is presumably about the FLNG's mooring system which holds the FLNG facility in place. This system consists of 24 mooring chains arranged in four groups of six. Each mooring chain is comprised of chain top and bottom separated by steel wire in the middle section. All sections of the mooring chain have a diameter of approximately 20cm and the FLNG facility has a dead weight of approximately 600,000 tonnes when fully ballasted. The dimensions of each mooring chain and the tension load that the chains are held under means that the mooring system behaves almost as a solid structure and there is simply no possibility that whales or cetaceans can become entangled in these chains. Due to the dimensions of the chains and the tension loads, the FLNG Facility mooring system is not comparable in any way to shark nets or cray pot ropes which are known to have caused entanglement of cetaceans including whales.

The mooring system of the FLNG facility is essentially identical to the systems used by FPSOs around the globe, including the 12 FPSO's in northern Australia mentioned in Section 4.5 of the Draft EIS. Shell is unaware of any recorded cases of cetacean or turtle entanglement with FPSO mooring systems. No mitigation measures to minimise entanglement or collision risks of cetaceans or turtles with subsea infrastructure or the FLNG mooring system are proposed because this is not a real risk and mitigation measures are not warranted.

### 2.5.2 Anchors and drilling

Reference Number	Submission Party	Issue Raised
18	DEWHA	<p><u>Anchoring to benthos</u></p> <p>The proposed facility will be held in position by four groups of six anchor chains, arranged at the four quadrants around the FLNG turret. The chains are secured by suction piles which will penetrate deep into the benthos. The pile will be 10m in diameter and 20-30m in length – each weighing between 140-180 tonnes.</p> <p>Given the proponent intends to deploy anchorage devices onto the benthos and the significant size and weight of the anchors, we request the development of an anchoring procedure to minimise disturbance to the benthic habitat.</p> <p>The preparation of an anchoring procedure was included in the Marine Division's advice for referrals EPBC 2009/5160 and EPBC 2009/5122. These proposals were relatively less complex than this proposal.</p> <p><u>Discharge of waste</u></p> <p>Drill cuttings – the drilling of eight wells into the benthos will produce 8,000m<sup>3</sup> of drill cuttings. Rock and sand particles will be separated from drilling fluid and discarded over the side of the drilling rig. The discharge of cuttings will lead to an increase in water sedimentation ("turbidity") over 1-2km<sup>2</sup> area.</p> <p>To mitigate the moderate levels of harm posed by the discharge of drill cuttings, the proponent states it will follow "[s]tandard Australian industry drilling practices". We recommend that the proponent outline which standard Australian industry practices it intends to follow, and elucidate how these will mitigate the potential harm risk.</p>

The precise location of the suction anchors used to hold the FLNG Facility in place is the subject of ongoing geotechnical investigations to determine the suitability of the seabed and the precise location of each anchor. However, environmental surveys of the benthic environment where the subsea infrastructure is to be installed, including the mooring system, which are described in Section 5.3.4 and 6.3 of the Draft EIS, concluded that the seafloor benthic community local to the proposed FLNG Facility is broadly distributed and of low environmental sensitivity. The seabed is comprised of



soft sediments and there are no significant topographical features in the region of the FLNG facility. The magnitude of the impact on the benthic environment was concluded to be low. A work procedure will be developed to control the installation of the anchors.

The drilling practices to be used for the drilling of the development wells for the Prelude Project are described in Section 4.8.1 of the Draft EIS:

*“Well drilling for the Prelude FLNG Project will use two types of muds, both water based mud (WBM) and synthetic based mud (SBM). The SBM will be used on the deeper and more challenging well sections. WBMs are usually discharged to sea at the end of their useful life or at the end of the drilling program, whereas SBMs are recovered and returned onshore for recycling or disposal. Table 4.3 provides the proposed mud properties to be used at Prelude.*

*Cuttings from sections drilled with SBM are passed through a dryer before discharge to reduce the volume of synthetic mud coating the rock. Some small quantities of mud will nevertheless be lost overboard with the drill cuttings, estimated at approximately 36 m<sup>3</sup> of SBM for each well.*

*Following completion of the well, the well will be flowed to the drilling rig to remove liquids from the well (well cleanup), before closing in the well to await hookup to the subsea facilities.*

*Cleanup involves flowing well fluids and brine to the rig storage tanks and diverting reservoir gas to burners. Well cleanup will typically involve flowing the well at up to 150 million scfd and burning the produced fluid for one to two days to ensure all drilling liquids are removed from the well. During clean-up, the well's flowing performance will be assessed. It is likely that all eight well clean-ups will be undertaken one after the other at the end of the drilling program.....*

### *Liquid Waste*

*Liquid wastes from the drilling program are expected to include:.....*

- *WBM, which is discharged to sea in bulk at the end of the drilling program as per standard oil industry practice.*
- *Minor volumes of SBM (approximately 36 m<sup>3</sup> per well) – all discharges of cuttings contaminated with SBM mud will be measured using standard Australian oilfield procedures and should contain less than 6.9% residual SBM by weight. There will be no dumping of bulk SBM.”*

Further details will be provided in the ‘Drillings and Completion Program’ and the ‘Drilling Environment Plan’ which must be approved by the regulator prior to drilling activities commencing-see Section 2.4 of the Draft EIS.

### 2.5.3 Light

Reference Number	Submission Party	Issue Raised
16	DEWHA	<p><b>Light emissions (turtles)</b></p> <p>..... We request a copy of the full assessment which was prepared for the proponent by Environmental Resources Management (2009) in order to verify the assessment findings.</p> <p>..... The proponent states that they will limit the practice of flaring, however it does not provide projected frequencies or timings.</p> <p>..... We recommend that the proponent monitors (with the assistance of experts) the effect of flaring (and other artificial lighting) on marine turtles on Browse Island, and if necessary introduce additional mitigation measures to avoid disorientation of nesting turtles or hatchlings.</p> <p>We also recommend the proponent provide a copy of the following materials for our review:</p> <ul style="list-style-type: none"> <li>- a full copy of the assessment which was prepared for the proponent by Environmental Resources Management (2009) regarding artificial lighting, marine turtles and Browse Island;</li> <li>- a full copy of the modelling report regarding lighting and migratory birds</li> </ul>

Section 6.4 of the Draft EIS presents a detailed assessment and proposed mitigation measures to address the potential impacts of FLNG Facility lighting on turtles at Browse Island. Section 6.4 of the Draft EIS was based on the line of sight assessments undertaken by ERM (ERM, 2009b). A copy of the ERM report (ERM, 2009b) was provided to DEWHA on the 23rd July, 2009 along with the Draft EIS. The line of sight assessment determined that operational lights on the process deck of the FLNG facility can be seen by a turtle out to a distance of 27 km from the facility. Browse Island is located 40 km from the FLNG Facility so it is correctly concluded in the Draft EIS that process deck lighting can not impact adult turtles or hatchlings in the vicinity of or on Browse Island.

The FLNG facility flare is a 154m structure and when operational, the line of site assessment found that the flare can be seen out to a distance of 51 km from the facility, which encompasses Browse Island. However, as documented in the Draft EIS, the FLNG has been designed so that flaring is not required for routine operations and only required for process upsets or emergencies which are not planned. After commissioning of the facility, once steady state operations have been achieved, it is estimated that the flaring will occur less than 1% of the time (p 71, Section 4.8.4 of the Draft EIS).

Therefore, given:

- Process lighting will not be visible at Browse Island with a 13km buffer zone;
- *“Once in the water, turtle hatchling navigation is understood to be influenced predominantly by wave motion, currents and the earth’s magnetic field (Lohmann and Lohmann, 1992), rather than light.”* (p131 Draft EIS);
- Flaring is expected to occur less than 1 % of the time during normal operations (p 71, Section 4.8.4 of the Draft EIS);
- *“Studies also suggest that light generated by flares may not affect hatchlings as much as other light sources.”* (p131 Draft EIS). This is further supported by DEWHA comment in their submission: *“Adult and hatchling green turtles are most receptive to the green and blue portions of the visible light spectrum and least receptive to the yellow orange to red portions.”*; and
- *“As the flare will be low on the horizon, the Island’s landmass will block light from the flare to the southern beaches so that no beaches on Browse Island will be subjected to light from the flare on their landward horizon and the landward horizons will remain unaltered to nesting and hatchling turtles.”* (p133 Draft EIS)



the Draft EIS concludes that the impacts of lighting on turtle hatchlings and adult turtles are considered to be of a low magnitude, unlikely and assessed to be of minor significance. Prelude poses no real risk to turtles on Browse Island. Therefore, there is no need to undertake monitoring of turtles on Browse Island and Shell is not proposing to undertake any monitoring.

Reference Number	Submission Party	Issue Raised
17	DEWHA	<p><b>Lighting Plan</b></p> <p>We hold concerns for the proponent’s intention to utilise green or blue artificial lighting (we note this colour range is least attractive to migratory seabirds). Adult and hatchling green turtles are most receptive to the green and blue portions of the visible light spectrum and least receptive to the yellow/orange to red portions. Thus green or blue artificial lighting has the potential to disrupt adult and hatchling orientation at night and inhibit nesting attempts by females (which would be of concern if such light reached Browse Island). Furthermore, turtles transiting the area may be attracted to the facility – making them more susceptible to vessel strike or entanglement in the infrastructure array.</p> <p>We recognise that the proponent will develop a detailed plan of lighting for the FLNG facility during the Front-End Engineering and Design phase (at 128) and recommend that the light management plan be developed with input from experts in the field. This will ensure that the most appropriate types of lighting are selected to limit potential negative impacts on turtles.</p> <p>The proponent should proceed to develop and implement an effective lighting plan during the Front-End Engineering and Design phase (at 128) that will ensure that the most appropriate types of lighting are selected to limit the potential negative impacts on seabirds as well as marine turtles.</p> <p>Additionally, we require the proponent to:</p> <ul style="list-style-type: none"> <li>- provide a copy of its proposed lighting plan and supporting scientific information to DEWHA; and</li> <li>- document its “no flaring” principle into a plan (to be subsequently provided to DEWHA)</li> </ul>

Section 6.4 of the Draft EIS discusses the potential impacts of lighting on environmental receptors. Shell outlined three design mitigation measures which reduce the potential for adverse impacts on the marine environment, birds and turtles in particular. These are:

- *‘Locating the FLNG facility in an area that is distant to the closest known significant environmental sensitivities.’* The FLNG facility is located 40 km from Browse Island and process lighting cannot be seen by turtles on or near Browse Island (see above response);
- *‘The FLNG facility will be designed to reuse hydrocarbon waste streams generated by normal operations (“no flaring principle”), limiting the extent and duration of flaring.’* Flaring is expected to occur less than 1 % of the time during normal operations; and
- *‘Lighting of the FLNG facility will be designed with the objective of reducing light spill, subject to meeting all workplace health and safety, and navigational requirements. Design measures that will be considered will include:*
  - *limiting the effects of reflecting surfaces by assessing the location of luminaries and the use of low-reflective paints;*
  - *locating luminaries in such a way that they are shielded as far as practicable from direct line-of sight from surrounding view points;*
  - *directing luminaries inwards on the FLNG facility and away from the ocean; and*
  - *the preferential use of low-impact spectrum illumination (including the use of green or blue lighting) over red, orange and white external lighting.’*

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The commitment to consider the preferential use of *‘low-impact spectrum illumination (including the use of green or blue lighting) over red, orange and white external lighting’* was to minimise potential impacts on migratory birds which are more sensitive to the orange-red portion of the visible light spectrum (see Section 6.4.6 of Draft EIS). Turtles are sensitive to lighting as hatchlings and when nesting but less sensitive to lighting when in the water. While turtles are more sensitive to wavelengths in the range of 300 to 500 nanometers, which includes the blue and green wavelengths, the FLNG facility is located sufficiently distant from Browse Island such that process lighting is not visible within 13 km of Browse Island (see response above). Given the large separation distance between Browse Island and the visible extent of process lighting, it is sensible to consider the preferential use of low-impact spectrum illumination (including the use of green or blue lighting) for the FLNG facility. Shell will seek expert input into the design of lighting on the FLNG facility, including advice on the appropriate use of low-impact spectrum illumination.





## APPENDIX A

### *SUBMISSIONS RECEIVED FOR THE PRELUDE FLOATING LNG PROJECT*

#### Submission 1: Rudi Oversman

30 October 2009

Prelude Draft EIS  
Shell Development (Australia) Pty Ltd  
250 St Georges Terrace  
Perth WA 6000

#### Re : Submission on the Prelude Draft EIS

Dear Sir/Madam,

I have read with much interest your very thorough Prelude Draft EIS. The project is very interesting. Liquefying natural gas near the wellhead in a floating plant offers many advantages. Both technical such in this particular case and political in future other cases. With political I mean that investing billions of dollars to build a plant in a failed state can be very risky. Doing the same job with a floating platform that can be towed away will in the future be a much better solution.

The economic benefits of this Prelude project to Australia will be significant. The environmental impact will be very small. Of course, every human activity has an environmental impact. But well managed, these impacts are minor and can be accepted.

A few minor points that need correcting or are not clear

- Table 6.30 page 169. Reservoir CO<sub>2</sub> Should be 966,000 instead of 966
- Page 285 mV is millivolt, not megavolt.
- Page 160 *chlorine*. It is well known that free residual chlorine in waste water can result in the formation of toxic, carcinogenic chlorinated organic compounds. This is accepted because the benefits of chlorination far exceed the small potential problems these chlorinated compounds can cause. However I cannot understand how bromium containing organic compounds such as bromoform are formed as a result of chlorination. Is this via natural occurring bromium compounds in sea water?

Further I would like to tell you that my submission is not confidential and that I do not have any special interest in the Prelude FLNG Project.

Wishing you all the best with this exciting project

Yours sincerely,



Rudi H. Overmars



## Submission 2: Ari Chakrabarti

**From:** Ari Chakrabarti [mailto:████████████████████]  
**Sent:** Tuesday, 17 November 2009 3:18 PM  
**To:** SDA Preludedrafteis SDA  
**Subject:** Comment on Shell Prelude FLNG EIS

Regarding Shell Prelude FLNG EIS,

Draft EIS Figure 6.18 shows comparison of GHG intensity for a group of 10 existing world scale LNG facilities benchmarked against the Prelude FLNG facility. However, it is not clear how the figures of 10 existing facilities have been estimated. The detailed calculation basis, including amount of subtracted as upstream operation, should be elaborated.

In EIS for recent LNG projects in Australia, benchmarked comparison has been presented, and it shows specific names of each project. For Prelude project, similar comparison should be presented also. The examples are:

- Queensland Curtis LNG EIS Volume 7 Chapter 2 - Figure 7.2.4 Benchmarked Greenhouse Emissions Intensity
- Pluto LNG Project Greenhouse Gas Abatement Program, Chapter 4 - Figure 6 Greenhouse Intensity of Major LNG Plants Worldwide
- Gladstone GLNG Project Environmental Impact Statement, Section 6 - Figure 6.9.1 Benchmarked GHG Efficiency

EIS for recent LNG projects in Australia presents detailed basis of GHG emission, however, Prelude EIS does not show the basis of 1,260 ktpa in Table 4.6. Detailed estimate basis, such as CO<sub>2</sub> emission from steam boilers, steam consumption of various turbines, and so on, should be presented. It is commonly recognized in LNG industry that thermal efficiency of steam turbine driven will be lower than that of gas turbine driven.

From the referrals of recent LNG projects in Australia, the emission rates (tGHG/tLNG&LPG) are indicated as below.

North West Shelf Train 4 (2000)	0.44
Darwin (2002)	0.46
Gorgon (2004)	0.35
Pluto (2007)	0.33
Gladstone (2009)	0.35
Curtis Island (2009)	0.26
Prelude (2009)	0.33

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Compared to Curtis Island design, Prelude should have a lot of possibilities to improve emission rate and thermal efficiency.

Table 6.32 does not show any excess gas from end flash stage being sent to flare. It appears that the assumption is that all the Nitrogen rich gas from the end flash is used as fuel gas. What is the Nitrogen level in the feed gas assumed? Please state Nitrogen in feed gas and what sensitivity of this is allowed in making these emission figures.

Section 6.8.3: Reduced boil-off due to shorter product line is included in emission reduction calculation. This is only a temporary effect eventually all the lighter gases and nitrogen will boil-off the storage tank in course of time. What about increased boil-off due to constant sloshing in the storage tanks, has this been taken into account?

EIS should highlight potential large LNG spill due to FLNG to LNGC or LNGC to LNGC collision and its impact.

End of comments

Specify whether you wish for your submission to remain

confidential: Not Applicable

**Personal details:**

**Name:** Ari Chakrabarti

**Address:** [REDACTED]

**Interest in Prelude FLNG:** General interest in Energy projects in Australia



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## Submission 3: Simon Dean

**From:** Simon Dean [mailto:██████████@kpoc.com.my]

**Sent:** Friday, 20 November 2009 2:03 PM

**To:** SDA Preludedrafteis SDA

**Subject:** Comments on draft EIS

I have a number of comments.

1. The selection of steam boilers for main power generation over a combined cycle gas turbine and waste heat recovery system means that you have to comply with World Bank EHS requirements of 320 mg/m<sup>3</sup> NO<sub>x</sub> concentration in the exhaust stream. A combined cycle gas turbine system would have a lower limit of 25 ppmv (equivalent to 47 mg/m<sup>3</sup> at 25C). Therefore, the selection of steam boilers for main power generation as opposed to combined cycle gas turbines is not the best available technology for minimisation of NO<sub>x</sub> emissions.

2. The Pluto LNG GHG Abatement Program (copy attached) contains a graph (Figure 6) that shows the Tonnes of GHG per tonne of LNG produced. A rough calculation for Prelude indicates that the development will emit -0.43 Te CO<sub>2</sub> per Te LNG (equivalent). This is hardly best in class so how does this compare to an onshore LNG facility?

regards,

Simon Dean

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## Submission 4: DEWHA

Hi [REDACTED]

Further to our conversation yesterday (3 December 2009). Attached are the finalised comments on the draft EIS document for the Prelude Floating LNG including further requirements for the final EIS document.

With regards to the discussion about the Carbon Pollution Reduction Scheme (CPRS), it was noted that your referral initially raised the possibility of using geosequestration as a method to reduce carbon emissions. Your draft EIS document also noted on page 100 that geosequestration may be considered at a later stage in the life of the project but provided no further commitment to this. Given the current uncertainty regarding the CPRS, the Department considers that Shell needs to outline further options to offset or mitigate green house emissions which will be implemented throughout the operation life of the facility.

Kind regards

[REDACTED]  
[REDACTED]

Environment Assessment Branch  
Department of the Environment, Water Heritage and the Arts  
PO Box 787 Canberra ACT 2600



EPBC REFERRAL NO 2008/4146  
SHELL PRELUDE FLOATING LNG PROJECT  
Comments re Draft Environmental Impact Statement

## PROPOSAL:

Shell Development (Australia) Pty Ltd proposes the development of a Floating Liquefied Natural Gas (FLNG) facility in the northern Browse Basin within Petroleum Exploration Permit Area WA-371-P.

The site is located in Commonwealth waters approximately 200km NW from the Western Australian coastline and 475km NNE of Broome. Water depth ranges between 200-250m. The site is located 40km NNE from Browse Island and approximately 200km from the Maret Islands.

The proposed FLNG facility is similar in concept to FPSOs (Floating Production, Storage and Offloading) facilities for the production of oil and gas) that operate around the North-west Marine Region. Its dimensions include a length of 480m, a width of 70-80m and a maximum height of 134m. Around 400 personnel will be required on board to operate the facility.

The facility will produce 5.2 million tonnes of hydrocarbon per annum (3.6 million tonnes of LNG and 0.4 million tonnes of LPG and 1.3 million tonnes of condensate). The production of this amount of hydrocarbon will in turn produce 2.3 million tonnes of carbon dioxide (CO<sup>2</sup>) per annum. Gas from the Prelude gas reservoir will be extracted from subsea wells and will flow via flowlines and flexible risers to the internal turret of the FLNG facility.

The facility will be moored to the seabed via a rotating turret that will enable the facility to manoeuvre in synchrony with sea and wind movements (i.e. “weathervane”). The facility is designed to withstand severe cyclonic activity.

Frequent vessel traffic to and from the facility is anticipated. It will include LNG tankers (four per month), LPG tankers (one per month), condensate tankers (two each month), supply vessels (four per month) and tugs (two present at each LNG and LPG tanker berthing, and one per condensate tanker berthing).

## Cetaceans

### **Vessel Strike**

When operations commence, around 23 vessels will undertake round journeys to the FLNG facility each month. We consider that this increase in vessel traffic between the proposed facility and the ports of Broome and Darwin could increase the risk of vessel strike on cetaceans because vessels transiting between the Port of Broome and the proposed facility between the months of July to November will intersect the humpback whale migration pathway.

The proponent intends to mitigate this risk by developing and implementing “Vessel cetacean interaction procedures” (at 207). These procedures would require drilling, construction and supply contractors engaged by Shell to maintain a watch for cetaceans when transiting, to not knowingly approach within 500m of cetaceans, to take actions to avoid cetaceans located within a distance of 500m from the vessel when safe to do so. The contractors would be required to complete a ‘Whale and Dolphin Sighting Report Sheet’ in the event that cetaceans were sighted.

However – given the correlation between higher vessel speeds and the incidence of vessel strike – we recommend the proponent consider limiting vessel speeds for vessels transecting the humpback whale migratory pathway between July and November.

Note that the Marine Division's Cetacean Section has requested that it does not need to be provided with these sheets and that the proponent should direct records to AWD.

### Noise emissions

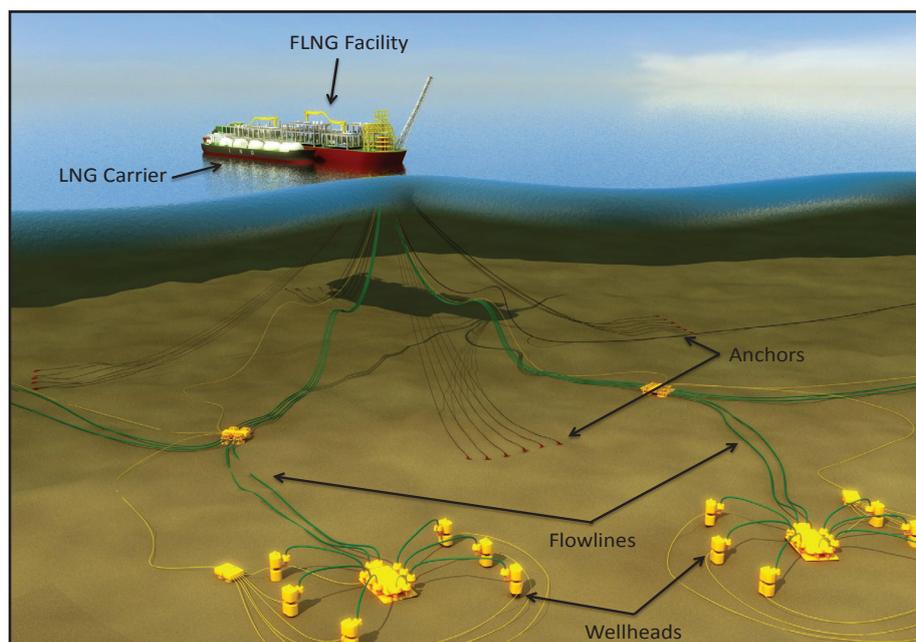
The proponent states on page 144 that: “[t]he noise frequencies produced during operation of the FLNG facility will overlap with hearing and vocalisation frequencies of baleen whales and to a lesser extent toothed whales”. The noise generated from the facility will exceed 150 dB re 1µPa within 200 m of the FLNG facility during off take activities and 30 m during normal operations.

Scientific advice we have received states that the sound energy produced by the facility is likely to elicit avoidance behaviour in cetaceans. However, as significant and/or constant concentrations of cetaceans are unlikely to be within the area of the facility the noise emitted from the FLNG facility is unlikely to significantly effect major migratory behaviour or disturb calving or resting activities.

### Subsea infrastructure collision/entanglement

The proposed facility extracts hydrocarbon through a subsea infrastructure array which includes anchors, flexible risers, flowlines, riser base manifolds, umbilicals and wellheads. These devices will cover 7,701m<sup>2</sup> of seafloor.

These devices may pose a collision and/or entanglement risk to cetaceans and marine turtles. Therefore we recommend that the proponent:



- iii) outlines its rationale as to why its subsea infrastructure poses no collision and/or entanglement risk to cetaceans and,
- iv) devises mitigation measures to minimise harm posed by its subsea infrastructure to marine fauna (i.e. cetaceans and marine turtles) if collision/entanglement is identified as a risk

## Turtles

The nearest known turtle breeding, nesting, or feeding grounds are located on Browse Island which is approximately 40 km to the south-east of the proposed facility. Green turtles that nest on Browse Island are a regionally significant breeding population that is likely to be part of the small genetically distinct Scott Reef breeding unit. The proposed facility is not located near flatback turtle nesting beaches, however this species may transit through the proposed development area between nesting beaches and foraging areas.

Impacts are likely to be heightened during the mating and nesting season for turtles, although turtles are unlikely to forage at depth ranges of 200-250m.

## Light emissions

Light emissions may disorientate marine turtles and disrupt biologically important behaviours – i.e. migration, nesting, breeding and foraging. Moreover, light emissions may *concurrently* attract and concentrate marine turtles and predators to and around the light source – exposing the former to injury or mortality.

The proponent commissioned an assessment of the potential effect on turtles nesting on Browse Island as a result of light emanating from the facility at normal operations. The assessment found that the light from the facility was visible to turtles to a maximum distance of 27 kms (at 132). This was under normal operations. When flaring, light would be visible to turtles out to a distance of 51 km from the facility – which puts it within the range of turtle nesting and foraging at Browse Island. The proponent indicates that although the light may be visible on the island's northern beaches and low on the seaward horizon, it is unlikely that the light would be visible on the southern beaches due to the island's topography. As a result, the proponent claims that the landward horizon would remain unaltered – thus limiting the risk of nesting and hatchling disorientation. We request a copy of the full assessment which was prepared for the proponent by Environmental Resources Management (2009) in order to verify the assessment findings.

The proponent states that they will limit the practice of flaring, however it does not provide projected frequencies or timings. Flaring will be visible from Browse Island, which is an important green turtle nesting site. While we recognise the important safety function of flaring, we support the proponent's intention to minimise flaring where considerations of operational safety allow (especially during peak nesting periods).

It is unknown whether light from the proposed facility's flare stack would disorientate nesting turtles and hatchlings at a beach 40km from the flare. We recommend that the proponent monitors (with the assistance of experts) the effect of flaring (and other artificial lighting) on marine turtles on Browse Island, and if necessary introduce additional mitigation measures to avoid disorientation of nesting turtles or hatchlings.

We recognise the proponent's aim to design the facility in a manner that mitigates the potential effects of lighting. It intends to:

- utilise low reflective paints and assess location of luminaries to reduce area of reflective surfaces;
- position luminaries in a position (i.e. inward towards the facility) so as to reduce seaward reflection of light;
- implement a "no flaring" principle that limits the use of the flare stack where possible;
- where possible, avoid continuous illumination of the proposed facility's work and accommodation areas; and,
- ensure vessels restrict use of artificial lighting to the minimum level required for navigation and safety

We hold concerns for the proponent's intention to utilise green or blue artificial lighting (*we note this colour range is least attractive to migratory seabirds*). Adult and hatchling green turtles are most receptive to the green and blue portions of the visible light spectrum and least receptive to the yellow/orange to red portions. Thus green or blue artificial lighting has the potential to disrupt adult and hatchling orientation at night and inhibit nesting attempts by females (which would be of concern if such light reached Browse Island). Furthermore, turtles transiting the area may be attracted to the facility – making them more susceptible to vessel strike or entanglement in the infrastructure array.

We recognise that the proponent will develop a detailed plan of lighting for the FLNG facility during the Front-End Engineering and Design phase (at 128) and recommend that the light management plan be developed with input from experts in the field. This will ensure that the most appropriate types of lighting are selected to limit potential negative impacts on turtles.

### **Noise emissions**

The proponent states that noise generated from the facility will exceed 150 dB re 1µPa within 200 m of the FLNG facility during off take activities and 30m during normal operations. Turtles have been reported to increase their swimming activity at 155 dB re 1µPa and show more erratic swimming patterns at 164 dB re 1µPa.

Given scientific knowledge on the effects of noise on turtles is limited, it is difficult to determine what effect the proposed facility will have on turtles over its 25 year lifespan. Marine turtles transiting the project area between nesting and foraging sites may be affected by noise associated with the FLNG facility. Overall, noise is unlikely to affect turtle nesting behaviour at Browse Island because of its distance (40km) from the facility.

### **Migratory Birds**

Seabird nesting and roosting sites and feeding areas are located on the offshore atolls of the North-west Marine Region. Individuals and flocks of mixed and single seabird species have been observed in the vicinity of the proposed project area. A number of migratory seabirds also pass through the proposed project area. Southward migration occurs between September-October while the northward migration occurs in April. Coastal feeding occurs between December-February.

### **Light emissions**

#### *Effect of lighting from the facility on nesting populations*

The proposed facility will emanate artificial light from generic illumination, visual berthing aids, navigation lights and a flare stack. Importantly, the flare stack is anticipated to stand 154m above sea level.



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The principal issue posed by artificial lighting is positive phototaxis (Poot et al. 2008) – a phenomenon whereby species are attracted and drawn to an artificial light source. The associated risks of positive phototaxis include:

- disorientation;
- disruption of migration;
- depletion of energy reserves; and,
- possible incineration (where flame stacks are operational)

The proponent undertook an assessment of the potential affects of artificial lighting on migratory birds. The proponent found that:

- seabirds have a propensity to be attracted to the artificial red and orange portion of the visible light spectrum. Conversely, the green and blue portion does not (we note this colour range is most attractive to marine turtles);
- seabirds flying beyond a >5km radius of illuminated offshore platforms are unlikely to be attracted/deviate from their flight path; and,
- seabirds flying at an altitude of 600m would be receptive to the proposed facility's artificial lighting at an approximate distance of 151km when the flare is operational and 127km when the flare is not operational.

To mitigate the potential harm risks, the proponent states it will:

- utilise low reflective paints and assess location of luminaries to reduce area of reflective surfaces;
- position said luminaries in a position (i.e. inward towards the facility) so as to reduce seaward reflection of light;
- where possible, utilise low-impact spectrum illumination (i.e. blue or green lighting) instead of high-impact lighting (i.e. red or orange lighting – noting that red or orange lighting is least attractive to marine turtles);
- implement a “no flaring” principle that limits the use of the flare stack;
- where possible, avoid continuous illumination of the proposed facility's work and accommodation areas; and,
- ensure vessels restrict use of artificial lighting to the minimum level required for navigation and safety.

The proponent asserts that “...it is unlikely that migratory birds will be attracted to the lighting of the FLNG facility in significant numbers” and that “... the magnitude of the effect [of artificial lighting] on the seabirds is low. “The significance of artificial lighting on seabirds is therefore assessed to be minor”.

Overall, we would require more detail regarding proposed light management arrangements before we could conclude that the proposed facility is unlikely to pose significant risks to migratory birds.

In particular:

- the proponent should proceed to develop and implement an effective lighting plan during the Front-End Engineering and Design phase (at 128) that will ensure that the most appropriate types of lighting are selected to limit the potential negative impacts on seabirds as well as marine turtles.

Additionally, we require the proponent to:

- provide a copy of its proposed lighting plan and supporting scientific information to DEWHA; and
- document its “no flaring” principle into a plan (to be subsequently provided to DEWHA)

## Marine Environment

### Anchoring to benthos

The proposed facility will be held in position by four groups of six anchor chains, arranged at the four quadrants around the FLNG turret. The chains are secured by suction piles which will penetrate deep into the benthos. The pile will be 10m in diameter and 20-30m in length – each weighing between 140-180 tonnes.

Given the proponent intends to deploy anchorage devices onto the benthos and the significant size and weight of the anchors, we request the development of an anchoring procedure to minimise disturbance to the benthic habitat.

The preparation of an anchoring procedure was included in the Marine Division’s advice for referrals EPBC 2009/5160 and EPBC 2009/5122. These proposals were relatively less complex than this proposal.

### Discharge of waste

The proposed facility will produce a range of solid and liquid wastes that may pose a harm risk to the marine environment.

*Drill cuttings* – the drilling of eight wells into the benthos will produce 8,000m<sup>2</sup> of drill cuttings. Rock and sand particles will be separated from drilling fluid and discarded over the side of the drilling rig. The discharge of cuttings will lead to an increase in water sedimentation (“turbidity”) over 1-2km<sup>2</sup> area.

To mitigate the moderate levels of harm posed by the discharge of drill cuttings, the proponent states it will follow “[s]tandard Australian industry drilling practices”. We recommend that the proponent outline which standard Australian industry practices it intends to follow, and elucidate how these will mitigate the potential harm risk.

*Discharge of cooling water* – seawater drawn from the ocean will be utilised as a heat exchange medium for the cooling of machinery engines and in the petroleum production process. 50,000m<sup>3</sup> of seawater (i.e. the volume equivalent of 25 olympic swimming pools) will be dispersed into the ocean *each hour* at a temperature between 39C°–42C° (approximately 7.5C°–16C° above seasonal ambient water temperatures).

This equates to the volume of an olympic swimming pool being circulated approximately once every 2.5 minutes.

Sodium hypochlorite – also commonly known as bleach – will be added to the cooling water to inhibit marine growth within the pipework of the water cooling system. It is anticipated that the discharged cooling water will contain traces of sodium hypochlorite at a level of 0.2 ppm. Given the nature and massive volume of liquid in question, we are concerned that the proposed discharge will pose a threat to the marine environment. Thus we recommend the proponent undertake hydrographical modelling to determine the flow and dispersal characteristics of discharged heated sodium hypochlorite treated water, and whether this poses a harm risk to the marine environment. Measures will also need to be taken to ensure that seawater intakes do not pose a significant risk to marine fauna.



*Disposal of sewage, grey water, food waste and putrescibles* – the proponent intends to dispose treated sewage, treated grey water, food waste and putrescibles into the ocean.

**Sewage and grey water** – will be treated and discharged in accordance with MARPOL guidelines. The facility is estimated to produce 30m<sup>3</sup> of sewage and grey water per day during the commissioning process and 10m<sup>3</sup> per day once operations commence.

**Food waste and putrescibles** – the proponent intends to macerate all food waste and putrescibles through a 25mm screen before disposing it overboard from the facility. Approximately 1L of food waste and putrescibles will be produced per person onboard the facility each day. This equates to the collective production of 100L of food waste and putrescibles per day during the well drilling and completion phase, and up to 400L per day during the commissioning phase (to span a six month period).

It is likely the discharge of these materials will increase nutrient levels in the waters around the facility. We recommend the proponent assesses the potential impacts that enhanced nutrient levels may pose the marine environment, and (if necessary) how these may be mitigated.

## SUMMARY:

We recommend the proponent include the following information and measures in its upcoming referral:

### *Vessel operations:*

- projected frequency and timing of vessel movements between the Port of Broome and the proposed facility;
- vessel sizes; and,
- operational vessel speeds

### *Subsea infrastructure:*

- an outline of its rationale as to why its subsea infrastructure poses no collision and/or entanglement risk to cetaceans and marine turtles; and,
- development of mitigation measures to minimise harm posed by its subsea infrastructure to marine fauna (i.e. cetaceans and marine turtles)

### *Lighting:*

- development of a light management plan during the Front-End Engineering and Design phase to mitigate potential harm risks to marine turtles and migratory seabirds with input from field experts;
- documentation of its “no flaring” principle into a written plan;
- development of a monitoring program (with the assistance of field experts) regarding the effect of flaring and other artificial light sources on marine turtles nesting on Browse Island.

### *Marine environment:*

- development of an anchoring procedure to minimise disturbance to the benthic habitat;

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- an outline that confirms which “standard Australian industry practices” are to be applied to minimise the potential harm posed by drilling operations;
  - a hydrographical model that depicts the flow and dispersal characteristics of discharged heated sodium hypochlorite treated water, and an assessment as to whether this poses a risk to the marine environment;
  - in regards to the discharge of treated sewage and greywater, food waste and putrescibles, a report that outlines the potential implications and impacts that enhanced nutrient levels may pose the marine environment.

We also recommend the proponent provide a copy of the following materials for our review:

- a full copy of the assessment which was prepared for the proponent by Environmental Resources Management (2009) regarding artificial lighting, marine turtles and Browse Island;
- a full copy of the modelling report regarding lighting and migratory birds

Overall, provided the proponent adheres to the mitigation measures stated in this document and fulfils the abovementioned recommendations, the proposed activity is unlikely to have a significant impact on any matters of national environmental significance.

**Prepared by:** Tropical West Marine Conservation, with input from Tropical North Conservation, Cetacean Conservation, the Migratory Bird taskforce and the Australian Antarctic Division’s Australian Marine Mammal Centre.

Cleared by:

Rowan Wylie  
for Tania Rishniw  
Assistant Secretary  
Tropical Marine Conservation Branch  
Marine Division  
04 December 2009





## APPENDIX B

### CROSS-REFERENCE TABLE LISTING ISSUES RAISED IN THE SUBMISSIONS AND THE LOCATION OF SHELL'S RESPONSE

Reference Number	Issue Raised	Submission Party	Relevant Sections in Draft EIS	Response Section														
1	A few minor points that need correcting or are not clear <ul style="list-style-type: none"> <li>Table 6.30 page 169. Reservoir CO<sub>2</sub> Should be 966,000 instead of 966</li> <li>Page 285 mV is millivolt. not megavolt.</li> </ul>	Rudi Overmars	Table 6.30 Page 285	Section 2.1														
2	Page 160 chlorine. It is well known that free residual chlorine in waste water can result in the formation of toxic, carcinogenic chlorinated organic compounds. This is accepted because the benefits of chlorination far exceed the small potential problems these chlorinated compounds can cause. However I cannot understand how bromium containing organic compounds such as bromoform are formed as a result of chlorination. Is this via natural occurring bromium compounds in sea water?	Rudi Overmars	Section 6.7.5	Section 2.2.1														
3	Draft EIS Figure 6.18 shows comparison of GHG intensity for a group of 10 existing world scale LNG facilities benchmarked against the Prelude FLNG facility. However, it is not clear how the figures of 10 existing facilities have been estimated. The detailed calculation basis, including amount of subtracted as upstream operation, should be elaborated.	Ari Chakrabarti	Section 6.8	Section 2.3.2														
4	In EIS for recent LNG projects in Australia, benchmarked comparison has been presented, and it shows specific names of each project. For Prelude project, similar comparison should be presented also. The examples are: <ul style="list-style-type: none"> <li>Queensland Curtis LNG EIS Volume 7 Chapter 2 - Figure 7.2.4 Benchmarked Greenhouse Emissions Intensity</li> <li>Pluto LNG Project Greenhouse Gas Abatement Program, Chapter 4 - Figure 6 Greenhouse Intensity of Major LNG Plants Worldwide</li> <li>Gladstone GLNG Project Environmental Impact Statement, Section 6 - Figure 6.9.1 Benchmarked GHG Efficiency</li> </ul>	Ari Chakrabarti	Section 6.8	Section 2.3.1														
5	EIS for recent LNG projects in Australia presents detailed basis of GHG emission, however, Prelude EIS does not show the basis of 1,260 ktpa in Table 4.6. Detailed estimate basis, such as CO <sub>2</sub> emission from steam boilers, steam consumption of various turbines, and so on, should be presented	Ari Chakrabarti	Section 6.8	Section 2.3.3														
6	It is commonly recognized in LNG industry that thermal efficiency of steam turbine driven will be lower than that of gas turbine driven.	Ari Chakrabarti	Section 4.7	Section 2.3.4														
7	From the referrals of recent LNG projects in Australia, the emission rates (tGHG/tLNG&LPG) are indicated as below. <table border="0"> <tr> <td>North West Shelf Train 4 (2000)</td> <td>0.44</td> </tr> <tr> <td>Darwin (2002)</td> <td>0.46</td> </tr> <tr> <td>Gorgon (2004)</td> <td>0.35</td> </tr> <tr> <td>Pluto (2007)</td> <td>0.33</td> </tr> <tr> <td>Gladstone (2009)</td> <td>0.35</td> </tr> <tr> <td>Curtis Island (2009)</td> <td>0.26</td> </tr> <tr> <td>Prelude (2009)</td> <td>0.33</td> </tr> </table> <p>Compared to Curtis Island design, Prelude should have a lot of possibilities to improve emission rate and thermal efficiency.</p>	North West Shelf Train 4 (2000)	0.44	Darwin (2002)	0.46	Gorgon (2004)	0.35	Pluto (2007)	0.33	Gladstone (2009)	0.35	Curtis Island (2009)	0.26	Prelude (2009)	0.33	Ari Chakrabarti	Section 6.8	Section 2.3.5
North West Shelf Train 4 (2000)	0.44																	
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Pluto (2007)	0.33																	
Gladstone (2009)	0.35																	
Curtis Island (2009)	0.26																	
Prelude (2009)	0.33																	



8	Table 6.32 does not show any excess gas from end flash stage being sent to flare. It appears that the assumption is that all the Nitrogen rich gas from the end flash is used as fuel gas. What is the Nitrogen level in the feed gas assumed? Please state Nitrogen in feed gas and what sensitivity of this is allowed in making these emission figures.	Ari Chakrabarti	Section 4.7.7 and Figure 4.7	Section 2.3.7
9	Section 6.8.3: Reduced boil-off due to shorter product line is included in emission reduction calculation. This is only a temporary effect eventually all the lighter gases and nitrogen will boil-off the storage tank in course of time. What about increased boil-off due to constant sloshing in the storage tanks, has this been taken into account?	Ari Chakrabarti	Section 6.8.3	Section 2.3.8
10	EIS should highlight potential large LNG spill due to FLNG to LNGC or LNGC to LNGC collision and its impact.	Ari Chakrabarti	Section 6.9.2	Section 2.4.2
11	The selection of steam boilers for main power generation over a combined cycle gas turbine and waste heat recovery system means that you have to comply with World Bank EHS requirements of 320 mg/m <sup>3</sup> NO <sub>x</sub> concentration in the exhaust stream. A combined cycle gas turbine system would have a lower limit of 25 ppmv (equivalent to 47 mg/m <sup>3</sup> at 25C). Therefore, the selection of steam boilers for main power generation as opposed to combined cycle gas turbines is not the best available technology for minimisation of NO <sub>x</sub> emissions.	Simon Dean	Section 4.7 and Section 6.8	Section 2.3.4
12	The Pluto LNG GHG Abatement Program (copy attached) contains a graph (Figure 6) that shows the Tonnes of GHG per tonne of LNG produced. A rough calculation for Prelude indicates that the development will emit -0.43 Te CO <sub>2</sub> per Te LNG (equivalent). This is hardly best in class so how does this compare to an onshore LNG facility?	Simon Dean	Section 4.4.2 and Section 6.8	Section 2.3.5
13	With regards to the discussion about the Carbon Pollution Reduction Scheme (CPRS), it was noted that your referral initially raised the possibility of using geosequestration as a method to reduce carbon emissions. Your draft EIS document also noted on page 100 that geosequestration may be considered at a later stage in the life of the project but provided no further commitment to this. Given the current uncertainty regarding the CPRS, the Department considers that Shell needs to outline further options to offset or mitigate green house emissions which will be implemented throughout the operation life of the facility	DEWHA	Section 4.4.2 and Section 7.10	Section 2.3.6
14	<b><u>Vessel Strike</u></b> When operations commence, around 23 vessels will undertake round journeys to the FLNG facility each month. We consider that this increase in vessel traffic between the proposed facility and the ports of Broome and Darwin could increase the risk of vessel strike on cetaceans because vessels transiting between the Port of Broome and the proposed facility between the months of July to November will intersect the humpback whale migration pathway. The proponent intends to mitigate this risk by developing and implementing “Vessel cetacean interaction procedures” (at 207). These procedures would require drilling, construction and supply contractors engaged by Shell to maintain a watch for cetaceans when transiting, to not knowingly approach within 500m of cetaceans, to take actions to avoid cetaceans located within a distance of 500m from the vessel when safe to do so. The contractors would be required to complete a ‘Whale and Dolphin Sighting Report Sheet’ in the event that cetaceans were sighted. However – given the correlation between higher vessel speeds and the incidence of vessel strike – we recommend the proponent consider limiting vessel speeds for vessels transecting the humpback whale migratory pathway between July and November.	DEWHA	Section 4.8.4	Section 2.4.1

14 <i>continued</i>	<p><b>SUMMARY</b></p> <p>We recommend the proponent include the following information and measures in its upcoming referral:</p> <p>Vessel operations:</p> <ul style="list-style-type: none"> <li>- projected frequency and timing of vessel movements between the Port of Broome and the proposed facility;</li> <li>- vessel sizes; and,</li> <li>- operational vessel speeds</li> </ul>	DEWHA	Section 4.8.4	Section 2.4.1
15	<p><b><u>Subsea infrastructure collision/entanglement</u></b></p> <p>The proposed facility extracts hydrocarbon through a subsea infrastructure array which includes anchors, flexible risers, flowlines, riser base manifolds, umbilicals and wellheads. These devices will cover 7,701m<sup>2</sup> of seafloor.</p> <p>These devices may pose a collision and/or entanglement risk to cetaceans and marine turtles. Therefore we recommend that the proponent:</p> <ul style="list-style-type: none"> <li>v) outlines its rationale as to why its subsea infrastructure poses no collision and/or entanglement risk to cetaceans and,</li> <li>vi) devises mitigation measures to minimise harm posed by its subsea infrastructure to marine fauna (i.e. cetaceans and marine turtles) if collision/entanglement is identified as a risk</li> </ul> <p><b>SUMMARY</b></p> <p>We recommend the proponent include the following information and measures in its upcoming referral:</p> <ul style="list-style-type: none"> <li>- an outline of its rationale as to why its subsea infrastructure poses no collision and/or entanglement risk to cetaceans and marine turtles; and,</li> <li>- development of mitigation measures to minimise harm posed by its subsea infrastructure to marine fauna (i.e. cetaceans and marine turtles)</li> </ul>	DEWHA	Section 6.6.6	Section 2.5.1
16	<p><b><u>Light emissions</u></b></p> <p>Light emissions may disorientate marine turtles and disrupt biologically important behaviours – i.e. migration, nesting, breeding and foraging. Moreover, light emissions may concurrently attract and concentrate marine turtles and predators to and around the light source – exposing the former to injury or mortality.</p> <p>The proponent commissioned an assessment of the potential effect on turtles nesting on Browse Island as a result of light emanating from the facility at normal operations. The assessment found that the light from the facility was visible to turtles to a maximum distance of 27 kms (at 132). This was under normal operations. When flaring, light would be visible to turtles out to a distance of 51 km from the facility – which puts it within the range of turtle nesting and foraging at Browse Island. The proponent indicates that although the light may be visible on the island’s northern beaches and low on the seaward horizon, it is unlikely that the light would be visible on the southern beaches due to the island’s topography. As a result, the proponent claims that the landward horizon would remain unaltered – thus limiting the risk of nesting and hatchling disorientation. We request a copy of the full assessment which was prepared for the proponent by Environmental Resources Management (2009) in order to verify the assessment findings.</p> <ul style="list-style-type: none"> <li>- development of a monitoring program (with the assistance of field experts) regarding the effect of flaring and other artificial light sources on marine turtles nesting on Browse Island.</li> </ul> <p>We also recommend the proponent provide a copy of the following materials for our review:</p> <ul style="list-style-type: none"> <li>- a full copy of the assessment which was prepared for the proponent by Environmental Resources Management (2009) regarding artificial lighting, marine turtles and Browse Island;</li> </ul>	DEWHA	Section 6.4	Section 2.5.3



<p>16 <i>continued</i></p>	<p>The proponent states that they will limit the practice of flaring, however it does not provide projected frequencies or timings. Flaring will be visible from Browse Island, which is an important green turtle nesting site. While we recognise the important safety function of flaring, we support the proponent’s intention to minimise flaring where considerations of operational safety allow (especially during peak nesting periods).</p> <p>It is unknown whether light from the proposed facility’s flare stack would disorientate nesting turtles and hatchlings at a beach 40km from the flare. We recommend that the proponent monitors (with the assistance of experts) the effect of flaring (and other artificial lighting) on marine turtles on Browse Island, and if necessary introduce additional mitigation measures to avoid disorientation of nesting turtles or hatchlings.</p> <p>We recognise the proponent’s aim to design the facility in a manner that mitigates the potential effects of lighting. It intends to:</p> <ul style="list-style-type: none"> <li>- utilise low reflective paints and assess location of luminaries to reduce area of reflective surfaces;</li> <li>- position luminaries in a position (i.e. inward towards the facility) so as to reduce seaward reflection of light;</li> <li>- implement a “no flaring” principle that limits the use of the flare stack where possible;</li> <li>- where possible, avoid continuous illumination of the proposed facility’s work and accommodation areas; and,</li> <li>- ensure vessels restrict use of artificial lighting to the minimum level required for navigation and safety</li> </ul> <p><b>SUMMARY</b></p> <p>We recommend the proponent include the following information and measures in its upcoming referral:</p> <ul style="list-style-type: none"> <li>- development of a monitoring program (with the assistance of field experts) regarding the effect of flaring and other artificial light sources on marine turtles nesting on Browse Island.</li> </ul> <p>We also recommend the proponent provide a copy of the following materials for our review:</p> <ul style="list-style-type: none"> <li>- a full copy of the assessment which was prepared for the proponent by Environmental Resources Management (2009) regarding artificial lighting, marine turtles and Browse Island;</li> </ul>	<p>DEWHA</p>	<p>Section 6.4</p>	<p>Section 2.5.3</p>
<p>17</p>	<p><b>Light emissions</b> <i>continued</i> <i>Turtles</i></p> <p>We hold concerns for the proponent’s intention to utilise green or blue artificial lighting (we note this colour range is least attractive to migratory seabirds). Adult and hatchling green turtles are most receptive to the green and blue portions of the visible light spectrum and least receptive to the yellow/orange to red portions. Thus green or blue artificial lighting has the potential to disrupt adult and hatchling orientation at night and inhibit nesting attempts by females (which would be of concern if such light reached Browse Island). Furthermore, turtles transiting the area may be attracted to the facility – making them more susceptible to vessel strike or entanglement in the infrastructure array.</p> <p>We recognise that the proponent will develop a detailed plan of lighting for the FLNG facility during the Front-End Engineering and Design phase (at 128) and recommend that the light management plan be developed with input from experts in the field. This will ensure that the most appropriate types of lighting are selected to limit potential negative impacts on turtles.</p>	<p>DEWHA</p>	<p>Section 6.4</p>	<p>Section 2.5.3</p>

<p>17 <i>continued</i></p>	<p><b>Birds</b> In particular:</p> <ul style="list-style-type: none"> <li>- the proponent should proceed to develop and implement an effective lighting plan during the Front-End Engineering and Design phase (at 128) that will ensure that the most appropriate types of lighting are selected to limit the potential negative impacts on seabirds as well as marine turtles.</li> </ul> <p>Additionally, we require the proponent to:</p> <ul style="list-style-type: none"> <li>- provide a copy of its proposed lighting plan and supporting scientific information to DEWHA; and</li> <li>- document its “no flaring” principle into a plan (to be subsequently provided to DEWHA)</li> </ul> <p><b>SUMMARY</b> We recommend the proponent include the following information and measures in its upcoming referral:</p> <ul style="list-style-type: none"> <li>- development of a light management plan during the Front-End Engineering and Design phase to mitigate potential harm risks to marine turtles and migratory seabirds with input from field experts;</li> <li>- documentation of its “no flaring” principle into a written plan;</li> </ul> <p>We also recommend the proponent provide a copy of the following materials for our review:</p> <ul style="list-style-type: none"> <li>- a full copy of the modelling report regarding lighting and migratory birds</li> </ul>	<p>DEWHA</p>	<p>Section 6.4</p>	<p>Section 2.5.3</p>
<p>18</p>	<p><b><u>Anchoring to benthos</u></b> The proposed facility will be held in position by four groups of six anchor chains, arranged at the four quadrants around the FLNG turret. The chains are secured by suction piles which will penetrate deep into the benthos. The pile will be 10m in diameter and 20-30m in length – each weighing between 140-180 tonnes. Given the proponent intends to deploy anchorage devices onto the benthos and the significant size and weight of the anchors, we request the development of an anchoring procedure to minimise disturbance to the benthic habitat. The preparation of an anchoring procedure was included in the Marine Division’s advice for referrals EPBC 2009/5160 and EPBC 2009/5122. These proposals were relatively less complex than this proposal. <b>SUMMARY</b> We recommend the proponent include the following information and measures in its upcoming referral: <b>Marine environment:</b></p> <ul style="list-style-type: none"> <li>- development of an anchoring procedure to minimise disturbance to the benthic habitat;</li> <li>- an outline that confirms which “standard Australian industry practices” are to be applied to minimise the potential harm posed by drilling operations;</li> </ul>	<p>DEWHA</p>	<p>Section 6.3</p>	<p>Section 2.5.2</p>



19	<p><b>Discharge of waste</b></p> <p>The proposed facility will produce a range of solid and liquid wastes that may pose a harm risk to the marine environment.</p> <p>Drill cuttings – the drilling of eight wells into the benthos will produce 8,000m<sup>2</sup> of drill cuttings. Rock and sand particles will be separated from drilling fluid and discarded over the side of the drilling rig. The discharge of cuttings will lead to an increase in water sedimentation (“turbidity”) over 1-2km<sup>2</sup> area.</p> <p>To mitigate the moderate levels of harm posed by the discharge of drill cuttings, the proponent states it will follow “[s]tandard Australian industry drilling practices”. We recommend that the proponent outline which standard Australian industry practices it intends to follow, and elucidate how these will mitigate the potential harm risk.</p> <p>Discharge of cooling water – seawater drawn from the ocean will be utilised as a heat exchange medium for the cooling of machinery engines and in the petroleum production process. 50,000m<sup>3</sup> of seawater (i.e. the volume equivalent of 25 olympic swimming pools) will be dispersed into the ocean each hour at a temperature between 39C°–42C° (approximately 7.5C°–16C° above seasonal ambient water temperatures).</p> <p>This equates to the volume of an olympic swimming pool being circulated approximately once every 2.5 minutes.</p> <p>Sodium hypochlorite – also commonly known as bleach – will be added to the cooling water to inhibit marine growth within the pipework of the water cooling system. It is anticipated that the discharged cooling water will contain traces of sodium hypochlorite at a level of 0.2 ppm. Given the nature and massive volume of liquid in question, we are concerned that the proposed discharge will pose a threat to the marine environment. Thus we recommend the proponent undertake hydrographical modelling to determine the flow and dispersal characteristics of discharged heated sodium hypochlorite treated water, and whether this poses a harm risk to the marine environment. Measures will also need to be taken to ensure that seawater intakes do not pose a significant risk to marine fauna.</p> <p>Disposal of sewage, grey water, food waste and putrescibles – the proponent intends to dispose treated sewage, treated grey water, food waste and putrescibles into the ocean.</p> <p>Sewage and grey water – will be treated and discharged in accordance with MARPOL guidelines. The facility is estimated to produce 30m<sup>3</sup> of sewage and grey water per day during the commissioning process and 10m<sup>3</sup> per day once operations commence.</p> <p>Food waste and putrescibles – the proponent intends to macerate all food waste and putrescibles through a 25mm screen before disposing it overboard from the facility. Approximately 1L of food waste and putrescibles will be produced per person onboard the facility each day. This equates to the collective production of 100L of food waste and putrescibles per day during the well drilling and completion phase, and up to 400L per day during the commissioning phase (to span a six month period).</p> <p>It is likely the discharge of these materials will increase nutrient levels in the waters around the facility. We recommend the proponent assesses the potential impacts that enhanced nutrient levels may pose the marine environment, and (if necessary) how these may be mitigated.</p> <p><b>SUMMARY</b></p> <p>We recommend the proponent include the following information and measures in its upcoming referral:</p> <ul style="list-style-type: none"> <li>- a hydrographical model that depicts the flow and dispersal characteristics of discharged heated sodium hypochlorite treated water, and an assessment as to whether this poses a risk to the marine environment;</li> <li>- in regards to the discharge of treated sewage and greywater, food waste and putrescibles, a report that outlines the potential implications and impacts that enhanced nutrient levels may pose the marine environment.</li> </ul>	DEWHA	Section 6.7	Section 2.2.2
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