PRELUDE FLNG

ENVIRONMENT PLAN
2020

Prelude FLNG Environment Plan

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REVISION HISTORY					
Ver.	**Change Description**	**Date**	**Originator**	**Reviewed by**	**Approved by**
1	Issued for Review	23/04/2015	Environment Advisor (Project)	Prelude Technical HSE Lead Prelude HSE Manager Prelude OIM Logistics Manager Environment Manager Services Coordinator Commissioning Leads Subsea Engineer HSSE Advisor Wells Manager Start Up Process Engineer External Affairs Advisor	Prelude Project Director
2	Issued for Review	12/06/2015	Environment Advisor (Project)	Ver.1 reviewers plus the following: Prelude Asset Manager Prelude Project Director Prelude Production Manager General Manager HSSE Construction Manager Process Surveillance Lead Production Chemistry Lead	Prelude Project Director
3	Issued for Review	15/09/2015	Environment Advisor (Project)	Prelude Technical HSE Lead	Prelude Project Director
4	Issued for Use	08/06/2016	Environment Advisor (Project)	Prelude Technical HSE Lead Prelude Asset Manager Prelude Project Director Prelude Production Manager Environment Manager External Affairs Advisor Process Surveillance Lead	Prelude Project Director
5	Issued for Use	11/10/2016	Environment Advisor (Project)	Prelude Technical HSE Lead Prelude Production Manager Environment Manager External Affairs Advisor	Prelude Project Director
6	Approved for Use (Accepted by NOPSEMA)	15/12/2016	Environment Advisor (Project)	N/A	Prelude Project Director
7	Approved for Use	07/07/2017	Environment Advisor (Project)	Prelude Environment Engineer Shell Australia Environment Advisor Prelude HSSE Manager Prelude Production Manager Prelude Technical HSE Lead	Prelude Asset Manager

REVISION HISTORY					
Ver.	**Change Description**	**Date**	**Originator**	**Reviewed by**	**Approved by**
				Environment Technical Authority	
8	Approved for Review (incorporated EP Changes: MEG, MBP, Boiler Blowdown, STP, Chemicals, Smokeless Flare, updated IMS residual risk assessment)	20/12/2018	Prelude Environment Engineer Shell Australia Environment Advisor	Startup Manager Prelude HSSE Manager Prelude Technology Manager Prelude Production Manager QMI Engineer Startup Process Engineering Lead Startup Process Engineer	Prelude Asset Manager
9	Approved for Use prior to SURU	21/12/2018	Prelude Environment Engineer Shell Australia Environment Advisor	Startup Manager Prelude HSSE Manager Prelude Technology Manager Prelude Production Manager QMI Engineer Startup Process Engineering Lead Startup Process Engineer	Prelude Asset Manager
9.1	Approved for Review for formal EP resubmission	2/10/2019	Prelude Environment Engineer Shell Australia Environment Advisor Environment Consultant	Offshore Installation Manager Maintenance Manager Snr Process Engineer 3x Design Process Engineer Production Coordinator Services Coordinator Production Chemist Snr Instrument Engineer Principal Environment Advisor Emergency Response Coordinator Head of Marine HSSE Advisor External Relations Advisor Snr Legal Counsel	
10	Approved EP resubmission for NOPSEMA Assessment	6/2/2020	Prelude Environment Engineer Shell Australia Environment Advisor	External Relations Advisor	Prelude Asset Manager

REVISION HISTORY					
Ver.	**Change Description**	**Date**	**Originator**	**Reviewed by**	**Approved by**
11	Response to NOPSEMA comments	4/09/2020	Shell Australia Environment Lead	Prelude HSSE Manager Principal Environment Advisor Emergency Response Coordinator HSSE Advisor Production Chemist External Relations Advisor Well Engineering Manager Snr Legal Counsel	Prelude Asset Manager
12	Approved for use. Response to NOPSEMA comments	05/01/2021	Prelude Environment Lead Shell Australia Environment Lead	Prelude HSSE Manager Principal Environment Advisor Environment TA2 Emergency Response Coordinator External Relations Advisor Production Support Manager Snr Legal Counsel	Prelude Asset Manager

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1.0 Environment Plan Summary Statement

This Prelude Environment Plan (EP) summary has been prepared from material provided in this EP. The summary consists of the following as required by Regulation 11(4):

EP Summary material requirement	Relevant section of EP containing EP Summary material
The location of the activity	6.2
A description of the receiving environment	7.0
A description of the activity	6.0
Details of the environmental impacts and risks	9.0
The control measures for the activity	9.0
The arrangements for ongoing monitoring of the titleholders environmental performance	10.4.1
Response arrangements in the oil pollution emergency plan	9.14 and 10.7
Consultation already undertaken and plans for ongoing consultation	5.0
Details of the titleholders nominated liaison person for the activity	10.5.5

2.0 Introduction

Shell Australia Pty Ltd (Shell) operates the Prelude Floating Liquefied Natural Gas (FLNG) Project (EPBC 2008/4146) in the Petroleum Permit Area WA-44-L (Figure 2-1). Prelude is in Commonwealth marine waters in the northern Browse Basin, 200km offshore northwest Australia and 460km north-north east of Broome. Shell is the Titleholder and Operator of Prelude FLNG in joint venture with INPEX, KOGAS and OPIC.

The Prelude FLNG Project comprises the FLNG facility itself and subsea systems including: production wells and manifolds; flowlines; riser base manifolds; flexible risers that transport the gas, condensate and any produced formation water to the FLNG facility; and umbilicals used to control the wells and associated equipment (Figure 2-1).

The entire Prelude FLNG Project was referred by Shell under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) ("EPBC Act") which is further addressed in Section 3.1.2.

Environmental management for the Prelude FLNG is undertaken in agreement with this EP, which was prepared in accordance with the requirements of the Prelude FLNG Project (EPBC 2008/4146) Conditions of Approval (see Section 3.1.2) and the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth) ("OPGGS(E) Regulations"), and describes the following:

- Shell's Health, Security, Safety and Environment and Social Performance (HSSE and SP) Commitment and Policy and the environmental performance objectives that derive from the Policy
- The consultation process undertaken with the Relevant Persons and the associated resolution of and/or responses to any objections or claims
- The area of operations, the proposed activities and its expected time frame
- The environmental management framework for the activity including legislation and other requirements
- The existing physical, natural, social and economic environments of the region, including issues or sensitivities particular to the activity
- The impacts and risks to the environment from both planned (normal) and unplanned (abnormal) operations
- The Environmental Performance Outcomes (EPOs), Environmental Performance Standards (EPSs) and Measurement Criteria (MC) against which environmental performance is measured
- The Implementation Strategy, including key roles and responsibilities that are employed to achieve the program's environmental performance goals[1]
- A system for documenting, monitoring, reporting and reviewing the success of the Implementation Strategy to facilitate improvement of environmental performance and external reporting as required.

[1] The Prelude FLNG Oil Pollution Emergency Plan (OPEP) (HSE_PRE_013075), APPEA OSMP Framework and the Operational and Scientific Monitoring Bridging Implementation Plan (HSE_PRE_016370) are presented as standalone documents, submitted together with this EP.

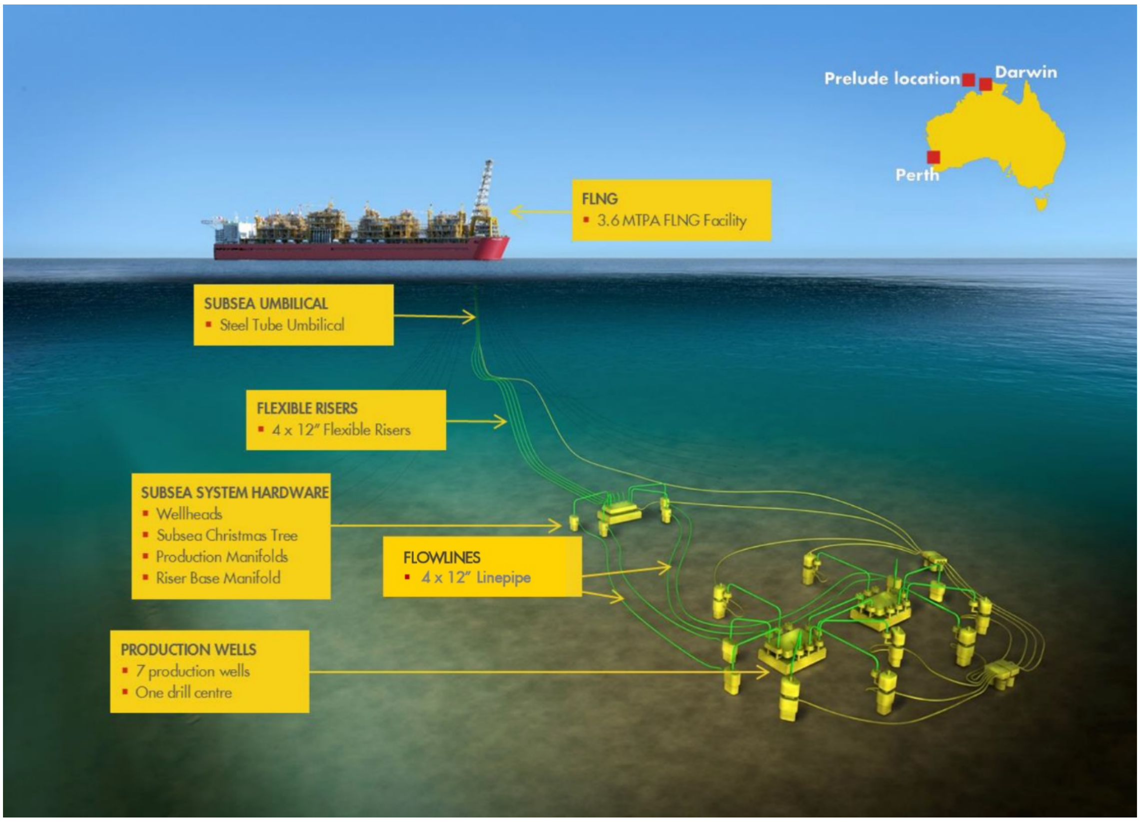


Figure 2-1: Prelude FLNG and Associated Subsea Infrastructure Schematic

3.0 Requirements

This section is intended to fulfil the requirements of Regulation 13 (4) of the OPGGS(E) Regulations and meet NOPSEMA's expectations stated in the Environment Plan Content Requirements Guidance Note (2019). Regulation 13 (4) – Requirements of the OPGGS(E) Regulations stipulates that an EP must:

> *"(a) describe the requirements, including legislative requirements, that apply to the activity and are relevant to the environmental management of the activity; and*
>
> *(b) demonstrate how those requirements will be met*."

The Environment Plan Content Requirements Guidance Note (NOPSEMA 2019a) provides additional information on NOPSEMA's expectations of EP content relating to Regulation 13 (4). NOPSEMA does not expect that requirements that are not relevant to the environmental management of petroleum activities be included in the EP.

This section contains the following, which are intended to meet the requirements stated above:

- Legislation (including the EPBC approval conditions applied to the Prelude FLNG project)
- Standards and guidelines
- International agreement and conventions.

3.1 Legislation

This section describes the Australian legislation that is applicable to the environmental management of the petroleum activities within the scope of this EP. The name of each piece of legislation is provided, along with a description of its relevance to the petroleum activities. A link to the section of the EP related to how these legislative requirements have been considered is also provided.

As the planned activities considered in the EP take place entirely in Commonwealth waters, legislation relating to the environmental management of the petroleum activities considered in this EP are primarily Commonwealth Acts and subsidiary legislation. Key Acts include the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) (OPGGS Act) and the EPBC Act. These Acts and subsidiary legislation are discussed in Sections 3.1.1 and 3.1.2 respectively; additional Commonwealth legislation is considered in Section 3.1.3.

Large volume unplanned hydrocarbon releases may under some circumstances impact upon the environment within the jurisdiction of the State of Western Australia. Western Australian legislation that may be applicable to the environmental management of such hydrocarbon releases has also been considered in Section 3.1.3.

3.1.1 Offshore Petroleum and Greenhouse Gas Storage Act 2006

The OPGGS Act provides the regulatory framework for petroleum exploration, production and greenhouse gas activities in Commonwealth waters. The OPGGS Act is supported by a range of subsidiary legislation, including:

- the *Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009* (Cth) which ensure that facilities are designed, constructed, installed, operated, modified and decommissioned in Commonwealth waters only in accordance with Safety Cases that have been accepted by NOPSEMA;
- the *Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011* (Cth) which require that a Well Operations Management Plan (WOMP) are assessed and accepted by NOPSEMA for existing or proposed offshore facilities; and
- the OPGGS(E) Regulations.

Of relevance to this activity, under Section 572 of the OPGGS Act, a titleholder is required to maintain all structures, equipment and property in a title area in good condition and repair, and to remove property when it is neither used not to be used in connection with operations authorised by the title.

> *Maintenance of property etc.*
>
> (2) A titleholder must maintain in good condition and repair all structures that are, and all equipment and other property that is: (a) in the title area; and (b) used in connection with the operations authorised by the permit, lease, licence or authority.
>
> *Removal of property etc.*
>
> (3) A titleholder must remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations: (a) in which the titleholder is or will be engaged; and (b) that are authorised by the permit, lease, licence or authority.

The requirements under Section 572 (2) and (3) of the OPGGS Act, will be met through the activity as discussed in the sections further.

Of particular relevance to this EP are the OPGGS(E) Regulations, which require the environmental impacts and risks of offshore petroleum and greenhouse gas storage activities be managed to a level that is acceptable and as low as reasonably practicable (ALARP). The OPGGS(E) Regulations are discussed further below.

3.1.1.1 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009

The OPGGS(E) Regulations provide for the protection of the environment in Commonwealth waters by requiring that petroleum and greenhouse gas storage activities be managed in a way that:

- reduces the environmental impacts and risks of the activity to a level that is ALARP;
- reduces the environmental impacts and risks of the activity to an acceptable level; and
- is consistent with the principles of Ecologically Sustainable Development (ESD), as defined in section 3A of the EPBC Act, which includes:
  - decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations
  - if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
  - the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
  - the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
  - improved valuation, pricing and incentive mechanisms should be promoted.

The methodology applied to assess environmental impacts and risks from the petroleum activities considered in this EP details how impacts and risks are managed to a level that is acceptable, ALARP and consistent with the principles of ESD. This methodology is described in Section 8.0 and Sections 9.1-9.2, with aspect-specific demonstrations provided in each of the impact and risk assessment in Sections 9.3-9.14.

Regulation 13(3) of the OPGGS(E) Regulations requires EPs to consider Matters of National Environmental Significance (MNES) protected under the EPBC Act, including the following:

- the world heritage values of a declared World Heritage property within the meaning of the EPBC Act
- the national heritage values of a National Heritage place within the meaning of that Act
- the ecological character of a declared Ramsar wetland within the meaning of that Act
- the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act
- the presence of a listed migratory species within the meaning of that Act
- any values and sensitivities that exist in, or in relation to, part or all of:
  - a Commonwealth marine area within the meaning of that Act
  - Commonwealth land within the meaning of that Act.

MNES that may credibly be impacted, or are at risk of being impacted, are described in Section 7.0 and are considered in the assessment of environmental impacts and risks.

Regulation 10A of the OPGGS(E) Regulations states the criteria for acceptance of an EP. These are summarised in Table 3-1, along with the sections of this EP that relate to each of the criteria.

Table 3-1: Relationships between OPGGS(E) Regulation 10A requirements and EP sections

OPGGS (E) Regulation	Requirement	Relevant Section of EP
10A (a)	The EP is appropriate for the nature and scale of the activity	Section 6.0 and Section 13.0 detail the nature and scale of the petroleum activities considered within this EP. Section 7.0 describes the environmental receptors that may credibly be impacted, or are at risk of being impacted, by the planned and unplanned activities. Section 9.3 to Section 9.14 provides the environmental impact and risk assessments based on the context provided by Sections 6.0, Section 7.0 and Section 13.0 (as well as Shell's internal context and the context provided by Relevant Persons).
10A (b)	The EP demonstrates that the environmental impacts and risks of the activity will be reduced to ALARP	Section 9.1 to Section 9.2 details the method by which Shell demonstrates environmental impacts and risks are managed to a level that is ALARP. Aspect-specific ALARP demonstrations are provided in the impact and risk assessments provided in Section 9.3 to Section 9.14.
10A (c)	The EP demonstrates that the environmental impacts and risks of the activity will be of an acceptable level	Section 8.0 details the method by which Shell demonstrates environmental impacts and risks are managed to a level that is acceptable. Aspect-specific demonstrations of acceptability are provided in the impact and risk assessments provided in Section 9.3 to Section 9.14.
10A (d)	The EP provides or appropriate EPOs, EPSs and MC.	EPOs, EPSs and MCs are detailed in Section 9.3 to 9.14.
10A (e)	The EP includes an appropriate implementation strategy and monitoring, recording and reporting arrangements	The implementation strategy for the EP is provided in Section 10.0.
10A (f)	The EP does not involve the activity or part of the activity, other than arrangements for environmental monitoring or for responding to an emergency,	Section 6.0 and Section 13.0 detail the planned petroleum activities considered in this EP, none of which will occur within a World Heritage Area.

OPGGS (E) Regulation	Requirement	Relevant Section of EP
	being undertaken in any part of a declared World Heritage property within the meaning of the EPBC Act.	
10A (g) (i) & 10A (g) (ii)	The EP demonstrates that: (i) the titleholder has carried out the consultations required by Division 2.2A; and (ii) the measures (if any) that the titleholder has adopted, or proposes to adopt, because of the consultations are appropriate	The consultation undertaken in relation to the EP are detailed in Section 5.0, including Shell's responses to any claims or objections made by Relevant Persons. Any management measures adopted in response to stakeholder consultation outcomes are considered in the aspect-specific impact and risk assessments in Section 9.3 to Section 9.14.
10A (h)	The EP complies with the Act and the regulations.	Section 3.1.1 (i.e. this section) shows the relationship between the Act, regulations and components of the EP.

3.1.2 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act and supporting regulations provide for the protection of the environment and the conservation of biodiversity in Australia. Amendments to the OPGGS Act and OPGGS(E) Regulations in February 2014, undertaken as part of the streamlining of environmental approvals for petroleum activities in Commonwealth waters, require impacts and risks to matters protected under Part 3 of the EPBC Act (i.e. MNES) be considered in the EP. Following the streamlining arrangements, NOPSEMA became the sole environmental regulator for petroleum activities (i.e. regulates activities under the OPGGS Act and EPBC Act) in Commonwealth waters.

The matters protected under Part 3 of the EPBC Act that are required by the OPGGS(E) Regulations are outlined above in Section 3.1.1.1 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations. As part of the streamlining arrangements, matters protected under Part 3 of the EPBC Act must be considered by NOPSEMA when assessing an EP.

3.1.2.1 Consolidated Approval Conditions

The Prelude FLNG Project was referred for assessment under the EPBC Act in 2008 (EPBC 2008/4146) and was deemed to be a 'controlled action'. The Project was assessed through an Environmental Impact Statement (EIS), following which the Project was approved on 12 November 2010 subject to a series of conditions via approval decision EPBC 2008/4146. These conditions were varied on 8 September 2015 and the consolidated approval conditions subsequently published. The consolidated conditions, along with the associated sections of the EP relevant to the conditions, are provided in Table 3-2.

Table 3-2: EPBC Approval Conditions (EPBC 2008/4146) and related EP sections

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
1) The person taking the action must submit, for the Minister's approval, a plan (or plans) for managing the offshore impacts of the action. The plan (or plans) must include measures for: a) Production drilling activities: a) Well locations; b) Drilling fluid types and disposal method; c) Drill cutting disposal method; d) Fuel and chemical handling and transfer procedures; e) Cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the *Environment Protection and Biodiversity Conservation Regulations 2000*; and f) Cetacean sightings reporting. b) Offshore construction and installation, including: a) Design and construction that allows for the complete removal of all structures and components above the seafloor during decommissioning; b) Details of the anchor type and placements, methods for connection of mooring lines, installation of the risers and flowline paths; c) Measures to minimise seabed disturbance; d) Hydrotest fluid type, handling and disposal methods; e) Cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the *Environment Protection and Biodiversity Conservation Regulations 2000*; f) Cetacean sightings reporting; and g) Measures for reporting environmental incidents. c) Operations, including: a) Offtake tanker vetting procedures; b) Produced formation water and naturally occurring radioactive materials monitoring and management;	Shell has prepared, submitted for assessment and implemented EPs for all stages of the Prelude FLNG development to date. This EP relates only to the start-up and operations phases of the action or as amended from time to time. 1a) Production drilling activities are beyond the scope of the petroleum activities considered in this EP. 1b) Offshore construction and installation activities are beyond the scope of the petroleum activities considered in this EP. 1c) i) Offtake tanker vetting procedures are provided in Section 10.4.3. ii) The impacts and risks from produced formation water and naturally occurring radioactive materials, along with monitoring and management measures, are assessed in Section 9.9, Section 9.12 and Section 10.4.1. iii) The impacts and risks from artificial lighting and noise, along with monitoring and management measures, are assessed in Section 9.4 and Section 9.5. iv) Procedures for supply vessels and aircraft that are consistent with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000 are provided in Section 9.5 and Section 9.7. v) Measures for reporting environmental incidents are provided in Section 10.5.2. This EP was originally submitted greater than two months prior to commencing Prelude FLNG operations.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
c) Measures to reduce artificial lighting and noise associated with operation; d) Cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the *Environment Protection and Biodiversity Conservation Regulations 2000*; e) Cetacean sightings reporting; and f) Measures for the reporting of environmental incidents. The plan (or plans) must be submitted at least two months prior to the commencement of these activities. Individual offshore activities, as defined within these conditions, may not commence until the plan (or plans) for that specific activity have been approved. The approved plan (or plans) must be implemented.	
4) The person taking the action must develop and submit to the Minister for approval, an Oil Spill Contingency Plan that demonstrates the response preparedness of the person taking the action for any hydrocarbon spills, including the capacity to respond to a spill and mitigate the environmental impacts. The Plan must include, but is not limited to: a) Oil spill trajectory modelling for potential spills from the action. This should include consideration of a well blow out or uncontrolled release. The modelling should be specific to the characteristics of the hydrocarbons contained in the Prelude gas field, the likely volumes released in a worst-case scenario spill, and the potential time over which the oil may be released in a worst-case scenario spill, including a scenario of eleven (11) weeks uncontained spill. b) A description of resources available for use in containing and minimising impacts in the event of a spill and arrangements for accessing these. c) A demonstrated capacity to respond to a spill at the site, including application of dispersants, if required and appropriate, and measures that can feasibly be applied within the first 12 hours of a spill occurring. d) Identification of sensitive areas that may be impacted by a potential spill, in particular Browse Island, specific response measures for these areas and prioritisation of these areas during a response. e) Training of staff in spill response measures and identifying roles and responsibilities of personnel during a spill response. f) Procedures for reporting oil spill incidents.	Shell has undertaken a detailed hydrocarbon spill risk assessment, developed an Oil Pollution Emergency Plan (OPEP) (HSE_PRE_013075) and an associated Operational and Scientific Monitoring Plan (OSMP) (which includes the APPEA OSMP Framework and supporting Operational and Scientific Monitoring Bridging and Implementation Plan) which combined with this EP, meet the requirements of condition 4 as per the following: a) Key outputs from oil spill trajectory modelling for potential spills are provided in Section 9.13. b) Spill resource availability and access requirements are addressed in the OPEP. c) Demonstrated capacity (including dispersant application) to respond to a spill is provided for in the OPEP. d) Environmental sensitivities (including Browse Island) located within the Zone of Potential Impact (ZPI) are described in Section 9.13. Specific response measures for Browse Island and the Spill Impact Mitigation Assessment (SIMA) process are provided in the OPEP.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
The Oil Spill Contingency Plan must be submitted at least three months prior to the commencement of drilling activities. The person taking the action must not commence Prelude production drilling activities until the Oil Spill Contingency Plan is approved. The approved Oil Spill Contingency Plan must be implemented.	e) Training requirements for personnel undertaking oil spill response are provided in Section 10.7.9. Roles and responsibilities for spill response are contained within the OPEP. f) Requirements for reporting oil spill incidents are provided in Section 10.5.2 and the OPEP.
5) The person taking the action must develop and submit to the Minister for approval, and Operational and Scientific Monitoring Program that will be implemented in the event of an oil spill to determine the potential extent and ecosystem consequences of such a spill, including, but not limited to: a) Triggers for the initiation and termination of the Operational and Scientific Monitoring Program, including, but not limited to, spill volume, composition, extent, duration and detection of impacts; b) A description of the studies that will be undertaken to determine the operational response, potential extent of impacts, ecosystem consequences and potential environmental reparations required as a result of the oil spill. c) Inclusion of sufficient baseline information on the biota and the environment that may be impacted by a potential hydrocarbon spill, to enable an assessment of the impacts of such a spill. d) A strategy to implement the scientific monitoring plan, including timelines for delivery of results and mechanisms for the timely peer review of studies, and e) Provision for periodic review of the program. The Operational and Scientific Monitoring Program must be submitted at least three months prior to the commencement of drilling activities. The person taking the action must not commence Prelude production drilling activities until the Operational and Scientific Monitoring Program is approved. The approved Operational and Scientific Monitoring Program must be implemented.	As stated above, Shell has adopted an OSMP that may be implemented in the event of a hydrocarbon spill. The OSMP scales in response to the nature and scale of the spill and the environmental receptors at risk. The OSMP has discrete initiation and termination criteria for each of the components of the OSMP. The OSMP includes consideration of baseline data and provides for sampling of receptors identified at being at risk prior to being contacted by hydrocarbons in the event of a spill. The arrangements by which Shell maintains preparedness to implement operational and scientific monitoring are detailed in the OSMP, the OPEP and Section 10.7.
7) The person taking the action must submit a Decommissioning Plan to the Minister for approval one year prior to the decommissioning of the Prelude Floating Natural Gas Facility or any subsea wells, flowlines or associated infrastructure. The Decommissioning Plan must consider the	No decommissioning activities are planned as part of the petroleum activities considered in this EP.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
complete removal of all structures and components above the sea floor. The approved Decommissioning Plan must be implemented.	
11) The person taking the action may choose to revise a management plan approved by the Minister under conditions 1, 4, 5 and 7 without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the revised plan would not be likely to have a new or increased impact. If the person taking the action makes this choice they must: i) Notify the Department in writing that the approved plan has been revised and provide the Department with an electronic copy of the revised plan; ii) Implement the revised plan from the date that the plan is submitted to the Department; and iii) For the life of this approval, maintain a record of the reasons the person taking the action considers that taking the action in accordance with the revised plan would not be likely to have a new or increased impact.	Shell may revise the EP, OPEP and OSMP without providing notification to the Minister or NOPSEMA if no significant new environmental risks/impacts or increases to identified environmental risks/impacts considered in these plans are identified. Triggers for submission of an EP revision to NOPSEMA are provided in Section 10.1.9.
11A) The person taking the action may revoke their choice under condition 11 at any time by notice to the Department. If the person taking the action revokes the choice to implement a revised plan, without approval under section 143A of the Act, the plan approved by the Minister must be implemented.	Shell does not intend to revoke their choice in relation to the submission of plans detailed in condition 11. If Shell do elect to revoke their choice, they will implement the plan approved by the Minister.
11B) If the Minister gives a notice to the person taking the action that the Minister is satisfied that the taking of the action in accordance with the revised plan would be likely to have a new or increased impact, then: i) Condition 11 does not apply, or ceases to apply, in relation to the revised plan; and ii) The person taking the action must implement the plan approved by the Minister. To avoid any doubt, this condition does not affect any operation of conditions 11 and 11A in the period before the day the notice is given. At the time of giving the notice the Minister may also notify that for a specified period of time that condition 11 does not apply for one or more specified plans required under the approval.	Shell accepts that any new or increased impact in a revision to a management plan specified in condition 11 will result in condition 11 not being applicable and Shell will implement the plan accepted by the Minister.
11C) Conditions 11, 11A and 11B are not intended to limit the operation of section 143A of the Act which allows the person taking the action to submit a revised management plan to the Minister for approval.	Not directly applicable to this EP.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
14) A plan or program required by condition 1, 4 or 5 has been approved by the Minister and the measures (as specified in the relevant conditions) are included in an environment plan (or Environment Plans) that: a) Was submitted to NOPSEMA after 27 February 2014; or b) Either: i) Is in force under the OPGGS Environment Regulations; or ii) Has ended in accordance with regulation 25A of the OPGGS Environment Regulations.	Noted – Shell intends to meet the requirements of the consolidated conditions detailed in EPBC 2008/4146 by submitting the EP, OPEP and OSMP to NOPSEMA.
14A) Where a plan or program required by condition 1, 4 or 5 has been approved by the Minister and the measures (as specified in the relevant condition) are included in an environment plan (or Environment Plans) that: a) Was submitted to NOPSEMA after 27 February 2014; or b) Either: i) Is in force under the OPGGS Environment Regulations; or ii) Has ended in accordance with regulation 25A of the OPGGS Environment Regulations. the plan or program approved by the Minister no longer needs to be implemented provided the environment plan remains in force.	Shell has submitted the plans required by conditions 1, 4 and 5 to NOPSEMA as part of an EP submission for the activity.
14B) Where an environment plan, which includes measures specified in the conditions referred to in conditions 14 and 14A above, is in force under the OPGGS Environment Regulations that relates to the taking of the action, the person taking the action must comply with those measures as specified in that environment plan.	Shell intends to comply with the conditions in the EP submissions made to NOPSEMA.

3.1.2.2 Australian Marine Park Management Plans

The EPBC Act provides for the declaration of Australian Marine Parks (AMPs) based on the International Union for the Conservation of Nature (IUCN) principles and guidelines for categorising protected areas. Australia has established a network of AMPs throughout Commonwealth waters, which are managed under a series of region-based management plans. These plans detail the management objectives of the AMPs, the environmental values within each of the AMPs and the activities that area permissible within the zones of the AMPs. AMPs are part of the Commonwealth Marine Area, which is an MNES.

The planned petroleum activities considered within this EP will not credibly impact upon any AMPs, however an unplanned hydrocarbon spill from a worst-case loss of well containment was identified as potentially impacting upon several AMPs. These AMPs are described in Section 7.3.2 and managed under the Australian Marine Parks - North Marine Parks Network Management Plan 2018 (Director of National Parks 2018a) and Australian Marine Parks - North-west Marine Parks Network Management Plan 2018 (Director of National Parks 2018b).

The requirements of the management plans for AMPs are considered as part of Shell's determination of the acceptability of environmental impacts and risks. Refer to Section 9.3 to Section 9.14 for further information.

3.1.2.3 Recovery Plans and Conservation Advice

Species and communities listed as threatened under the EPBC Act are MNES and receive protection under Commonwealth law. The Threatened Species Scientific Committee may publish conservation advice for a threatened species, which provides information on threats and conservation management. Recovery plans relating to threatened species may also be published by the Commonwealth Department of the Environment and Energy. Recovery plans are intended to provide a framework to prevent further decline, and facilitate the recovery, of threatened species. Recovery plans may contain actions that warrant consideration during the assessment of environmental impacts and risks. Recovery plans may also identify habitat critical for the survival of a species; such habitat is protected under the EPBC Act.

Shell has identified a number of threatened species that may credibly be impacted, or are at risk of being impacted, by the petroleum activities considered in this EP. Details on these species, along with relevant information from recovery plans and conservation advice, are provided in Section 7.2.8.

3.1.3 Other Legislation

Other legislation applicable to the environmental management of the petroleum activities considered in this EP, along with a justification as to why they are relevant, are provided in Table 3-3.

Table 3-3: Summary of Relevant Legislation

Legislation	Summary	Relevance to the Project
Australian Heritage Council Act 2003	This Act identifies areas of heritage value, including those listed on the World Heritage List, National Heritage List and the Commonwealth Heritage List (all of which are MNES under the EPBC Act).	The EP will take into consideration any heritage values (see Section 7.3.1 for details).
Australian Maritime Safety Authority Act 1990	Provides that a function of AMSA is to combat pollution in the marine environment. AMSA is the control agency for vessel-based non-petroleum activity spills in commonwealth waters.	Vessel emergencies, including oil spills in Commonwealth waters.
Biodiversity Conservation Act 2016 (WA) *Biodiversity Conservation Regulations 2018*	Requires WA conservation management agencies to take a lead role in oiled wildlife response in Western Australia. DBCA has the responsibility and statutory authority to treat, protect and destroy wildlife.	Oiled wildlife response will comply with this Act.
Biosecurity Act 2015	The Act and its supporting legislation are the primary legislative means for managing risk of pests and diseases entering Australian territory. The Act includes requirements for pre-arrival reporting, ballast water management plans and certificates.	The EP will comply with biosecurity requirements, specifically in relation to biofouling and ballast water requirements.
Emergency Management Act 2005 (WA)	Requires the WA DoT (Hazard Management Agency) shall be the Control Agency for spills within or entering WA state waters. It is the legislative basis for the WA WestPlan – MOP.	Emergencies including oil spills which enter state waters.
Environment Protection (Sea Dumping) Act 1981	This Act protects is intended to prevent pollution of the sea by prohibiting the discharge of potentially harmful materials to the sea.	Chemical inventories onboard the Prelude FLNG facility may potentially breach this convention if unpermitted via this EP and deliberately discharged to the sea.
Hazardous Waste (Regulation of Exports and Imports) Act 1989	This Act regulates the export, import and transport of hazardous waste to ensure that hazardous waste is managed appropriately so that human health and the	The project will comply with the export, import and transport requirements for hazardous waste.

Legislation	Summary	Relevance to the Project
	environment are protected from the harmful effects of the waste.	
National Environment Protection (National Pollutant Inventory) Measure 1998 (established under the *National Environment Protection Council Act 1994*)	This measure provides the framework for the development and establishment of the National Pollutant Inventory (NPI), which provides publicly available information on the types and amounts of 93 toxic substances being emitted into the Australian environment. These substances have been identified as important due to their possible effect on human health and the environment.	The project will comply with the NPI NEPM through the reporting of relevant NPI substances.
National Environment Protection Council Act 1994	This Act establishes the National Environment Protection Council (NEPC). The primary functions of the NEPC are to define National Environment Protection Measures (NEPMs) to ensure that Australians have equivalent protection from air, water, soil and noise pollution, and assess and report the implementation and effectiveness of NEPMs.	The project will comply with the requirements of the relevant NEPMs.
National Greenhouse and Energy Reporting Act 2007 *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*	The Act provides a single, national framework for the reporting and distribution of information related to greenhouse gas (GHG) emissions, GHG projects, energy production and energy consumption. Reporting obligations are imposed upon corporations that meet emissions/energy thresholds. The Act includes National Greenhouse and Energy Reporting (NGER) requirements and the Safeguard Mechanism requirements.	Shell reports as a corporate group under the Act which includes emissions from the Prelude FLNG. Prelude FLNG has committed to a baseline under the Safeguard Mechanism requirement.
Navigation Act 2012 *Navigation Regulations 2013* *Marine Order 21 (Safety and emergency arrangements) 2016*	This Act relates to maritime safety and the prevention of pollution of the marine environment in Australian waters. It gives effect to several international conventions relating to maritime issues to which Australia is a signatory. The Act also has subordinate	The project, including vessels, will adhere to the Act and subsidiary legislation enabled by the Act, such as Marine Orders relating to the international conventions listed in Section 3.3.

Legislation	Summary	Relevance to the Project
Marine Order 27 (Safety of navigation and radio equipment) 2016 *Marine Order 28 (Operations standards and procedures) 2015* *Marine Order 30 (Prevention of collisions) 2016* *Marine order 60 (Floating offshore facilities) 2001* *Marine Order 71 (Masters and deck officers) 2014*	legislation contained in Regulations and Marine Orders.	
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 and Regulations 1995	The Act protects the environment by reducing emissions of ozone depleting substances (ODSs) and synthetic greenhouse gases (SGGs). It controls the manufacture, import and export of ODSs and SGGs and products containing these gases.	The project will adhere to restrictions on import and use of ODSs/SGGs through implementing appropriate measures that control procuring of products which contain these gases.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 *Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994* *Marine Order 91 (Marine pollution prevention — oil) 2014* *Marine Order 93 (Marine pollution prevention — noxious liquid substances) 2014* *Marine Order 94 (Marine pollution prevention — packaged harmful substances) 2014* *Marine Order 95 (Marine pollution prevention — garbage) 2018* *Marine Order 96 (Marine pollution prevention — sewage) 2018* *Marine Order 97 (Marine pollution prevention — air pollution) 2013*	The Act regulates discharges from ships to protect the sea from pollution. This includes regulation of discharges of oil or oily mixtures, noxious liquid substances, packaged harmful substances, sewage and garbage to the sea. The Act imposes a duty to report certain incidents involving prohibited discharges and to maintain record books and management plans. The Act and subsidiary Marine Orders enact the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL).	The FLNG and vessels within the Operational Area are subject to this Act and will adhere to the requirements for discharges and waste management outlined in the relevant MARPOL and Marine Orders (as appropriate to vessel class).

Legislation	Summary	Relevance to the Project
Underwater Cultural Heritage Act 2018	An Act to protect Australia's underwater cultural heritage. The Act came into effect on 1 July 2019, replacing the *Historic Shipwrecks Act 1976*. This act protects Australia's shipwrecks, and broadens protection to sunken aircraft and other types of underwater cultural heritage.	Planned petroleum activities will not interfere with any underwater cultural heritage sites (see Section 7.3.1 for details).

3.2 Standards and Guidelines

3.2.1 Industry Good Practice Standards

In Australia, the petroleum exploration and production industry operate within an industry code of environmental practice developed by the Australian Petroleum Production and Exploration Association (APPEA) (APPEA 2008). This code provides guidelines for activities and has evolved from the collective knowledge and experience of the oil and gas industry both nationally and internationally. The code provides the Australian petroleum industry with guidance on management measures to protect the environment during exploration, production and decommissioning phases. Shell is a signatory to the APPEA guidelines and will align with their intent in the implementation of this EP.

The following Australian guidelines are also applicable to the project:

- GN1344 Environment Plan Content Requirements Guidance Note (NOPSEMA 2019a)
- GN1785 Petroleum activities and Australia marine parks (NOPSEMA 2018a)
- GN1488 Oil Pollution Risk Management (NOPSEMA 2018b)
- IP1349 Operational and Scientific Monitoring Programs (NOPSEMA 2016)
- IP1765 Acoustic impact evaluation and management (NOPSEMA 2018c)
- Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017)
- National Biofouling Management Guidance for the Petroleum Production and Exploration Industry 2009 (Department of Agriculture, Fisheries and Forestry 2009)
- Technical Guideline for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities (AMSA 2015)
- Advisory Note for Offshore Petroleum Industry Consultation with Respect of Oil Spill Contingency Plans (AMSA 2018), and the corresponding Marine Oil Pollution: Response and Consultation Arrangements (Department of Transport 2020).

The following international guidelines are also applicable to the project:

- Improving Social and Environmental Performance: Good Practice Guidance for the Oil and Gas Industry (IPIECA 2017)
- Environmental Management in Oil and Gas Production (United Nations Environment Program and Oil Industry International Exploration and Production Forum 1997).

3.2.2 International Standards and Guidelines

Shell refers to World Bank (WB)/International Finance Corporation (IFC) guidelines as the basis for many of its operation guidelines, as aligned with the Shell HSSE & SP Control Framework. The WB/IFC guidelines are the minimum environmental, social and health standards for WB funded projects, unless the standards of the host country are more stringent.

The WB/IFC guidelines of primary relevance to the project include:

- IFC Performance Standards on Environmental and Social Sustainability (IFC 2012)
- General Environmental, Health, and Safety (EHS) Guidelines (IFC 2007)
- EHS Guidelines for Offshore Oil and Gas Development (IFC 2015).

3.2.3 Shell Health, Security, Safety, Environment and Social Performance Management Framework

Shell maintains and implements a Health, Security, Safety, Environment and Social Performance Management Framework, which contains a range of standards and guidelines. It is the means by which Shell ensures that the industry good practice standards and international standards and guidelines detailed in Sections 3.2.1 and 3.2.2 are implemented. It forms the basis of the implementation strategy of this EP. Refer to Section 4.0 for further information.

3.3 International Agreements and Conventions

Australia is signatory to several international conventions and agreements that are relevant to the environmental management of the petroleum activities considered in this EP. These are typically implemented by Commonwealth legislation, much of which is detailed above in Section 3.1. Relevant international agreements and conventions, along with a justification of their relevance to the petroleum activities considered in this EP, are provided in Table 3-4.

Table 3-4: Summary of relevant international agreements and conventions

Agreement / Convention	Summary	Relevance to the Project
Convention on the Conservation of Migratory Species of Wild Animals 1979 (the Bonn Convention)	This convention aims to conserve migratory fauna species throughout their ranges, particularly where their range crosses international jurisdictional boundaries. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under the Bonn Convention to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several species listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Refer to Section 7.2.8.
The East Asian - Australasian Flyway Partnership 2006 (EAAFP)	Adopted in the list of the World Summit on Sustainable Development as a Type II initiative which is informal and voluntary, the Partnership was launched on 6 November 2006 and aims to protect migratory waterbirds, their habitat and the livelihoods of people dependent upon them. There are currently 37 Partners including 18 countries, 6 intergovernmental agencies, 12 international non-governmental organisations (NGOs) and 1 international private enterprise.	Several migratory birds species that utilise the East Asian - Australasian Flyway were identified as potentially being impacted by the petroleum activities considered in this EP. Section Refer to Section 7.2.8.
The Agreement on the Conservation of Albatrosses and Petrels (ACAP)	ACAP through its 13 Parties strives to conserve albatrosses and petrels by coordinating international activities to mitigate threats to their populations.	Several albatross and petrel species were identified as potentially being impacted by the petroleum activities considered in this EP. Section Refer to Section 7.2.8.
Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974 (JAMBA)	This agreement aims to conserve migratory bird species that travel between Japan and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under JAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Section Refer to Section 7.2.8.
Agreement between the Government of Australia and the Government of the People's Republic of China for the	This agreement aims to conserve migratory bird species that travel between China and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Refer to Section 7.2.8.

Agreement / Convention	Summary	Relevance to the Project
Protection of Migratory Birds and their Environment 1986 (CAMBA)	makes provision for species listed under CAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	
Agreement between the Government of Australia and the Government of the Republic for Korea for the Protection of Migratory Birds and their Environment 2007 (ROKAMBA)	This agreement aims to conserve migratory bird species that travel between the Republic of Korea and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under ROKAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Refer to Section Refer to Section 7.2.8.
International Convention on Wetlands of International Importance 1975 (Ramsar)	This convention aims to conserve and promote the sustainable human use of wetlands. Many wetlands have been identified as important habitat for migratory bird species, and Ramsar wetlands are of importance in conserving many species of migratory shorebirds and waders. Ramsar wetlands are protected under the EPBC Act and are MNES.	The Ashmore Reef Ramsar wetland was identified as potentially being impacted in the event of an unplanned release of large volumes of hydrocarbons (e.g. loss of well control). Refer to Section 7.2.5.
Memorandum of Understanding between the Government of Australia and the Government of the Republic of Indonesia Regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Exclusive Fishing Zone and Continental Shelf 1974	This memorandum recognises the long history of traditional Indonesian fishermen exploiting biological resources within Timor Sea waters within Australia’s exclusive economic zone. The memorandum provides for an area (commonly referred to at the MoU box) within which traditional Indonesian fishing is permitted. The area includes several offshore reefs, including Ashmore Reef, Cartier Island, Scott Reef and Seringapatam Reef.	The Prelude FLNG Project is situated within the MoU box. Refer to Section 7.3.3.
London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention)	This convention is an agreement to control pollution of the sea by intentional disposal at sea of potentially harmful materials. It is implemented under Commonwealth law by the *Environment Protection (Sea Dumping) Act 1981*.	Chemical inventories onboard the Prelude FLNG facility may potentially breach this convention if unpermitted via this EP and deliberately discharged to the sea.

Agreement / Convention	Summary	Relevance to the Project
Minamata Convention on Mercury 2017	This convention is an agreement to protect human and environmental health from the effects of releases of mercury and mercury-containing compounds to the environment. The convention is not yet ratified by Australia, and hence is not currently implemented in Commonwealth law. Australia has signed the convention and is currently undertaking an assessment process prior to ratification.	Petroleum production by the Prelude FLNG may result in mercury compounds being produced from petroleum reservoirs as a by-product. Mercury may pose a risk to the environment if not managed appropriately.
International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL)	This convention is an agreement to minimise the pollution of the marine environment by ships. The convention provides a standardised approach to the environmental management of international and domestic shipping. The convention is implemented in Commonwealth law by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and a series of Marine Orders made under this Act.	All marine support vessels are required to comply with MARPOL.
International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW)	This convention provides a standardised approach to the qualifications and competencies of masters, officers and watch personnel. It is implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels and crew are required to comply with STCW.
International Convention for the Safety of Life at Sea 1974 (SOLAS)	This convention provides internationally agreed minimum standards for the construction, equipment and operation of vessels. It is implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels are required to comply with SOLAS.
International Regulations for Preventing Collisions at Sea 1972 (COLREGS)	These regulations provide internationally agreed rules for the navigation of vessels, which are intended to reduce the likelihood of vessel collisions. COLREGS are implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels are required to comply with COLREGS.

Agreement / Convention	Summary	Relevance to the Project
Paris Agreement on Climate Change (2015)	The Paris Agreement is an instrument made under the UNFCCC, with the central aim of strengthening the global response to the threat of climate change by keeping the global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius in order to prevent dangerous human caused interference with the climate system. It deals with GHG emissions mitigation, adaptation, and finance. The agreement's language was negotiated by representatives of 196 state parties, including Australia, and adopted by consensus on 12 December 2015, before entering in to force in late 2016. Australia has since ratified the Paris Agreement. The Paris Agreement requires each party to: • volunteer its own Nationally Determined Contributions (NDCs), to report against them annually, and improve them if it is determined that the collective commitment to NDCs is considered ineffective or insufficient to keep global temperature increases to less than 2ºC below pre-industrial levels. This allows for variation in emissions reduction performance according to the development status of the country; and • determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. No mechanism forces a country to set a specific emissions target by a specific date, but each target should go beyond previously set targets. Australia has set Nationally Determined Contribution under the Paris Agreement of 26% to 28% reduction over 2005 levels. (Source: climatetracker.org – LULUCF means land use, land-use change, and forestry). The Intergovernmental Panel on Climate Change (IPCC) released a report in October 2018 on the 1.5 degrees Celsius	The Paris Agreement provides the international framework and context around Australia’s NDC, which is important to establishing the defined acceptable level of GHG emissions from the Prelude FLNG.

Agreement / Convention	Summary	Relevance to the Project
	target; it concluded that global emissions need to reach net zero around mid-century to give a reasonable chance of limiting warming to 1.5 degrees Celsius.	

4.0 Shell Environmental Management Framework

4.1 Shell Health, Security, Safety, Environment and Social Performance Management Framework

Shell, as a subsidiary of Royal Dutch Shell plc, is a member of the Shell group of companies (and in this EP, where there is reference to Shell's activities globally, the term "Shell Group" is used).

The Shell Group operates under a common set of business principles, supported by policies, standards and business controls which are implemented throughout the organisation structure. In support of the business principles, there is a Shell Group HSSE and SP Policy which requires every Shell Company to manage HSSE and SP in a systematic manner.

The Shell Group HSSE and SP Control Framework is a corporate management framework which applies to every Shell Group company, contractor and joint venture under Shell's operational control.

4.2 HSSE & SP Policy

The Shell Commitment and Policy on HSSE & SP applies across the Shell Group and is designed to protect people and the environment. The policy, endorsed and adopted by Shell, is presented in Figure 4-1. The policy illustrates the commitment made by the senior management and all staff of Shell to achieve not only compliance with environmental standards set by the Australian Government and the Company, but also to seek continual improvements in performance.

Key features of the policy are:

- systematic approach to HSSE and SP management designed to ensure compliance with the law and to achieve continuous performance improvement
- targets for improvement and measurement, appraisal and performance reporting
- requirement for contractors to manage HSSE and SP in line with this policy
- effective engagement with neighbours and impacted communities.

SHELL COMMITMENT AND POLICY ON HEALTH, SECURITY, SAFETY, THE ENVIRONMENT AND SOCIAL PERFORMANCE

COMMITMENT

In Shell we are all committed to:

- Pursue the goal of no harm to people;
- Protect the environment;
- Use material and energy efficiently to provide our products and services;
- Respect our neighbours and contribute to the societies in which we operate;
- Develop energy resources, products and services consistent with these aims;
- Publicly report on our performance;
- Play a leading role in promoting best practice in our industries;
- Manage HSSE & SP matters as any other critical business activity; and
- Promote a culture in which all Shell employees share this commitment.

In this way we aim to have an HSSE & SP performance we can be proud of, to earn the confidence of customers, shareholders and society at large, to be a good neighbour and to contribute to sustainable development.

POLICY

Every Shell Company:

- Has a systematic approach to HSSE & SP management designed to ensure compliance with the law and to achieve continuous performance improvement;
- Sets targets for improvement and measures, appraises and reports performance;
- Requires contractors to manage HSSE & SP in line with this policy;
- Requires joint ventures under its operational control to apply this policy, and uses its influence to promote it in its other ventures;
- Engages effectively with neighbours and impacted communities; and
- Includes HSSE & SP performance in the appraisal of staff and rewards accordingly.

Ben van Beurden
Chief Executive Officer

Tony Nunan
EVP / Country Chair Shell Australia

Originally published in March 1997 and updated by the Executive Committee December 2009.

General Disclaimer: The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this Policy the expression "Shell" is sometimes used for convenience where references are made to companies within the Shell group or to the group in general. Likewise, the words "we", "us" and "our" are also used to refer to Shell companies in general or those who work for them. These expressions are also used where no useful purpose is served by identifying specific companies.

Figure 4-1: Shell Australia's HSSE & SP Policy

4.3 HSSE & SP Control Framework

All Shell's operations are conducted in accordance with Shell's HSSE & SP Control Framework, a comprehensive corporate management framework. This Framework defines a set of mandatory requirements that define minimum HSSE & SP principles and expectations, which are documented in a set of manuals. Figure 4-2 outlines the various control framework manuals applicable to Prelude FLNG.

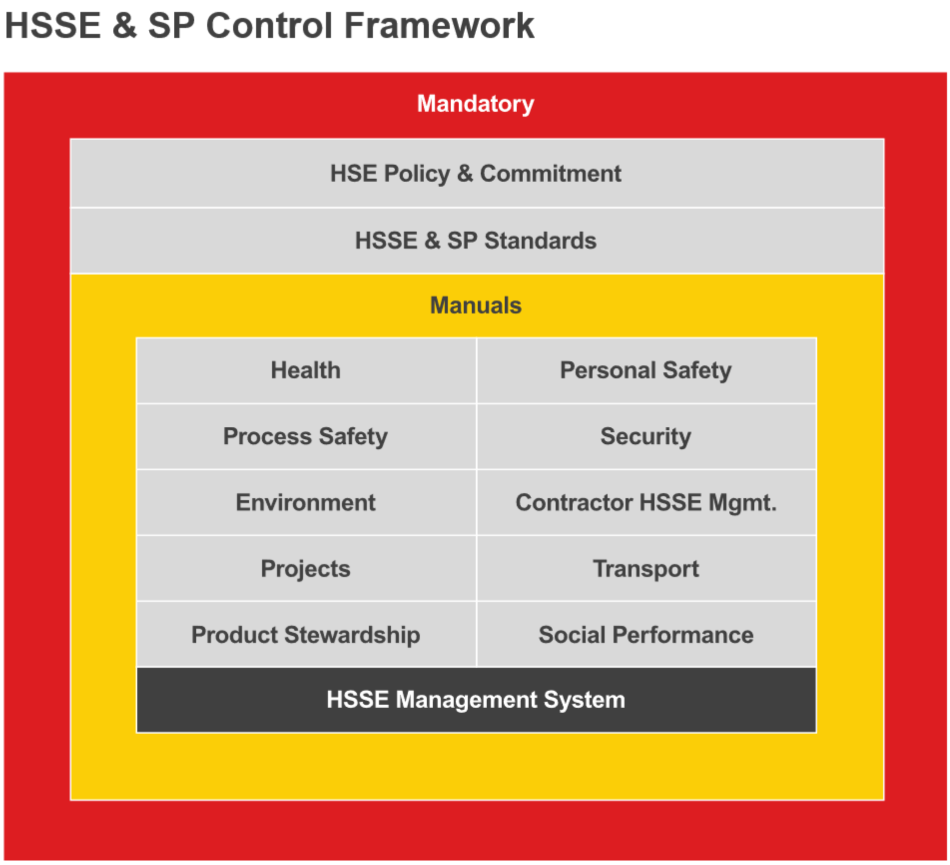


Figure 4-2: Shell HSSE & SP Control Framework

4.4 HSSE & SP Management System (MS)

The Shell HSSE &SP-MS provides a structured and documented system for the effective management of impacts and risks and demonstrates how the requirements of the Shell Group HSSE & SP Control Framework are implemented throughout Shell. The Shell HSSE & SP-MS Manual consists of the following elements:

- Leadership and Commitment
- Policy and Objectives
- Organisation, Responsibility and Resources, Standard and Documents
- Risk Management
- Planning and Procedures
- Implementation, Monitoring and Reporting
- Assurance, and
- Management Review.

The HSSE & SP-MS is subject to a continuous improvement 'plan, do, check, review' loop, with the eight elements as listed above. There are numerous, specific ongoing (typically annual) assurance activities against each of the eight elements in the HSSE & SP-MS Manuals, to ensure that the system is being implemented, is effective and to identify areas for improvement.

Environmental management for Prelude is through the implementation of the Shell HSSE & SP-MS, supplemented by facility/asset specific HSSE systems/procedures (e.g. Shell Permit to Work system and associated procedures such as Confined Space Entry, Isolations, etc. as appropriately developed at the stage of project implementation).

Shell implements specific pre- and post-contract award processes and activities aimed at ensuring that contracts consistently and effectively cover the management of HSSE & SP risks and deliver effective management of HSSE & SP risks for contracted activities. Contractor HSSE & SP Management is governed by the Shell HSSE & SP Control Framework.

As a minimum, all relevant field active contractors' HSSE & SP-MS will be assessed to ensure they meet materially equivalent outcomes to Shell's HSSE & SP-MS.

5.0 Stakeholder Consultation

As titleholder, Shell has consulted with relevant persons in accordance with the NOPSEMA Decision-making guideline – Criterion-10A(g) Consultation Requirements (N-04750-GL1721 Rev 6 2019a) and NOPSEMA's Bulletin #2 (2019c) under the OPGGS (E) Regulations 2009 for this EP (Document number: 2000-010-G000-GE00-G00000-HE-5880-00002).

Shell has ensured all Relevant Persons (Table 5-3) have been provided with sufficient information and had the opportunity to raise any objections or claims.

Shell has addressed objections and claims raised in relation to this EP and can demonstrate that the risk or impact in question has been reduced to ALARP and to an acceptable level.

5.1 Background

Consultation and stakeholder engagement for Prelude began when the gas field was first discovered in early 2007 and has continued since the Final Investment Decision (FID) was taken in May 2011. This included a thorough consultation process on the environmental impacts for the Prelude FLNG Project EIS. The project received environmental approval under the Environment Protection and Biodiversity Act 1999 on the 12th November 2010 (EPBC 2008/4146). Extensive consultation was subsequently carried out to support the acceptance of the Prelude Drilling and Completions Environment Plan (2012), the Prelude Subsea Installation EP (2014) and the Prelude Installation and Operations Environment Plan (2016).

This consultation overview outlines the approach for the submission of this revised Prelude EP now that Prelude has moved into production.

5.2 Shell General Business Principles and Stakeholder Engagement

Stakeholder engagement and consultation is an integral part of Shell's social performance, impact assessment and project development process, helping to both inform business decisions and identify issues that require action. Shell has internal policies and processes which outline the requirements of stakeholder engagement. These are underpinned by Shell's General Business Principles (refer to Section 3.2 Standards and Guidelines), which govern how the Shell companies that make up the Shell Group conduct their affairs.

Key principles for stakeholder engagement:

- Local communities – Shell aims to be a good neighbour by continuously improving the ways in which we contribute directly or indirectly to the general wellbeing of the communities within which we work. We manage the social impacts of our business activities carefully and work with others to enhance the benefits to local communities, and to mitigate any negative impacts from our activities. In addition, Shell companies take a constructive interest in societal matters, directly or indirectly related to our business.
- Communication and engagement – Shell recognises that regular dialogue and engagement with our stakeholders is essential. In our interactions with local communities, we seek to listen and respond to them honestly and responsibly. Part of this commitment is ensuring those people and organisations that are impacted by our activities are engaged, and that their concerns are heard and responded to.

5.2.1 Stakeholder Engagement Process

In supporting Shell's adherence to the Shell general Business Principles is a comprehensive stakeholder strategy which ensures that:

- the external context is monitored and understood;
- stakeholder needs, interests, concerns and expectations are understood, shared and outcomes defined;
- there is a clear and direct link between impacts and risks/opportunities;
- stakeholder engagement protocols established and consistent; and
- explicit inclusion of external perspectives in business decisions.

5.2.2 The Team

Shell Australia has a Perth based External and Government Relations (EGR) team, which includes Social Performance, who facilitate stakeholder and community engagement in Australia on behalf of the business with support teams in Canberra, Melbourne and Queensland.

The EGR team manages the interface for the business with external stakeholders such as; communities, NGOs, Government(s) and the media. Working as an integrated team allows a 'whole of Shell view' to be provided in stakeholder engagements and ensure stakeholders receive consistent and coordinated information. This is important where, for example, exploration activities and Crux (Prelude's primary backfill), have similar stakeholders to Prelude and therefore require an aligned approach. We call this grouping East Browse.

An EP specific meeting is held monthly between the relevant HSSE and External Relations leads which is driven by the EP commitments register.

5.2.3 Prelude Stakeholder Engagement Plan

The Stakeholder Engagement Plan is an overarching East Browse Engagement Plan. This includes a stakeholder matrix, an engagement strategy and a feedback mechanism.

Shell's approach to stakeholder engagement for Prelude, as is the case for all of Shell's assets, has always been "no surprises" which has driven proactive engagements with a range of stakeholders from an early stage. Shell has developed long-term working relationships with those who may be impacted by Prelude or who may have an interest in it.

5.2.4 EP Consultation Strategy

The East Browse Stakeholder Engagement Plan was used to develop a fit for purpose EP consultation strategy as illustrated in Figure 5-1.

Subject-matter experts were engaged, as needed throughout the process, to inform the development of the plan and to ensure the EGR Team had sound understanding of the Prelude environmental risks and mitigations.

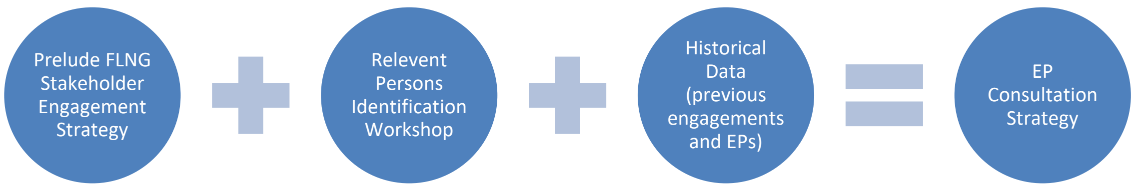


Figure 5-1: Development of Consultation Strategy

Relevant Persons

Shell has an internal process to identify, prioritise and understand stakeholders. The process includes the following steps:

1. Identify stakeholders against specific business objectives.
2. Prioritise stakeholders based on stakeholder views/concerns.
3. Analyse value drivers and views on our activities.
4. Define desired shared outcomes.
5. Early engagements with stakeholders to understand views of impacts, risks and opportunities.

This process was used to develop the Prelude FLNG Stakeholder Matrix and formed the foundation for a Relevant Persons Identification Workshop.

The workshop was attended by EGR representatives as well as Safety and Environment subject matter experts. During the workshop, each potential stakeholder was assessed based on how Prelude activities could impact their functions, interests or activity.

The workshop was informed by:

- historic information gathered as part of the initial Prelude EP submission and Shell Prelude stakeholder engagement process

- desktop research to identify the specific functions, interests and activities of each Relevant Person.

Once stakeholders were identified, Shell determined the most appropriate consultation approach and associated information to communicate based on the:

- functions, interests and activities of the person;
- prior feedback and information from Relevant Persons on their perspectives and how they prefer to be engaged gathered as part of the Prelude stakeholder engagement process; and
- information gathered during prior engagement activities and/or ongoing communication with stakeholders.

The result was a list of all Relevant Persons who require formal consultation and their information requirements are shown in Table 5-3. Upon acceptance of this EP, Shell will uphold its commitments to ensuring Relevant Persons continue to be consulted throughout the five-year duration of this plan.

Consultation is tailored to the specific functions, interests or activities of the Relevant Persons. The planned frequency of these consultations for each Relevant Person can be found in Table 5-3. The frequencies and requirements were identified and discussed in the Relevant Persons Identification Workshop and updated as feedback was gathered as part of the consultation process.

The assessment is dynamic and could change, for example changes to scope, in which case the Prelude FLNG Stakeholder Engagement Plan would be updated. Progress of planned consultation is tracked and recorded in the Prelude FLNG Stakeholder Engagement Plan, and it is subject to a half yearly review.

Relevant Persons themselves can and have identified their preferred ongoing engagements for Prelude. In such cases, that suggestion is considered and if appropriate, implemented.

Shell's internal 'management of change' process will also ensure that any material changes to the activity scope will trigger engagement with those who may be impacted.

Relevant Persons will be reviewed as part of the standing agenda for the Prelude EP Monthly Meeting.

EP Guidance on Consultation

Stakeholder consultation for this activity has also been guided by various stakeholder organisation expectations for consultation on planned activities. The guidance consulted included but is not limited to those summarised in Table 5-1.

Table 5-1: Guidance for EP Stakeholder Consultation

Organisation	Guidance
NOPSEMA	• Consultation with Commonwealth agencies with responsibilities in the marine area (N-06800-GL1887 2019). • NOPSEMA Decision-making guideline – Criterion-10A(g) Consultation Requirements (N-04750-GL1721 rev 6 Nov 2019a) • Clarifying statutory requirements and good practice (NOPSEMA Bulletin #2 2019c)

Australian Fisheries Management Authority (AFMA)	• Petroleum industry consultation with the commercial fishing industry
Commonwealth Department of Agriculture, Water and the Environment (DAWE)	• Fisheries and the Environment – Offshore Petroleum and Greenhouse Gas Act 2006 • Offshore Installations Biosecurity Guide 2019
WA Department of Primary Industries and Regional Development (DPIRD)	• Guidance statement for oil and gas industry consultation with the Department of Fisheries 2013
WA Department of Transport (DOT)	• Offshore Petroleum Industry Guidance Note July 2020

Reasonable Period

Shell determined that a minimum of 30 days is a reasonable period for formal consultation. This is a common duration specified for matters that are open to public comment and Shell's historic engagements supports that it is sufficient time to allow for a Relevant Person to assess the information provided by Shell in a letter containing all the risks as outlined in the EP and respond detailing any claims or objections.

The 30-day period acts as a minimum period in Shell's consultation planning processes, and Relevant Persons are explicitly asked to respond within that time. However, Shell acts on a case-by-case basis depending on the response received from Relevant Persons and will allow for requests to extend this period, if requested. Shell will also follow up within that 30-day period if no response is received, where contact details are available.

As part of the review, it was identified that a reasonable period needed to be defined for ongoing consultation. Table 5-2 outlines Shell's approach.

Table 5-2: Reasonable Period for Ongoing Consultation

Type of Consultation	Timing
New, formal consultation The 30-day period acts as a minimum period in the consultation planning process for new information distributed to Relevant Persons.	30 days
Ongoing consultation The 14-day period acts as a minimum period to respond to claims or objections received once in the ongoing consultation phase. This will be managed on a case-by-case basis so that timeframes will take into account other factors (such as how much correspondence there has been with the Relevant Person, the merits of the claim or objection and/or the complexity of the claim or objection).	14 days

Sufficient Information

When carrying out consultation with Relevant Persons, Shell considers the potential impacts of Prelude activities on the particular functions, interests and activities of each

Relevant Person to ensure that sufficient and appropriate information is provided. In summary, EP submission consultation involved the following:

Letter and accompanying factsheet

Shell provided Relevant Persons with a letter and accompanying information sheet outlining all the risks and mitigations extracted directly from the EP. This approach ensured that recipients had access to the impacts and risks outlined in the EP and the associated mitigations; and could make their own assessment on the impact of the activity. Therefore, removing potential for Shell to make any assumptions about what Relevant Persons would be interested or concerned about.

The factsheet also contained contact details, location specifics, details of the activity and the response period of 30 days (Appendix A: Detailed Facility Description), a link to the Prelude microsite and a link to the full draft EP, for those seeking more detailed information.

The letter and/or cover email was tailored to meet the needs of different Relevant Persons as determined by the Relevant Persons Identification workshop. For example, for Commercial Fishers who can only be contacted by mail.

Shell believes that this letter and factsheet, access to the full draft EP and the follow up process provided Relevant Persons with sufficient information to be able to consider the impacts on their functions, interests and activities.

Face-to-Face Meetings

In most cases, engagement for the EP did not require a face-to-face meeting and the majority of Relevant Persons did not wish to meet with Shell. However, in some cases where a Relevant Person showed considerable interest in the EP activities, face-to-face meetings were arranged to engage and share information. This also allowed access to and engagement with Shell subject-matter experts.

Prelude Website

Shell prepared a website outlining the content of the EP in digestible format for the general public. This website forms the basis for consultation, allowing stakeholders to select the information which interests them most. Once the EP is published on NOPSEMA's website, the Prelude website will provide a link to the EP submission for those that want more detailed information.

5.2.5 Assessment of merits of claims and objections

Shell has a claims process which guides our actions in response to claims and objections received from stakeholders related to Prelude. This process is included in Appendix A: Detailed Facility Description.

Claims received are processed through Shell's global system – Insight Browser. Identified Claims or Objections are tracked within this system. Failure to close out complaints in the system results in escalation to senior management and risks a breach of Shell's social performance standards.

Shell has adhered to NOPSEMA's guidance (N-04750-GL1721 Rev 6 2019a) in relation to the definitions of claims and objections, where an '*objection or claim*' is taken to mean:

- *To express opposition, protect, concern or complaint about the proposed activities; a request or demand that certain action be taken by the titleholder to address adverse impacts; and*

- *An assertion that there will be an adverse impact; or allegation to cast doubt about the manner in which the activities will be managed."*

5.2.6 Summary of Consultation

A summary of consultation activities undertaken, and the Relevant Persons consulted during the development of this EP are presented in Table 5-3 and Table 5-4. An assessment of merit was undertaken and is presented in Table 5-5.

Table 5-3: Assessment of Relevant Persons for the Activity

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
WA State and Commonwealth				
RP01	Australian Border Force (ABF)	Yes	Maintains the integrity of Australia's international borders including customs and immigration.	• As required through EP change assessments; or • When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP02	Australian Hydrographic Service (Department of Defence)	Yes	The RAN Australian Hydrographic Service is the Commonwealth Government agency responsible for the publication and distribution of nautical charts and other information required for the safety of ships navigating in Australian waters. Issue notice to mariners and update nautical charts.	
RP03	Department of Agriculture, Water and the Environment (DAWE)	Yes	Biosecurity regulator and responsible for Australia-Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf – 1974.	
RP04	Department of the Environment and Energy (DEE)	Yes	Administers the EPBC Act. Main functions are associated with providing oiled wildlife advice in commonwealth waters during an Oil spill.	
RP05	Department of Foreign Affairs and Trade (DFAT)	Yes	International relations with governments and other organisations. Specifically, DFAT will have functions relating to oil spills in international waters or foreign countries jurisdictions.	
RP06	Parks Australia (PA)	Yes	Parks Australia looks after Australia's natural treasures – including Kakadu, Uluru and our beautiful oceans. They are responsible for six national parks, 58 marine parks and the Australian National Botanic Gardens.	
RP07	Australian Marine Safety Authority (AMSA) including AMSA RCC.	Yes	Statutory agency for vessel safety and navigation and legislated responsibility for oil pollution response in Commonwealth Waters.	

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
RP08	Department of Water & Environmental Regulation (DWER)	Yes	Responsible for implementing Commonwealth policies and programs to support the agriculture, fisheries, food and forestry industries.	
RP09	WA Department of Mines, Industry Regulation & Safety (DMIRS)	Yes	Required to be consulted under the Regulations.	
RP10	WA Department of Primary Industries and Regional Development - Fisheries Division (DPIRD)	Yes	Responsible for managing State fisheries.	
RP11	Department of Primary Industry and Resources NT (DPIR)	Yes	Responsible for managing Territory fisheries.	
RP12	WA Department of Biodiversity, Conservation & Attractions (DBCA)	Yes	Responsible for managing WA's parks, forests and reserves. Planned activities do not impact DBCA's functions, interests or activities.	
RP13	WA Department of Transport (DOT)	Yes	Legislated responsibility for oil pollution response in State Waters.	
RP75	Director of National Parks	Yes	The Director of National Parks is the statutory authority responsible for administration, management and control of Commonwealth marine reserves.	
RP76	Clean Energy Regulator (CER)	Yes	Responsible for the administration of schemes legislated by the Australian Government for measuring, managing, reducing or offsetting Australia's GHG emissions.	
Northern Territory				
RP77	NT Department of Environment and Natural Resources	Yes	Responsible for marine pollution control in NT waters.	• As required through EP change assessments; or

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
RP78	NT Department of Infrastructure, Planning and Logistics – Marine Safety Branch	Yes	Responsible for marine safety in NT waters.	• When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
Commonwealth Fisheries				
RP14	Australian Fishery Management Authority (AFMA)	Yes	The AFMA is the Australian Government agency responsible for the efficient management and sustainable use of Commonwealth fish resources, in particular, Section 7 of the Fisheries Administration Act 1991.	• As required through EP change assessments; or • When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP15 – RP22	North West Slope Trawl Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Bottom trawl.	
RP23	Southern Bluefin Tuna Fishery	Yes	The Southern Bluefin Tuna Fishery covers the entire sea area around Australia, out to 200 nm from the coast. Pelagic long line and purse seine fishing gear is used.	
RP24	Western Tuna & Billfish Fishery	Yes	Activities exist in or in close proximity to Prelude. Near surface longline and minor line gear used.	
Recreational Fisheries				
RP25	RecFishWest	No	Shell contacted RecFishWest and they have confirmed that no fishing is undertaken as far offshore as Prelude, and therefore they are not relevant.	• Not required
WA State Fisheries				
RP30 – RP56	Mackerel Managed Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Near-surface trawling activities near coastal areas primarily.	• As required through EP change assessments; or

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
RP57 – RP59	North Coast Shark Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Primarily use demersal gillnets and longlines.	• When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP60 – RP67	Northern Demersal Scalefish Fishery License Holders	Yes	The only known active fishery that overlaps the operational area - primarily trap based fishery.	
RP68	Pearl Producers Association (PPA)	Yes	Peak industry representative body for the Pinctada maxima pearling industry licensees in Western Australia. Activities exist in or in close proximity to Prelude. Bottom drifting divers from Lacepede Islands south to Exmouth.	
RP69 – RP71	West Coast Deep Sea Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Baited pots >150m water depth, mostly between 500 – 800 m.	
RP72	Western Australian Fishing Industry Council (WAFIC)	Yes	Represents the interests of commercial fishers with licences in the WA State Managed Fishery.	
Industry				
RP73	INPEX	Yes	Adjacent titleholder; operator of WA-532-P and AC/P36	• As required through EP change assessments; or • When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP74	Finder No 13 Pty Ltd	Yes	Adjacent titleholder; operator of AC/P55	

Table 5-4: Stakeholder Consultation Activities During Development of EP

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
WA State and Commonwealth				
RP01	Australian Border Force (ABF)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		09 December 2019	Phone call	Followed up with a phone call.
		09 December 2019	Email	Email received closing out consultation.
RP02	Australian Hydrographic Service (Department of Defence)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		19 November 2019	Email	Email received closing out consultation.
RP03	Department of Agriculture, Water and the Environment (DAWE)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		10 December 2019	Email	Followed up with an email.
		11 December 2019	Email	Email response sent to the Department.
		11 December 2019	Email	Email response received from the Department - they are reviewing the documentation at the moment and will provide a departmental coordinated response.
		12 December 2019	Email	Email to the Department on MOU Box (74).
		18 December 2019	Conference call	Conference call arranged to discuss feedback and to walkthrough materials sent and clarify any questions from the Department.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
		20 December 2019	Email	Email received from the Department confirming the biosecurity controls in the EP is consistent with their expectations keeping in mind that there will be new policy coming out on which Shell will be consulted
RP04	Department of the Environment and Energy (DEE)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		19 December 2019	Phone call	Follow up phone call.
		19 December 2019	Email	Follow up email.
		3 February 2020	Email	Follow-up email. Email response received from the Department saying as NOPSEMA is the regulating agency for this matter, the Department of Environment has no feedback on the plan.
RP05	Department of Foreign Affairs and Trade (DFAT)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		18 December 2019	Phone call	Follow up phone call.
		18 December 2019	Email	Follow up email sent.
RP06	Parks Australia	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		25 November 2019	Email	Email received with request for further information.
		02 December 2019	Email	Map provided with coordinates and location relative to marine parks as requested.
RP07	Australian Marine Safety Authority	2 October 2019	Email	Initial email sent to AMSA to confirm if ‘relevant person’.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
	(AMSA) including AMSA RCC.	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		03 February 2020	Email	Follow up email to AMSA.
		09 June 2020	Email	Email to AMSA to request follow up discussion (following Shell's initial submission on Marine Order 47 consultation process in May 2020) specific to Prelude and the application of Marine Order 90 series.
		11 June 2020	Meeting	Virtual meeting to discuss application of Marine Order 90 series to Prelude.
		29 July 2020	Emailed letter	Mailed follow-up letter from meeting on 11th June 2020. Outlined Shell's position regarding compliance with Marine Order 90 series.
		13 August 2020	Email	Follow up email sent to AMSA to check status of letter response on Marine Order 90 series.
		13 August 2020	Email	Email from AMSA confirming finalisation of reply to Shell.
		24 August 2020	Email	Further follow up email to AMSA.
		26 August 2020	Email	Email from AMSA confirming imminent formal letter response to Shell's letter of 29 July 2020.
		27 August 2020	Emailed Letter	AMSA sent a letter responding to engagement with Shell and subsequent letter from Shell to AMSA sent on 29 July 2020.
RP14	Australian Fishery Management Authority (AFMA)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		17 December 2019	Email	Follow up email.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP08	Department of Water & Environmental Regulation (DWER)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		19 December 2019	Phone call	Follow up call provided. Requested to send through material again to generic mailbox.
		20 December 2019	Email	Info resent to requested inbox.
RP09	Department of Mines, Industry Regulation & Safety (DMIRS)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		16 December 2019	Email	Email received closing out consultation.
RP10	Department of Primary Industries and Regional Development - Fisheries Division (DPIRD)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		06 December 2019	Phone call	Phone call to discuss query regarding fish cube data and to test Shell’s analysis.
		06 December 2019	Email	Email to DPIRD regarding clarification of fish cube data.
		18 December 2019	Phone call	Follow up phone call, information has been received and will be reviewed in early 2020.
		19 December 2019	Email	Email from DPIRD confirming fish cube data information.
		9 January 2020	Phone call	Follow up call, left voice message.
		14 January 2020	Phone call	Follow up call, DPIRD confirmed response will be received by end of the week.
		17 January 2020	Email	Email received from DPIRD with feedback and comments.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
		31 January 2020	Email	Email response to DPIRD's comments.
RP11	Department of Primary Industry and Resources NT	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		18 December 2019	Phone call	Attempted follow up phone call to two contacts at the department with no response.
		18 December 2019	Email	Follow up email sent.
RP12	WA Department of Biodiversity, Conservation & Attractions (DBCA)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		18 December 2019	Email	Follow up email sent.
		18 December 2019	Email	Email received - automatic out of office reply.
		19 December 2019	Email	Email received closing out consultation.
		20 December 2019	Email	Email to close out consultation process.
RP13	WA Department of Transport (DOT)	01 October 2019	Email	Sent Draft OPEP provided for comment with supporting DOT industry guidance note information.
		07 November 2019	Email	Received from DoT with clarifications and comments on the draft OPEP
		19 November 2019	Email	Sent Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		27 November 2019	Email	Sent response to DOT comments/clarifications on the draft OPEP provided.
		19 December 2019	Email	Received asking two clarifications.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
		20 December 2019	Email	Sent response to DOT comments/clarifications.
		07 January 2020	Email	Received from DOT asking question about spill modelling result sent.
		09 January 2020	Email	Sent response to DOT answering the question regarding spill modelling.
		21 January 2020	Email	Received from DOT stating no more questions on the content provided.
RP75	Director of National Parks	19 December 2019	Email	Sent information on proposed activity with information sheet, link to Prelude EP microsite and full draft EP, including marine parks map.
		19 December 2019	Email	Received confirmation that planned activities do not overlap any Australian Marine Parks and no authorisation requirements from the DNP are required. Noted emergency response notification process to DNP if there are emergency oil/gas pollution incidents which occur within a marine park or are likely to impact on a marine park.
		31 January 2020	Email	Email to confirm consultation process closed.
RP76	Clean Energy Regulator (CER)	19 May 2020	Email	Email exchanges with the CER to request a meeting to discuss the Prelude EP.
		19 May 2020	Email	Email from the CER confirming suggested meeting dates.
		27 May 2020	Meeting	Virtual meeting with CER to provide latest information on forecasts for Prelude FLNG and to discuss potential options regarding revision to the Prelude safeguard mechanism baseline through a transitional calculated baseline.
		11 June 2020	Email	Meeting minutes and supporting information regarding Prelude FLNG provided following the virtual meeting on 27 May 2020.
Northern Territory				

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP77	Department of Environment and Natural Resources (NT DENR)	15 June 2020	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		07 July 2020	Email	Follow up email to the NT DENR.
		10 July 2020	Emailed letter	Emailed letter received form the NT DENR to Shell Australia confirming details to include in the Prelude emergency contingency plans.
		31 July 2020	Email	Email sent to NT DENR confirming receipt of letter and actions. Also confirmed consultation process is closed.
RP78	NT Department of Infrastructure, Planning and Logistics – Marine Safety Branch	10 July 2020	Email	A copy of the Shell Australia email sent to the NT Department of Environment and Natural Resources was forwarded internally to the NT Department of Infrastructure, Planning and Logistics – Marine Safety Branch.
		31 July 2020	Email	Email to the NT Department of Infrastructure, Planning and Logistics – Marine Safety Branch to follow up on the email sent by the NT DENR, to check if the Department has any claims, queries or objections.
		24 August 2020	Email	Further follow up email to the NT Department of Infrastructure, Planning and Logistics – Marine Safety Branch to check if the Department has any claims, queries or objections.
Commonwealth Fisheries				
RP15 – RP22	North West Slope Trawl Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
RP23	Southern Bluefin Tuna Fishery	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
RP24	Western Tuna & Billfish Fishery	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
WA State Fisheries				
RP26 – RP56	Mackerel Managed Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
RP57 – RP59	North Coast Shark Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
RP60 – RP67	Northern Demersal Scalefish Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		09 December 2019	Email	Bespoke information on the risks and impacts to the Northern Demersal Scalefish Fishery provided.
		09 December 2019	Email	Email received closing out consultation.
RP68	Pearl Producers Association (PPA)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		11 December 2019	Phone call	Follow up phone call – unavailable.
RP69 – RP71	West Coast Deep Sea Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
RP72	Western Australian Fishing Industry Council (WAFIC)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
		19 November 2019	Email	Email received from WAFIC requesting more bespoke information
		21 November 2019	Email	Email sent to WAFIC with more specific links to relevant information.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
		21 November 2019	Email	Email received from WAFIC.
		25 November 2019	Email	Response sent to WAFIC with clarification on Prelude resubmission and map of Operational Area.
		26 November 2019	Email	Email received from WAFIC.
		06 December 2019	Email	Response sent to WAFIC.
		19 December 2019	Email	Email received from WAFIC closing out consultation.
Industry				
RP73	INPEX	13 December 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.
RP74	Finder No 13 Pty Ltd	13 December 2019	Email	Info provided on proposed activity with information sheet, link to Prelude EP microsite and full draft EP.

Table 5-5: Stakeholder Claims and Objections – Assessment of Merit

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
		WA State, Northern Territory and Commonwealth			
RP01	Australian Border Force (ABF)	9 December 2019	Email received to say the ATT Delegate has not advised of any comments.	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP02	Australian Hydrographic Service (Department of Defence)	5 November 2019 19 November 2019	Email received to say that the Australian Hydrographic Office have everything they need.	No claim or objection received.	Not applicable
RP03	Department of Agriculture, Water and the Environment (DAWE)	18 December 2019 20 December 2019	Phone conference between Shell and the Department. The Department indicated that there will be a new mandatory biofouling management policy coming out in the new year, following from a consultation process. This will include alignment with new IMO standards, specific biofouling plans for vessels and contingency measures within those plans. Email received from the Department confirming the biosecurity controls in the EP is consistent with their expectations keeping in mind that there will be new policy coming out on which Shell will be consulted.	No claim or objection received.	Not applicable
RP04	Department of the Environment and Energy (DEE)	19 November 2019 19 December 2019 3 February 2020	Response received 3 February 2020 advising that as NOPSEMA is the regulating agency for this matter, the Department has no feedback on the plan.	No claim or objection received.	Not applicable
RP05	Department of Foreign Affairs and Trade (DFAT)	18 December 2019	Email received to confirm that DFAT cannot provide advice on the environmental approval processes as this matter does not fall within the remit of DFAT's policy responsibilities. Follow up phone call with DFAT Deputy Director (WA office), who confirmed that DFAT does not take a position on this type of consultation, so this closes out the	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
			consultation process with DFAT and no further action is required.		
RP06	Parks Australia (PA)	25 November 2019 20 December 2019	Guidance material developed by NOPSEMA in consultation with the Director of National Parks (DNP) requires that titleholders provide a description of the operational area including a map showing location of the activity relative to marine park boundaries. Relevant shapefiles for mapping are available at: https://parksaustralia.gov.au/marine/maps/ Stakeholder requested a map showing the distance to the mainland with coordinates showing Prelude location relative to marine parks.	No claim or objection received.	Not applicable
RP07	Australian Marine Safety Authority (AMSA) including AMSA RCC.	19 November 2019 3 February 2020	No response received	No claim or objection received.	Not applicable
		11 June 2020 29 July 2020 27 August 2020	Clarification was sought from AMSA on the applicability of the Marine Orders 90 series to the Prelude FLNG. AMSA responded to Shell's letter suggesting that the Marine Order 90 series and associated POTS (PPS) Act do apply to the Prelude FLNG including certifications for relevant systems which were in place when Prelude arrived on location. AMSA suggested Lloyd's Register would be the appropriate body to follow-up with on the detailed aspects of compliance with various aspects of Marine Order 90 series and associated POTS (PPS) (AFS) Act. The following summarises the	Shell notes the Marine Order 90 series apply to Prelude as enacted through the POTS (PPS and AFS) legislation. Shell will comply with these legislated requirements as required. This was considered a relevant matter for the EP. As AMSA suggested, Shell will engage with Lloyd Register on implementation of relevant Marine Order 90 series. Changes to reflect this have been made in the relevant	On 19 November 2020, Shell responded to AMSA's letter dated 27 August 2020, confirming that Shell will comply with the Marine Order 90 series as they apply to the Prelude FLNG. In addition, Shell confirmed that engagement will occur with the Recognised Organisation on the detailed matters relating to the implementation of Marine Order 90 series to Prelude FLNG. Shell has made relevant updates within the EP to ensure the

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
			advice provided by AMSA in its letter dated 27 August 2020: **MO 91 –** sets out the requirements for the prevention of pollution by oil. MO 91 gives effect to MARPOL Annex 1, of which regulation 1 defines the term "oil" and includes the substances listed in appendix 1 and Annex I. These substances include casing head (natural) and condensate, both of which AMSA understands are present on board Prelude. In considering the above, MARPOL Annex I, Regulation 39 special requirements for fixed and floating platforms will apply to Prelude. AMSA also suggests that Shell explore the application of IMO resolution MEPC.139(53)-Guidelines for the application of the revised MARPOL Annex I requirements to FPSO facilities and FSU's, as amended by resolution MEPC.142 (54), as referenced in this regulation. The list of compliance requirements is contained within the referenced Guidelines. **MO 93** – AMSA notes that MO 93 does not apply to Prelude as it is not designed to carry Noxious Liquid substances in bulk form. Considering the various products associated with Prelude's operations, and the quantities stored onboard, AMSA suggest that Shell discuss applicability of MO 93 with recognised organisation **MO 94** - sets out the requirement for preventing packaged harmful substances from polluting the marine environment. MO 94 gives effect to Annex III of MARPOL and prescribed matters relating to Part IIIA of POTS (PPS).	Marine Order 90 series controls outlined in section 9.0.	requirements outlined by AMSA on 27 August 2020 are accurately reflected within the EP. In addition, Shell will engage with the Recognised Organisation, Lloyd's Register.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
			AMSA suggests that Shell seek the Recognised Organisation's view on the systems and procedures necessary to ensure obligations under the above Part IIIA, as implemented by MO 94, are complied with. **MO 95** - sets out requirement for prevention of pollution by garbage from ships. MO95 gives effect to MARPOL Annex V and prescribes matters relating to POTS (PPS). Annex V requires Prelude keep a garbage record book. AMSA may waive the requirement to maintain a garbage record book, under Reg. 10(4)(2), however AMSA has no record of having received or issued to Prelude a waiver in relation to the Garbage Record Book. **MO 96** – sets out the requirement for the prevention marine pollution by sewage from the ships and effects MARPOL Annex IV – Sewage. Matters are addressed in Part IIIB Div. 2 of POTS (PPS). Prelude is required to demonstrate and maintain compliance with these regulations. **MO 97** - sets out the requirements for the prevention of air pollution by ships and gives effect to MARPOL Annex VI- Air. Matters are addressed in Part IIID of POTS (PPS). AMSA notes that MARPOL ANNEX VI Regs. 13 does not appear to have been addressed in the letter. **MO98 –** sets out the requirements for anti-fouling and their certification and gives effect to the anti-fouling certification requirement of POTS (AFS). AMSA notes that Lloyd's		

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
			Register has issued International Anti-Fouling System Certificate – 1425-LR KOJ 1200001 dated 28 June 2017, for the purpose of MO98.		
RP14	Australian Fishery Management Authority (AFMA)		No response received	No claim or objection received.	Not applicable
RP08	WA Department of Water & Environmental Regulation (DAWR)		No response received	No claim or objection received.	Not applicable
RP09	WA Department of Mines, Industry Regulation & Safety (DMIRS)	13 December 2019	Email received to say that no further information is required at this stage.	No claim or objection received.	Not applicable
RP10	WA Department of Primary Industries and Regional Development (DPIRD)- Fisheries Division	06 December 2019 18 December 2019 19 December 2019	Email to DPIRD regarding Fish Cube data clarification. Phone call to DPIRD. DPIRD to confirm fish cube data information in a follow up email and will respond formally with any specific EP comments in early 2020. DPIRD provided Shell with some clarification on Fish Cube data." Less than three vessels" does not constitute no fishing activity. Fish cube data differentiates between "less than 3 vessels" and "no fishing activity" for each block."	The suggestion of including "Administrative and Procedural controls" for supporting vessels which aligns with proposed "NOPSEMA Offshore Support Vessel Reference Case" process is considered to be a relevant matter and the EP has been updated to reflect. IMO biofouling guidelines considered 'best practice' for mitigation of transfer of invasive aquatic species to ALARP is considered to be a relevant matter and the EP has been updated to reflect.	Shell has reviewed the draft Biosecurity Reference Case (Maritime Industry Australia Ltd, 2020) and ensured controls described in Section 9.8.5 of the EP are consistent with the reference case. Supporting vessels attending site will meet IMO biofouling guidelines.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
		17 January 2020	DPIRD noted Shell committed (to WAFIC) to develop more bespoke material for the Northern Demersal Scalefish Fishery (NDSF) and set out specific information regarding impacts on fishing and fisheries activities related to Prelude activities. DPIRD had some additional minor comments on the draft prelude EP: • The *BAM Act 2007* is not mentioned in *Table 5-3: Prelude FLNG Environment Plan Relevant Persons and Consultation Process* • Typo in Table 5-3 relating to DPIRD entry "They administer the *Fish Resources Management Act 1984*" • Table 9-33: ALARP evaluation of IMS risk control measures o Suggest "Administrative and Procedural controls" for supporting vessels which aligns with proposed "NOPSEMA Offshore Support Vessel Reference Case" process. IMO biofouling guidelines considered 'best practice' for mitigation of transfer of invasive aquatic species to ALARP. Suggest supporting vessels encouraged to have	The suggestion that supporting vessels are encouraged to have vessel specific (as per IMO guidance) Biofouling Management Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP is considered to be a relevant matter and the EP has been updated to reflect this.. Application of an Antifoulant coating is only one mitigation action, of a 'best practice' IMO biofouling guidance approach. Shell acknowledged this claim. However, no update to the EP is proposed.	Supporting vessels attending site will have a BMP and BRB.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
			vessel specific (as per IMO guidance) Biofouling Management Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP. Application of an Antifoulant coating is only one mitigation action, of a 'best practice' IMO biofouling guidance approach. • DPIRD clarified contact information required in draft Prelude EP. DPIRD requested clarification on a statement in draft EP (page 224) "Low Risk Biosecurity Status Letter from the Department of Agriculture and Water Resources (DAWR)." The clarification related to the statement applying only the Prelude FLNG topside.		
RP11	Department of Primary Industry and Resources NT		No response received	No claim or objection received.	Not applicable
RP12	WA Department of Biodiversity, Conservation & Attractions	19 December 2019	Email received requesting we provide future notifications to EMBAdmin@dbca.wa.gov.au.	No claim or objection received.	Not applicable
RP13	WA Department of Transport (DOT)	07 November 2019 19 November 2019 19 December 2019	Requested clarification on reasoning for changes in worst credible spill scenarios. Requested to correct some incorrect references related to the DOT IGN.	Changes to worst case spill volumes were noted between the current EP/OPEP and the previous revisions reviewed by DOT. This was considered a	Shell confirmed the justification for changes to the worst credible spill scenarios presented in the EP/OPEP. Section 9.13.1 of the EP has been updated.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
		07 January 2020 21 January 2020	Clarification requested around some roles and responsibilities. Requested information of modelling outputs. Clarification requested around the basis for worst predicted waste volumes from shoreline contact. Detail of cost recovery arrangements requested. Clarification requested on limitations around scientific monitoring. Clarification requested on dispersant types to be used. More information requested on training requirements of responders. Request for modelling information Clarification on modelling information provided No further question from DoT at this time.	relevant matter and the EP has been updated to reflect. Outdated references to the DOT IGN suggested an older version may have been used. This was not considered a relevant matter resulting in an update to the EP.	Updates to the consultation materials provided to DOT were made to the ensure the correct references for the most recent version of the DOT IGN. Further details were also provided on the roles and responsibilities, modelling outputs & information, potential volumes of oil on shorelines and cost recovery arrangements. Details on scientific monitoring of marine megafauna, proposed dispersant types and training requirements of responders were also provided.
RP75	Director of National Parks	20 December 2019	Email received confirming that planned activities do not overlap any Australian Marine Parks and no authorisation requirements from the DNP are required. Noted emergency response notification process to DNP if there are emergency oil/gas pollution incidents which occur within a marine park or are likely to impact on a marine park.	No claim or objection received.	The EP includes confirmation that Shell's emergency response arrangements include relevant details and meet notification requirements.
RP76	Clean Energy Regulator (CER)	27 May 2020	A forecast of future Prelude FLNG GHG emissions were shared with the CER based on Operating Plan (OP) 2019 figures. Shell asked	No claim or objection received.	No changes were made to the EP as a result of this consultation.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
		11 June 2020	CER if they could comment on Prelude's forecast GHG emissions being of an "acceptable level of impact". CER could not comment on acceptability of forecast Prelude FLNG emissions, but referred to excess GHG emissions above the baseline requiring the acquisition of ACCU's to offset any exceedance. CER asked if forecasts provided were based on a calendar or financial year basis. Shell confirmed the information presented was based on a calendar year. CER requested a copy of the fact sheet provided to other Relevant Persons for the purposes of consultation in preparation of the Environment Plan.		
RP77	NT Department of Environment and Natural Resources	10 July 2020	Letter response detailed a requirement for Shell to include the following information in the emergency contingency plans: Initial point of contact for spills to NT coastal waters Email addresses for POLREPs Timeframe for notifications to be made (within 24 hours of titleholder becoming aware of an incident that could occur in NT coastal waters) Stakeholder consultation materials also sent to Marine Safety Branch of the NT Department of Infrastructure, Planning & Logistics.	The information received was considered to be a relevant matter and the OPEP updated to reflect.	Requested notification details have been included in the OPEP Table 4-1 *External Notifications and Reporting*.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP78	NT Department of Infrastructure, Planning & Logistics- Marine Safety Branch	31 July 2020 24 August 2020	Auto response email received stating that AMSA provides service delivery for owners, operators and crew of domestic commercial vessels and that waterways management queries will be responded to within 5 days. No further response received.	No claim or objection received.	No changes were made to the EP as a result of this consultation.
		Commonwealth Fisheries			
RP15 – RP22	North West Slope Trawl Fishery License Holders		No response received	No claim or objection received.	Not applicable
RP23	Southern Bluefin Tuna Fishery		No response received	No claim or objection received.	Not applicable
RP24	Western Tuna & Billfish Fishery		No response received	No claim or objection received.	Not applicable
		WA State Fisheries			
RP30 – RP56	Mackerel Managed Fishery License Holders		No response received	No claim or objection received.	Not applicable
RP57 – RP59	North Coast Shark Fishery License Holders		No response received	No claim or objection received.	Not applicable
RP60 – RP67	Northern Demersal Scalefish Fishery License Holders	09 December 2019	Email received from one license holder to say that the assumptions are reasonable.	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP68	Pearl Producers Association (PPA)		No response received	No claim or objection received.	Not applicable
RP69 – RP71	West Coast Deep Sea Fishery License Holders	09 December 2019	Email received from one license holder to explain what they do. No further comments noted.	No claim or objection received.	Not applicable
RP72	Western Australian Fishing Industry Council (WAFIC)	19 November 2019 21 November 2019 26 November 2019 19 December 2019	WAFIC notes that by and large for almost all EPs that the commercial fishing sector is the only "relevant potentially affected party" to operations as described in an EP. The information you have sent above regarding the revised and updated Prelude EP is not specific enough to potentially affected commercial fisheries. Please revert with the bespoke information, appropriate and relevant for a potentially affected party. Appreciate that for Prelude the key commercial fishing stakeholders are licence holders in the Northern Demersal Scalefish Fishery. You have noted that there is low fishing effort – please clarify what you mean by "low". Many thanks for the bespoke updated information, thank you also for on sending to NDSF fishers.	No claim or objection received.	Not applicable
		Industry			
RP73	INPEX		No response received	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP74	Finder No 13 Pty Ltd		No response received	No claim or objection received.	Not applicable

5.2.7 Ongoing Consultation

Shell will uphold its commitments to ensuring relevant authorities, persons and organisations continue to be consulted throughout the five-year duration of this EP through a number of activities detailed in Table 5-6. Consultations will be tailored to the specific functions, interests or activities of the stakeholders. This ongoing consultation is used to inform stakeholders on specific activity timing, duration, location and other information relevant to the activity and stakeholder needs.

Table 5-6: Ongoing Consultation Activities

Activity	Description
Monthly Meeting Implemented	Monthly meeting attended by HSSE and EGR representatives to track and assess consultation and EP compliance, manage requests for information and the assessment of merit of any claims and objections. Set agenda with actions tracked in Commitments Register.
Updated Commitments Register	Lists Relevant Persons, details consultation commitments as per EP Consultation Strategy and tracks consultation, and outlines EP compliance actions. Holds actions from monthly meetings.
Ongoing Consultation Procedure	Details the procedure of ongoing consultation with Relevant Persons.
Updates to Claims and Objections Process	Introduction of Shell's global system for reporting and follow up on complaints. Identified Claims or Objections will be tracked within this system. Failure to close out complaints in the system results in escalation to senior management and risks a breach of Shell's social performance standards.

Shell will continue to accept feedback from all stakeholders and work with them to address any future concerns if they arise throughout the duration of the Prelude EP. The process for ongoing consultation is managed in the same manner as described in Sections 5.2.1 to 5.2.6. Shell will ensure any claims or objections, or feedback, from the ongoing consultation are processed as per Shell's internal claims process in a timely manner, and any identified risks will be managed to ALARP levels as required in this EP.

In particular, Shell will continue to engage and consult with relevant stakeholders through:

- Direct stakeholder and community engagement as part our standard business processes
- Updated factsheets and notifications prior to commencement of major activities and key milestones
- Community Hotline number and the Prelude FLNG mailbox provided on factsheets and our website, mechanisms through which the public (including Relevant Persons) can share feedback or ask questions about the Prelude FLNG operations.

Consultation with relevant stakeholders also occurs via our ongoing strategic relationship engagements (for example, with Department of Transport and Department of Agriculture, Water and Environment) and ad hoc engagements by the External Relations and Social Performance team at social investment events.

In addition, to ensure we receive further input from our community stakeholders, Shell conducts an annual Prelude Pulse Survey, a community based survey that covers key stakeholders in Broome and Kimberley region and Darwin. The survey identifies, assesses and measures impacts, gauges the communities' perception of Shell and gathers feedback.

Identified relevant Persons were emailed a Prelude EP Fact Sheet, which is also published on Shell's website. Where possible, Shell has tailored communication to stakeholders. For example, marine stakeholders such as the Western Australian Fishing Industry Council and Parks Australia were provided with maps to show the location of Prelude in relation to fishing zones and marine parks.

6.0 Description of the Activity

6.1 Scope of the EP

This EP covers the following activities within the Operational Area (Figure 6-1) located within permit area WA-44-L and infrastructure license WA-2-IL:

- Operations and maintenance turnarounds of the FLNG and subsea facilities
- Operation within the designated safety zone of the installation, support, supply and in-field support vessels and helicopters required for the offshore works, commissioning & maintenance activities and operate phase
- Product offtake tankers or bunkering vessels only when they are attached to the Prelude FLNG (considered as petroleum activity)
- Well intervention activities using a light well intervention vessel
- Inspections, maintenance and repairs of systems and subsea infrastructure
- Emergency Response events.

Non-petroleum activities such as environmental field monitoring or metocean studies are outside of the scope of this EP.

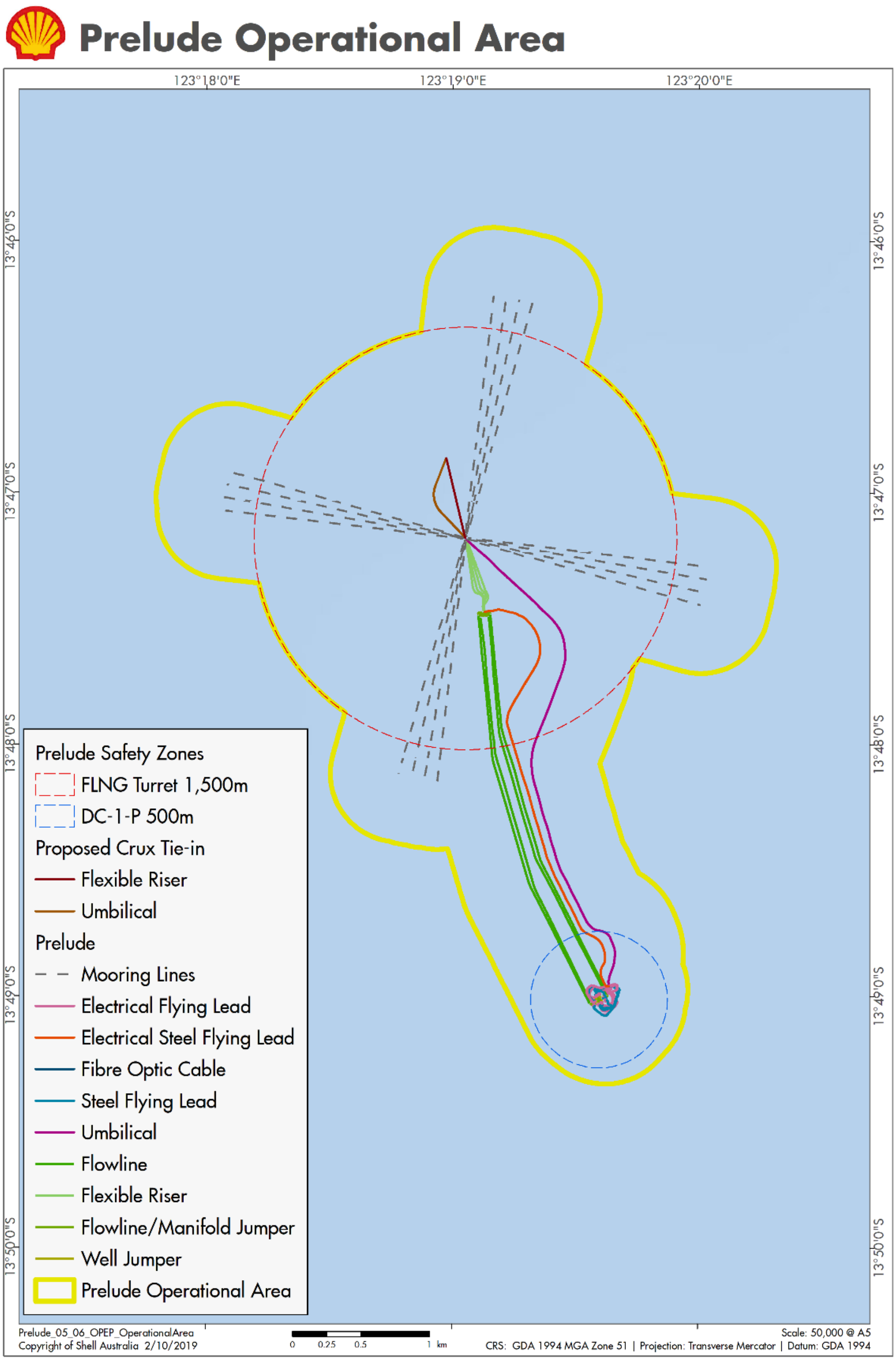


Figure 6-1: Prelude EP Operational Area

This EP does not include the general transit of vessels to or from the Operational Area. These activities will be undertaken in accordance with relevant maritime legislation, such as the Commonwealth Navigation Act 2012, and are within the jurisdiction of

AMSA. In addition, helicopter activities outside of a Petroleum Safety Zone (PSZ) are not defined as petroleum activities. Therefore, activities undertaken by the vessels and helicopters which are not carrying out petroleum activities are not considered in this EP. Any impacts and risks outside of these activities are provided for via the HSSE and SP Control Framework, outside of the formal EP acceptance and implementation process, to support the transparent, whole-of-project assessment process.

6.2 Location and Timing

The Prelude FLNG Project is in WA-44-L, in Commonwealth marine waters, 200 km offshore northwest Australia and 460 km north-north east of Broome (Figure 6-2), in 237 m from Mean Sea Level (MSL) water depth.

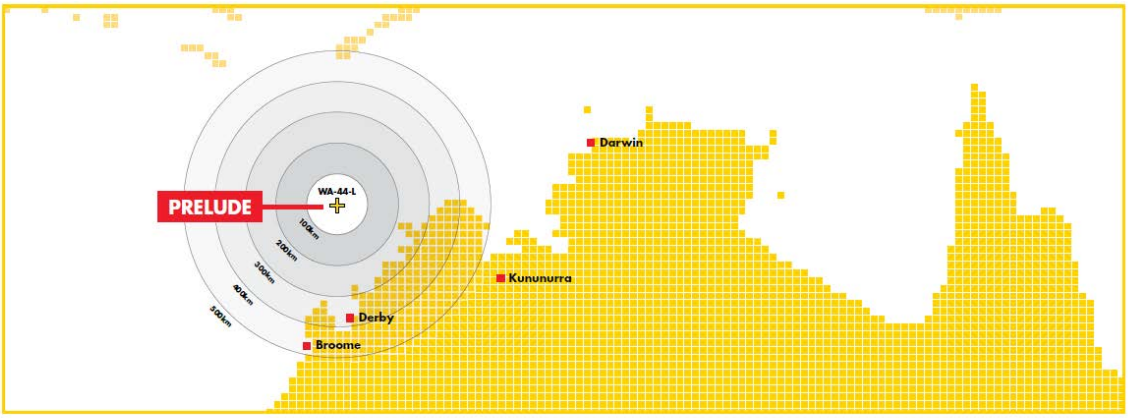


Figure 6-2: Location of Prelude (Permit Area WA-44-L)

The Prelude FLNG facility was towed from South Korea where it was constructed and partially commissioned, and arrived in field in July 2017. The installation, hook-up and commissioning occurred upon arrival of the FLNG and then the facility reached its ready for start-up (RFSU) milestone by introducing hydrocarbons from the wells on 26 Dec 2018. Steady state operation is defined as once the facility name plate capacity (i.e. design capacity) is reached following the completion of the well clean-up and performance testing process. The Prelude FLNG facility is designed to stay on location and operate for at least 25 years.

LNG, LPG and condensate will be transferred to offtake tankers with the following estimated frequency:

- LNG – every week
- LPG – every month
- Condensate – every 2 weeks.

6.3 Prelude FLNG Facility Overview

The next few sections provide a high-level description of the layout of the Prelude FLNG facility. There is more detailed information in Appendix A: Detailed Facility Description.

The Prelude FLNG facility (Figure 6-3) is a turret moored offshore floating production facility with gas processing and liquefaction units. The facility includes LNG, LPG and condensate storage as well as facilities for exporting these products to offtake carriers.

It is connected to the gas reservoir and wells via flexible risers routed to the turret. All reservoir, subsea control, processing, storage and loading are controlled from the Prelude FLNG facility. The facility will remain on station for 25 years without dry docking and is a permanently manned facility. Periodic major maintenance or turnarounds will be carried out in-field during operate phase. Figure 6-4 shows the Prelude field layout.

Prelude has one drill centre with two 6-slot manifolds and seven production wells at the drill centre DC-1P. The drill centre is located approximately 3 km south of the Prelude FLNG facility. The Prelude FLNG facility is connected to the gas reservoir via four 12” flowlines connecting the production manifolds to the riser base manifold.

Each flow path to the Prelude FLNG facility, consisting of flowlines and flexible risers, is equipped with a Fail Close Riser Base Valve (FCRBV) at the Riser Base Manifold (RBM), located at a horizontal distance of 550 m from the centre of the turret, to isolate the Prelude FLNG facility from the flowlines inventory.

The Prelude FLNG facility is moored using 16 mooring lines connected to piles grouped into four quadrants. A Fibre Optic (FO) cable connects the Prelude FLNG facility to the Australian FO network onshore.

The Prelude FLNG facility itself is 488 m long, 74 m wide and has an operating draft of 19 m and is permanently moored with weathervaning capability. The main elements of the Prelude FLNG facility are:

- An internal turret, which permanently moors the Prelude FLNG facility to the seabed via a catenary mooring system and provides interface with subsea systems
- Topsides containing all process units & part of the utilities systems
- A substructure with all necessary marine facilities, accommodation, cargo containment systems, and the remainder of the utilities systems:
    - Storage Tanks
    - Aft Machinery Space & Fwd Machinery Space
    - Side by Side Mooring and LNG/LPG Offloading
    - Accommodation / Living Quarters
    - Tandem Mooring and Condensate offloading
    - Water Intake Risers.

The substructure is separated from the Topsides by the main deck, on which piping systems such as cooling water, steam, fuel gas, rundown and loading lines are located. Topsides equipment is arranged in large modules over a series of process decks.

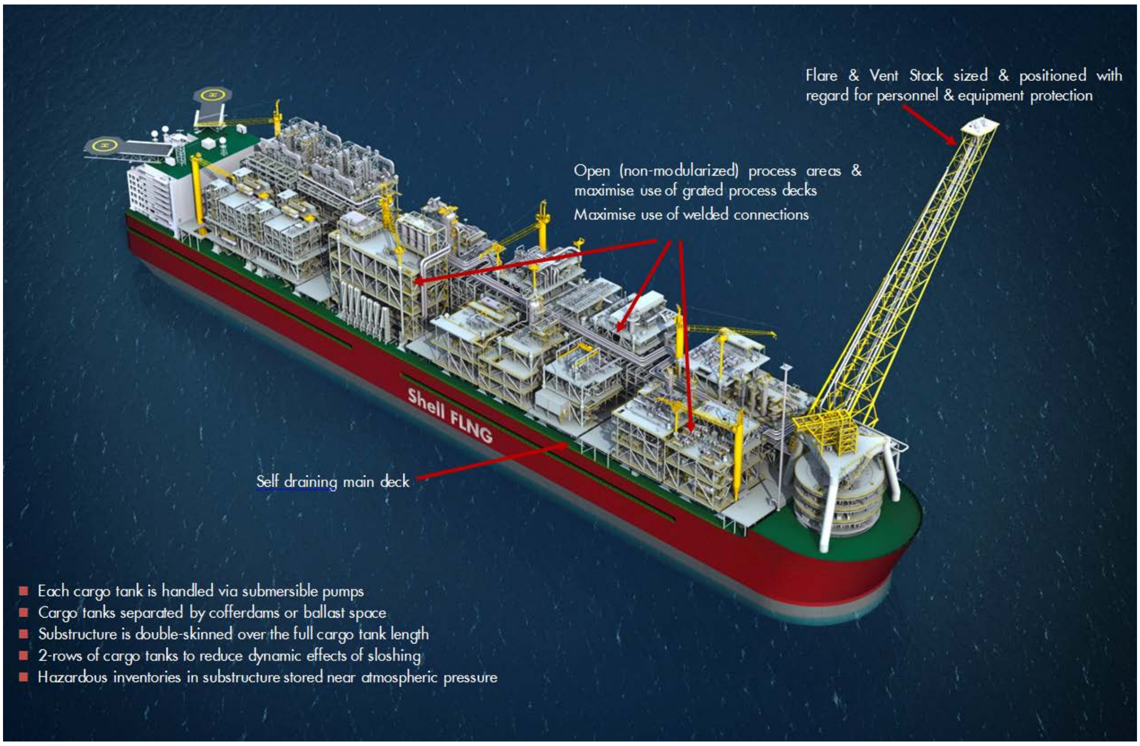
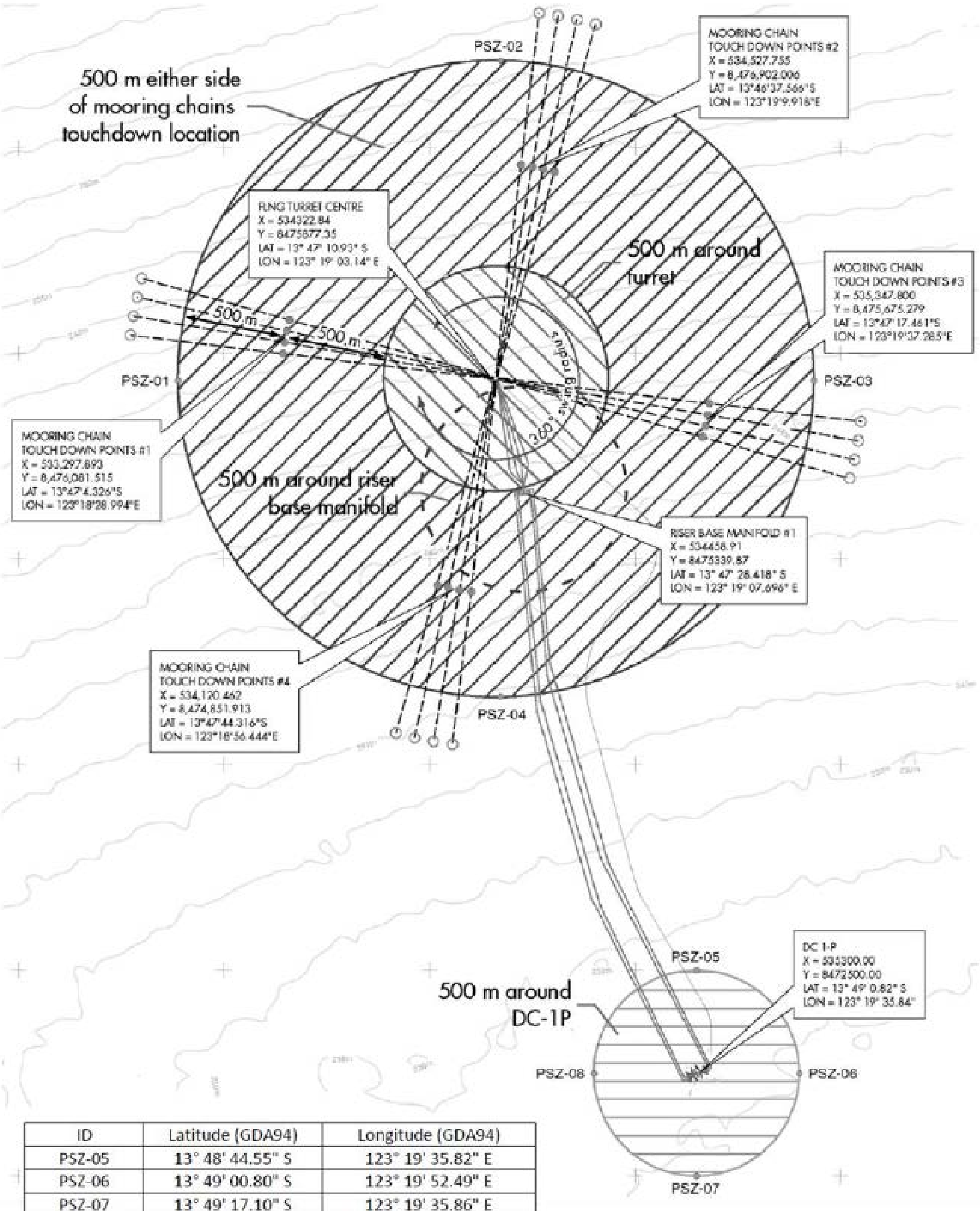


Figure 6-3: Overview of the Prelude FLNG Facility

6.3.1 Prelude Field Safety Zones

Prelude field safety zones are published under Commonwealth of Australia Gazette Notice: A441884 which extend around both the well infrastructure equipment and the Prelude FLNG facility as shown in Figure 6-4.

ID	Latitude (GDA94)	Longitude (GDA94)
PSZ-01	13° 47' 11.40" S	123° 18' 11.61" E
PSZ-02	13° 46' 20.57" S	123° 19' 03.74" E
PSZ-03	13° 47' 11.26" S	123° 19' 54.65" E
PSZ-04	13° 48' 01.29" S	123° 19' 03.88" E



ID	Latitude (GDA94)	Longitude (GDA94)
PSZ-05	13° 48' 44.55" S	123° 19' 35.82" E
PSZ-06	13° 49' 00.80" S	123° 19' 52.49" E
PSZ-07	13° 49' 17.10" S	123° 19' 35.86" E
PSZ-08	13° 49' 00.85" S	123° 19' 19.19" E

Figure 6-4: Prelude Field Layout and Safety Zones

6.3.2 Subsea Facilities

The subsea facilities are shown in Figure 2-1 with brief descriptions in Table 6-1.

Table 6-1: Prelude Subsea Equipment Description

Subsea Facility	Description
Wells	• Drilled from a single drill centre • 7 highly deviated/sub-horizontal wells • Prelude's 8th Well (P2): The well was permanently isolated from permeable zones, fluids, and pressures using verified plugs after well objectives were not met. • Each well can deliver up to 250 Mmscfd (Note: Dry (water free) gas flow rates) • Surface Controlled Sub-Surface Safety Value (SCSSV) installed in each well
Subsea Xmas Tree	• 690bar (10,000psi) 7" Enhanced Vertical Deepwater Tree, consisting of the following: o Production choke valve o Subsea venturi flowmeter o Subsea control module (SCM) o Pressure and temperature sensors o Chemical injection ports (for MEG and SI/PPD)
Jumper, Flowlines & Production Manifold	• Two 6-slot production manifolds provide tie-in for up to 12 gas production wells (five spare slots) • Manifolds have dual headers • Flow from each well can be directed to either header • Each manifold is connected to two flowlines (approx. 3 km in length) and the manifolds are connected via the manifold jumpers together to provide dual looped flow paths • Dedicated SCM on each production manifold
Riser Base Manifold (RBM)	• Flowlines are connected to the four 12" flexible production risers to the Prelude FLNG facility via the RBM • FCRBV installed at the RBM for each of the risers • Dedicated SCM on the RBM
Production Risers	• Prelude FLNG facility process modules are connected to the subsea facilities via four flexible risers connected to the turret • Design pressure of 400 bar and temperature of -20 / 128°C • Material for the critical pressure sheath layer (i.e. PVDF) is capable of handling Prelude fluid and design temperature • Installed in a lazy wave configuration with allowance for excursions around the Datum • End connections of the risers are fitted with bend stiffener to prevent damage to the riser's structure from over bending • Flexible risers are anchored at the Prelude FLNG facility using standard hang-off devices • A Riser Emergency Shutdown Valve is installed at the top of each riser on board the Prelude FLNG facility • Riser vent gas monitoring is provided to monitor diffusion of gas through the pressure sheath into the flexible pipe annulus
Wet Parking Frame	• The wet parking frame is retained at seabed as a contingency for significant maintenance or other works. It is planned to be removed from the seabed as with other subsea infrastructure in accordance with the eventual plan for decommissioning.

Umbilical and Subsea Distribution	• A dynamic control umbilical links the Prelude FLNG facility to the subsea system providing hydraulic, electrical and chemical services, and signal and power control communications to the subsea system • Designed to support eight production wells • End connection is fitted with a bend stiffener to prevent damage to the umbilical structure from over bending

Prelude subsea equipment is described in Table 6-1, with the status and location outlined in the Table 6-2, noting the inclusion of the Prelude P2 abandoned well and Concerto-1 exploration well. The maintenance of the subsea infrastructure is described in the Section 6.4.3, and well integrity management in Section 6.4.4.

Table 6-2 Prelude Subsea Infrastructure Inventory

Infrastructure	Status	Production Permit	Location
Wells – 7 Production wells	Active	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
Well – P2	Plugged and abandoned (subsurface only[2]). Low Pressure wellhead connector converted to subsea production tree parking mandrel	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
Concerto-1 exploration well	Plugged and abandoned with wellhead removed	WA-44-L (previously WA-371-L)	Latitude -13.674473 Longitude 123.343885
Subsea Xmas Tree	Active	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
Jumper, Flowlines & Production Manifold	Active	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
Riser Base Manifold (RBM)	Active	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
Production Risers	Active	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
Wet parking frame	Contingency	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
Umbilical and Subsea Distribution	Active	WA-44-L	Prelude field safety zone (Gazette Notice: A441884)
FLNG Mooring System	Active	WA-44-L WA-2-IL	Prelude field safety zone (Gazette Notice: A441884)

[2] Permanently isolated from permeable zones, fluids, and pressures using verified plugs in accordance with Well Abandonment Manual (WS 38.80.31.35-Gen.)

6.3.3 Turret Mooring System

The Turret Mooring System (TMS) is a major element that provides the station keeping function for the Prelude FLNG facility and connects the subsea infrastructure with the topsides process modules. The Prelude FLNG facility rotates freely about the turret subject to the influences of the prevailing winds, waves and currents, naturally adopting a heading (termed weathervaning). This weathervaning requires the use of a swivel stack to transfer the production stream, chemicals, power, and communications signals between the Prelude FLNG facility and the subsea equipment.

The Prelude FLNG facility is permanently moored and designed for cyclonic conditions offshore NW Australia. The mooring system is designed to withstand the design 10,000 years return period cyclone event when all lines are intact. In conditions, up to and including the 100 years return period cyclone, the mooring system offers redundancy following failure of any one mooring line, such that in any principal loading condition will not lead to progressive failure of the mooring system or exceed riser design limits.

6.3.4 Turret

The turret, shown in Figure 6-5, is an internal type turret and is located completely within the boundary of the substructure at the bow of the facility. All risers and mooring lines pass through the centre of the turret. This design enables mooring chains and risers to be protected from ship collision and direct wave actions.

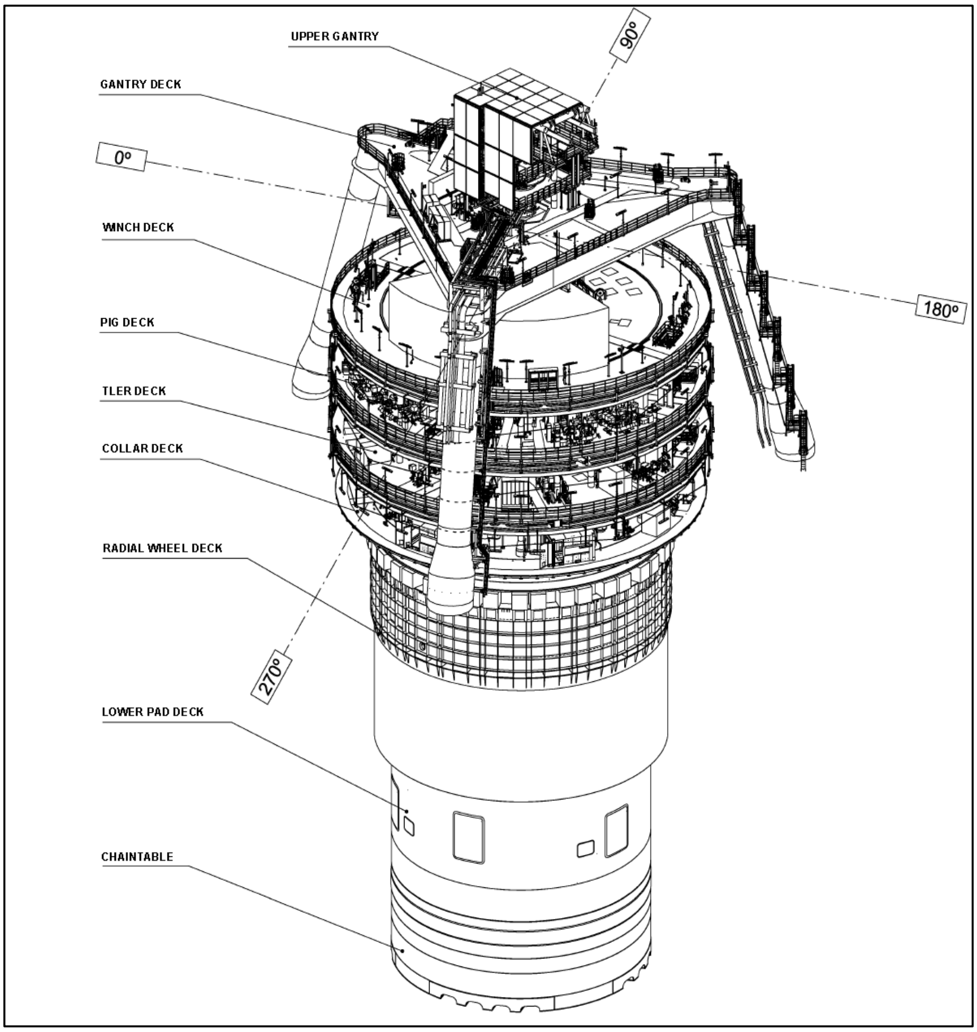


Figure 6-5: Turret 3D View

6.3.5 Topsides and Main Deck

The process units and other key utility units are located above the main deck in the form of modules, collectively called the Topsides. The process and utility units on the Topsides are split-up in 8 modules, further sub-divided into 14 sub-modules, 8 infill areas, lay-down areas, hull pipe rack with maintenance route, and 1 flare tower including the marine and CO_2 vent. Figure 6-6 shows a plan view of Prelude FLNG facility detailing the location of the process and utility sub-modules and the key equipment contained per sub-module.

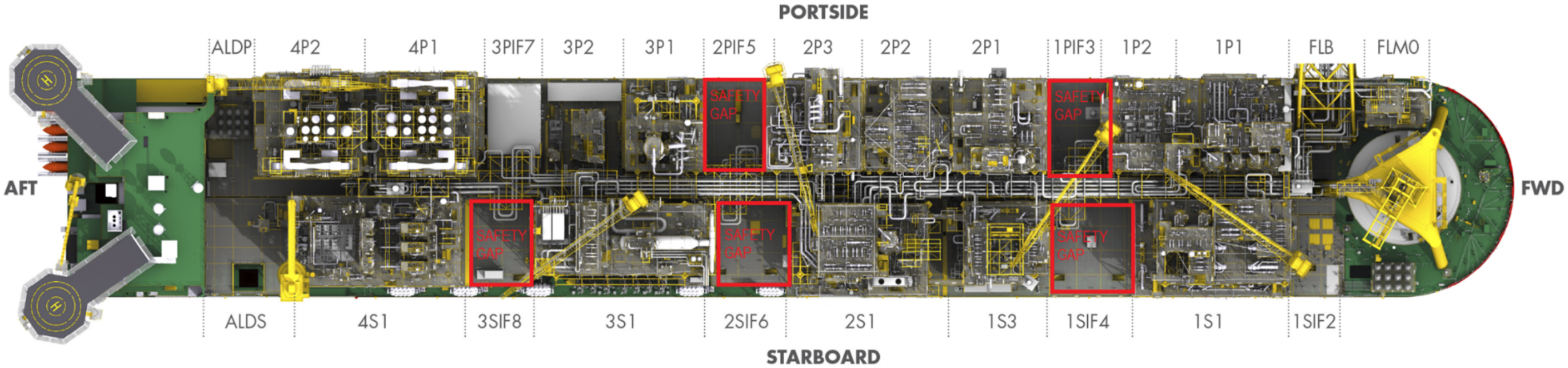
The process fluid from the wells passes through the Turret module to the processing module on the Topsides. The key function and equipment per modules are described below:

- **Module 1S (1S1, 1S3)** contains the inlet facilities and primarily separates the well stream into gas and liquid flows. This unit receives and conditions the feed gas and liquid hence located close to the turret area. Module 1S3 includes installed depletion compressor and its auxiliaries, which shall not be operated during the early phase of the well life.

- **Module 2S1** contains the acid gas recovery unit (AGRU) absorption column, gas dehydration (mole sieve dryers) & mercury removal (Hg guard bed) units. The regeneration facilities for the acid gas removal unit are located in module 3P1.
- **Module 1P (1P1, 1P2)** contains the NGL extraction, fractionation and booster compression units. Because of the amount of light liquid hydrocarbons (C2, C3, C4) and lower integration requirement with other units, the fractionation unit is located as far from the accommodation block as possible. For the same reason, this unit is located in the opposite side of the mooring location of the LNG/LPG carrier (when alongside). The condensers and accumulators are located on an elevated level to provide sufficient suction head (NPSH) for the pumps. All pumps are currently located underneath these vessels at the lowest level in the module.
- **Module 2P (2P1, 2P2, 2P3)** contains the liquefaction unit. The mixed refrigerant (MR) part in module 2P1 consists of the main cryogenic heat exchanger (MCHE) and condensing steam turbine driven MR compressor with its coolers and knockout facilities. The pre-cool mixed refrigerant (PMR) part in module 2P3 consists of the condensing steam turbine driven PMR compressor with its de-superheaters and condensers and knockout facilities. The PMR receiver and main pre-cooler (LP, MP, HP) i.e. coil wound heat exchangers are located in module 2P2 in between the MR and PMR part.
- **Module 3P (3P1, 3P2)** contains the AGRU stripping section, MEG regeneration and reclamation unit. The 3P1 module contains the solvent regeneration column, LP steam heated re-boilers, heat exchangers, filters and pumps. The solvent drain vessel is located on the main deck under 2S1 and solvent storage tanks are located in the hull. Module 3P2 contains the MEG regeneration, reclamation unit and nitrogen booster compressor and high-pressure nitrogen vessel. The nitrogen booster compressor only operates to top-up the high-pressure nitrogen vessel.
- **Module 3S1** contains the end-flash unit. This module contains the end flash vessel and associated end flash compressor. The fuel gas system with fuel gas heaters is located on an elevated deck. This module also contains the offloading analyser and metering stations. The side-by-side offloading loading arms and associated manifolds are located at main deck level. This module also contains the electrochlorination unit and CCW2 expansion vessel on the top deck.
- **Module 4P (4P1, 4P2)** contains seven marine steam boilers.
- **Module 4S1** contains the low pressure nitrogen generation unit, de-aerators, CCW2/3 expansion vessel, air compressor. These relatively low risk units (i.e. 4P and 4S) are located in the area between the accommodation and the process area.

The flare boom length is 155 m, inclined by 40° portside perpendicular to the hull. The flare knock out vessels and associated equipment are located adjacent to the flare stack structure in module FLM0.

Module, i.e. Process Deck A and above					
Infills (PIF) & Laydown Area	**4P1, 4P2 Steam Generation**	**3P1, 3P2 AGRU Stripping Side, MEG Regen & Reclaim**	**2P1, 2P2, 2P3 Liquefaction**	**1P1, 1P2 NGL Extraction & Fractionation, Booster Compressors**	**FLM0, FLB Flare Module, Flare Stack**
• 1PIF3 (Safety Gap) • 2PIF5 (Safety Gap) • 3PIF7 (LER) • Aft Laydown Portside - ALDP	• Steam Generation (U40000), • 4P1 - Marine Steam Boilers 1-4, • 4P2 - Marine Steam Boilers 5-7, • HP-LP PRS, Distribution • Boiler Blowdown vessels (U41000)	• 3P1 - AGRU (U11000), Solvent Regeneration and Filtration • 3P1 - LP PCL Flash Vessel & Pumps (U41000) • 3P2 - MEG Regeneration & Reclamation (U52000), High Pressure N_2 Compressor (U48000)	• Liquefaction Unit (U14000), 2P1 - NG Main Cryogenic Exchanger, MR compressor, 2P2 - PMR Reclaimer, NG Pre-Coolers (HP, MP, LP), 2P3 - PMR Compressor, • 2P2 - LNG vaporizer &Pump, Maintenance Compressor (U34000)	• 1P1 - NGL Extraction (U14000) NGL extraction column • 1P1 - Fractionation (U15000), De-Ethaniser, De-Propaniser, De-Butaniser • 1P1 - LP PCH Flash Vessel & Pumps (U41000) • 1P2 - NG Expander/ Re-compressor, NG Booster Compressor, Defrost gas heater (U14000)	• FLM0 - Flare Module contains the flare KO drums, stabilizer vessels (U63000) • FLB - Flare stack including marine and CO_2 Vents
Main Deck to Process Deck A (below each Module)					
	• Condensate offloading pumps • Open Non-hazardous drain vessel	• Butane offloading pump hatch • Open hazardous drain vessel and pumps	• LNG Offloading pump hatch • Propane offloading pump hatch	• CO_2 snuffing Skid • LP PCH transfer pumps • LNG Offloading pump hatch	• Wet Stabilizer Vessel • Ethane Refrigerant pump hatch • Propane/PMR Refrigerant pump hatch • Offspec reprocessing pumps



Module, i.e. Process Deck A and above				
Infills (SIF) & Laydown Area	**4S1 Utilities**	**3S1 End Flash, Boil Off and Fuel Gas**	**2S1, 1S3 AGRU Absorption Side Gas Dehydration and Hg Removal, Inlet Facilities**	**1S1, 1S3 Inlet Facilities**
• 1SIF2 • 1SIF4 (Safety Gap) • 2SIF6 (Safety Gap) • 3SIF8 (Safety Gap) • Aft Laydown Starboard - ALDS	• Service/Portable & Demin Water (U-43000), De-aerators • CCW2 Circulation Pumps (U45000), • CCW3 Expansion Vessels (U45000), • Air Compressor, IA generation (U47000), • N_2 Generation Unit (U48000)	• Liquefaction Unit (U14000), LNG Expander, End Flash Column & Compressor • Fuel Gas System (U44000), • CCW2 Expansion Vessel (U-45000), • Electrochlorination unit (U46000), • Propane/Butane metering (U35000) • Condensate metering (U36000)	• AGRU (U11000), Absorption Section • Molecular Sieve Dehydration Unit (U13000), • Mercury Removal Unit (U13500), • HP PCL Flash Vessel (U41000)	• 1S1, 1S3 - Inlet Facility (U10000), • HP Separators, LP Separator, Depletion Compressor, Condensate Stabilizer 1&2, Condensate Stabilizer Overhead compressor, • Produced Water Flash Gas package (U64000), • LER • Flare Maintenance Vent (U63000)
Main Deck to Process Deck A (below each Module)				
	• Condensate offloading pumps	• LPG/LNG offloading arms (U34000/ U35000) • Propane/Butane offloading pump hatches • Rich MEG transfer pump	• LNG Offloading pump hatches • Open hazardous drain vessel and pumps • Solvent Drain Vessel	• FWD rich MEG storage tank transfer pump • PW flash gas vessel pump and slop oil pump • Open hazardous drain vessel and pumps • PW flash gas vessel

Figure 6-6: Main Deck and Topsides Layout Plan

6.3.6 Water Intake Risers

The Prelude FLNG facility uses cold cooling water to increase the efficiency of the liquefaction process efficiency and reduce plot space. Water is required to be pumped from an average water depth of 170 m to meet the closed cooling water circuit demand.

6.3.7 Substructure

Storage Tank Layout

The following tanks are installed in the substructure:

- 6 LNG storage tanks
- 4 LPG storage Tanks
- 6 Condensate storage tanks
- 1 Produced water tank
- 2 Off spec tanks.
- 2 Rich MEG tanks plus 1 Fwd Rich MEG tank
- 2 Lean MEG tanks.
- 1 Solvent Storage Tank
- 1 Water Wash Storage Tank
- 1 Chemical Spills Collection Tank
- Slop tanks
- 1 PMR Tank
- 1 Ethane Tank.

The substructure is double hulled on each side extending over the full length of the storage tanks. LNG, LPG and Condensate storage tanks are located inboard of segregated ballast tanks covering the full length of the storage area. The tanks are fed directly from the Topsides rundown system.

The port and starboard LNG, LPG and Condensate tanks are separated from each other by a void space or ballast tank. The design of the hull structure is such that LNG, LPG and condensate storage tanks are separated from the plant hazardous area by a main deck which is designed to withstand explosion overpressure, jet fire and cryogenic spills. The LNG, LPG tank tops are double deck type arrangement with all piping systems above the main deck designed to survive blast overpressure load. There are no flange connections in the piping within the double deck. Heating system is installed to heat the transverse cofferdams and the upper portion of centreline water ballast tanks surrounding the cargo tanks to maintain the temperature of the structure.

Aft Machinery Spaces & Fwd Machinery Spaces

The aft machinery space is enclosed within the hull with facilities arranged over 7 decks and are mechanically ventilated. The machinery space is provided with normal access by stairways from the accommodation and the main deck. An enclosed mechanically ventilated space is located in the forward part of the Prelude FLNG facility to accommodate equipment associated with the turret and effluent treatment operation.

Side-by-Side Mooring and LNG/LPG Offloading/Import

LNG/LPG carriers are moored alongside the starboard side of the Prelude FLNG facility utilising mooring lines and separated via the fenders.

Condensate Offloading via Tandem mooring

A tandem mooring and offloading system is fitted at the stern of Prelude FLNG facility for offloading condensate cargo to a condensate tanker. The condensate tanker is moored to the Prelude FLNG facility by a tandem mooring hawser configuration. When not in use, the hawser is recovered.

Accommodation / Living Quarters (LQ)

The LQ houses 170 cabins. The cabins are designed as single rooms with the option to convert to double occupancy, therefore, a maximum of 340 POB can be accommodated. Each cabin has a private shower/toilet facility.

Helideck(s) and Refuelling System

Two helidecks, each with a helicopter parking area are located above the accommodation/LQ. The helideck pancake is self-draining “Safedeck” type made of aluminium.

Helicopter refuelling package (i.e. tote tank/storage tank/recycle system/pumps) and associated firefighting system are located on the top of the accommodation. Dispenser cabinets comprising of the fuelling reel, filter and sampling unit are provided at each helideck.

Provision of heli-fuel for the helicopter re-fuelling station is by way of 3 x 4000 L portable tote tanks.

6.4 Operational Activities

The following are the activities conducted on the facility to ensure safe production of hydrocarbon products:

- Production Operations - Activities to ensure that operations of the facility are conducted within their defined envelopes. This includes facility hydrocarbon commissioning, start-up and ramp-up (SURU) activities.
- Maintenance and Inspection - Activities to inspect and maintain hardware and equipment integrity and reliability.
- Underwater Inspection, Maintenance and Repair - Activities to inspect, maintain and/or repair the underwater/subsea facilities.
- Services - Includes the following activities:
    - Maritime and Terminal Operations - activities relating to the management of access and/or movement of marine vessels within the Safety Zone; and the management of product offloading/import activities
    - Helicopter Operations
    - Management of lifting and hoisting and deck services on the facility
    - Facility catering services.

6.4.1 Design Basis for Prelude FLNG and Current Status

Prelude FLNG was designed with a maximum capacity enabling up to about 12,000 tonnes per day (tpd) LNG, 2000 tpd LPG and 5000 tpd condensate production.

The key name plate capacities and technical maximums of Prelude FLNG are listed in the Table 6-3 below.

Table 6-3 Prelude FLNG Name Plate Capacities

Product	Design Basis (MTPA)
LNG	3.6
Condensate	1.3
LPG	0.4
Total Hydrocarbon Production	5.3

Since Prelude arrived onsite in 2017, Prelude has passed many key milestones in the journey to steady state operations. At the end of 2018, Prelude opened the wells and commenced the start-up/ramp-up process. Due to unforeseen technical challenges, Prelude has not yet been able to complete the start-up phase of the project which involves the performance test runs (running the wells at the technical maximum/100%) and getting the utilisation of Prelude up to 90%. Prelude is now expected to complete the performance test run at the start of 2021 and reach ~90% utilisation in 2023 or 2024. As of 2020, the forecast utilisation for 2021 and 2022 is between ~50-70%.

6.4.2 Maintenance, Shutdowns and/or Turnarounds

Regular maintenance activities are carried out on a daily basis on the Facility. Facility maintenance shutdowns and/or turnarounds are planned at regular frequencies to conduct inspection, maintenance and/or repair works that could not be completed during production operations. During a facility shutdown and/or turnaround, the topsides facility is predominantly shutdown and depressurised.

Further, maintenance shutdowns/turnarounds are supported by services activities such as helicopter operations and maritime activities including supply boat activities and bunkering.

Temporary facilities for accommodating additional personnel, wastes accumulated and materials may be likely required during major turnarounds, however, no other significantly different environmental risks from those described in Section 9 are expected. Details of the key air emissions, liquid discharges and waste generated by these activities are outlined in the respective areas of Section 9.0. A risk assessment and supporting demonstration that impacts and risks are managed to ALARP and Acceptable levels will be conducted for any temporary liquid discharges or air emissions generated by maintenance, shutdown or turnaround activities.

6.4.3 Preservation and Maintenance of Subsea Equipment

Prelude's IMR philosophy is to inspect and maintain the installed portfolio of subsea equipment such that its mechanical condition remains fit for the purposes specified in its original design requirements. These include, but are not limited to, mechanical integrity, availability, service life, and retrievability. Typical IMR activities consist of:

- regular visual inspection of equipment condition,
- inspection and, as appropriate, refurbishment of cathodic protection equipment
- ongoing management of a detailed integrity database which includes details of the location and condition of all subsea equipment
- repair/replacement and reinstatement of failed equipment items to support continued field operation (typically chokes, control modules, flying leads)

- provision of contracts, tooling and spares to support an effective IMR response over life-of-field

The Prelude Preservation and Storage strategy (2000-005-S001-SS01-G00000-UA-5980-00004) gives an overview of the approach that is used to ensure that project equipment is managed appropriately, including both dry and wet storage, prior to commencing operations.

The requirement for maintenance activities on the subsea equipment are expected to be limited because of the material selected for the equipment. However, as a result of the high pressures and naturally occurring metocean conditions in which subsea infrastructure operates, inspection and maintenance are required to ensure the integrity of the infrastructure and identify any problems before they present a risk of loss of containment or asset damage.

Through these activities Shell will meet the obligations under the OPGGS Act (s.572(2)) to 'maintain in good condition and repair all structures that are, and all equipment and other property that is: (a) in the title area; and (b) used in connection with the operations authorised by the permit, lease, licence or authority'.

In particular for Prelude P2 well, after it was permanently isolated from permeable zones, fluids, and pressures using verified plugs in accordance with the Shell Well Abandonment Manual, the low pressure wellhead connector was converted to a subsea production tree parking mandrel. The design of the mandrel coupled with the final cement abandonment plug rendered the P2 wellbore and associated low pressure wellhead unusable for future well activity (i.e. well production). In its current configuration, the P2 well parking mandrel provides subsea flexibility during XT changeouts within the DC-1P well centre and the intent is to retain the tree parking mandrel in its current status to allow use should there be requirement over the course of the field life.

In addition, through the implementation of the Prelude Preservation and Storage Strategy, information will be gathered over the life of the facility that ensures an appropriate level of planning for the eventual decommissioning. In doing so, this ensures Shell has plans in place to meet its regulatory obligation to remove property in accordance with the requirements of s.572 of the OPGGS Act.

The P2 subsea parking mandrel, complete with remaining low pressure wellhead system, will be rendered into final abandoned condition via severance and recovery of the conductor at the end of field life or when equipment field activities end if this occurs sooner. The majority of maintenance activities comprise non-intrusive inspections using ROVs such as general visual inspection, cathodic protection probe inspection and checks, marine growth checks, seabed and free span checking and measurements, azimuth and mooring surveys. Typical maintenance activities for P2 well comprise general visual inspection and cathodic protection survey. These surveys determine the physical condition of the subsea assets.

The wet parking frame will be left in situ for potential future use for subsea campaigns which require its use throughout the Prelude FLNG facility asset life. It will be appropriately monitored and maintained to ensure its purpose of intended use is maintained and also enabling future retrieval when it is no longer intended to be used. Surveillance via installed monitoring equipment includes continuous monitoring of pressures, temperatures, flow rates and sand production rates at various locations in the subsea system, supported by lab testing of produced fluids and the chemicals injected to maintain the production system. This ensures that the status of the system is continually known, and that any early indications of potential degradation/failure are acted upon promptly to maintain the condition of equipment/ hardware and structures in an appropriate state until cessation of production.

Frequency of inspection is generally selected based on Risk Based Inspection (RBI) principles; this approach is integral to Prelude's subsea inspection philosophy. Based on RBI, risk analysis is performed which considers the consequences of failure of each equipment item in terms of impact to people (safety), environment, production and costs of repair. From this assessment, a risk level and corresponding inspection effort are determined and assigned to each equipment type. An overall inspection plan and frequency of inspection is then provided for all structural components of the subsea system.

Subsurface Integrity Testing (SIT) inspection and maintenance activity on well systems is performed as per the current frequency specified within the Well Failure Model (WFM) and monitored / tracked within the eWIMS. Inspection and maintenance activities on subsea equipment is performed as per the current frequency specified, monitored and tracked within the Integrity Management System Application (IMSA). Typically, subsea systems are designed so that design life exceeds operating life, with the intent that proactive, planned repair activities are not necessary. However, unplanned intervention to address breakdown maintenance of certain equipment items is an inevitable part of the operation of any subsea field – most commonly, subsea chokes, control modules and flying leads may require replacement during the life of field; less commonly, well and flowline jumpers may require intervention if damaged.

Should repair and/or replacement of subsea infrastructure be required, a detailed risk assessment will be done prior to the repair activity. Repair activities are those required when a subsea system or component is degraded, damaged or has deteriorated to a level outside of acceptance limits as defined by design codes.

During these maintenance activities, minimal fluids are released as lines are depressurised and flushed prior to any intervention activities. Where equipment has failed, it is retrieved for replacement, the failed items are either refurbished and stored onshore for future use, or disposed/scrapped in an approved safe location onshore.

Marine Growth Covers (MGC) are provided for all critical Subsea hardware assets with ROV Interfaces. To maintain the infrastructure, a long term corrosion cap (LTCC) was manufactured and installed on the P2 well subsea parking mandrel. The objectives of the MGCs and LTCC are to reduce the amount of soft growth and thus reduce the time required for the ROV to clean the interfaces required during the commissioning phase and during an intervention in the operating life of the asset. Excess marine growth removal maybe undertaken on Prelude subsea facilities with an ROV. Various techniques for marine growth removal include:

- Water jetting – use of high pressure water
- Brush systems – use brushes attached to an ROV
- Use of chemicals
- Sand/abrasive blasting.

The long term corrosion cap was designed such that it has the capability of allowing injection of a corrosion inhibitor into the wellhead system, as such preserving all sealing bores and profiles across the wellhead internal housing.

Corrosion inhibitor injected into the P2 well parking mandrel via ROV, provides a cushion of inhibitor across all critical sealing profiles of the well head housing. The inhibitor is selected in accordance with the Prelude Chemical Selection Process.

Minor chemical discharge may be associated with marine growth removal, although non-chemical method is preferred.

An Underwater Services Contract is in place to execute all subsea/underwater inspections and maintenance activities. Subsea activities are typically performed from a support installation vessel via one or more ROVs. Typical support vessels use a DP system to avoid anchoring. The Underwater Services Contract manages the scope for planning, preparing and executing routine and ad-hoc underwater intervention and inspection for Prelude FLNG Moorings and Subsea Hardware. The contractor is responsible for the following:

- Perform engineering and develop procedures associated with the intervention and inspection activities
- Supply appropriate vessel(s) and associated support personnel
- Provision of all materials and equipment
- Undertake the intervention and inspection activities in accordance with approved procedures
- Provision of all reporting and documentation.

6.4.4 Well Intervention and Workover

There are no planned well intervention or well workover activities during the life of this EP. However, well intervention activities through the subsea tree system may be required due to a number of unforeseen circumstances that may occur during the operations phase of a wells lifecycle.

Interventions may be undertaken for reservoir surveillance, enhancing productivity, assessing wellbore condition and restoring well integrity. Well interventions may also include tree/wellhead maintenance, logging or surveys, mitigating safety critical failures (e.g. failed safety valve), and production logging improvement activities.

When top-up of the well annulus with MEG is required, up to 15 bbl of MEG will be injected into the annulus in 5 – 10 bbl increments (pressure dependent). After allowing the MEG to “flip” with the base oil in the annulus, annulus pressure will be bled off with returned base oil being flushed to the surface via the flow/return umbilical. Injection of MEG and return of base oil will be repeated until the required volume of MEG has been pumped into the annulus. Returned liquids will be stored onboard the Light Well Intervention Vessel in the waste liquid tank. As this is a closed loop system, there are no planned discharges to sea.

If required during the life of this EP, well operations would be executed and managed by the Wells Delivery team, interfacing and concurring with asset groups as appropriate. The work would be conducted in accordance with Prelude FLNG Permit to Work controls. Management of these activities are detailed in the Prelude WOMP.

ROV(s) are used from the vessel in support of the well intervention activities. The ROV(s) are a standard work class ROV, with any specialist equipment or tooling required mounted on the ROV. An observation class ROV may also be employed to assist the work class ROV where appropriate.

With respect to well integrity, management of the wells will be in accordance with the NOPSEMA accepted Prelude WOMP, which sets out requirements for ongoing wellhead monitoring and leak detection. Through implementation of the WOMP, Shell is meeting its regulatory obligation under the OPGGS Act (s.572(2)) to 'maintain in good condition and repair all structures that are, and all equipment and other property that is, in the title area and used in connection with the operations'.

For wells and seabed infrastructure, through the development and eventual implementation of the decommissioning plan, Shell will meet its obligations under s. 572 (3) of the OPGGS Act 'to remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations'.

6.4.5 Light Well Intervention

6.4.5.1 Light Well Intervention (LWI) Vessel Description

The following describes a typical vessel to be used for offshore well intervention activities.

Planned well intervention activities are executed by LWI vessels with an accepted vessel Safety Case for those activities consistent with the OPGGS(S) Regs 2009. Should the vessel scope demonstrate functionality or significant hazards that are not captured within the accepted vessel Safety Case scope, then a re-assessment shall be undertaken accordingly. This shall be followed by a consultation and revision to the existing vessel safety case, as required by the OPGGS(S) Regulations 2009.

Shell has framework agreements in place with a number of providers. The scope under these agreements is provision of a fully integrated LWI service including vessel, subsea intervention device (SID), ROVs, slickline/wireline services, bleed-off package services and project management under Shell's Well Engineering oversight. Having agreements in place with a number of providers improves response time to a potential well integrity issue requiring an intervention in the event the primary LWI service provider is unable to supply the requested service.

The selected LWI vessel contractor shall ensure that such a LWI vessel has the required vessel documentation accepted by the various legislative bodies for use offshore in Australian waters. More details on the specific LWI vessel used on Prelude can be found within the datasheet included in the vessel Safety Case.

Light Well Intervention Vessel Safety Critical Equipment

Safety critical equipment will be detailed in the LWI vessel safety case. Where applicable each LWI vessel safety case is reviewed by Shell in conjunction with the Prelude FLNG Safety Case (in force) to ensure that there are no omissions with regards to safety critical equipment. There are a number of key controls with interfaces to the Prelude FLNG Safety Case (in force) and this EP, which shall be scrutinised at this review of the vessel safety case, and thereafter at the maritime vessel assurance reviews. Examples of physical controls that relate to environmental protection and this EP include:

- Navigation equipment and aids (including audible and visible warnings)

- Communication equipment
- Dynamic positioning system
- Lifting equipment
- Back-up power supply
- Emergency shut-down, alarm and lighting systems.

Remotely Operated Vehicle(s) (ROVs)

ROVs are used from the LWI vessel in support of the LWI activities. The ROVs are standard work class ROVs, with any specialist equipment or tooling required mounted on the ROVs. Observation ROVs may also be employed to assist the work class ROVs where appropriate.

Subsea Intervention Device (SID)

Well interventions require well bore access into 'live' wells. A SID is deployed and utilised to allow wellbore access while maintaining well control. Basic particulars of a SID are listed below. Any selected vessel contractor shall ensure that such a SID shall meet the functionality and operability as per the approved WOMP as required by the OPGGS (Resource Management and Administration) Regulations 2011. SID typical details are as follows:

- System Working Pressure: 10,000 psi
- Umbilical pressure rating: 7,500 psi (4x ¾" (19mm) lines)
- Min Bores Size: 7-3/8" (187mm)
- SID Ram/Valve configuration: Capacity for two (2) sealing barriers in place for all well interventions
- Subsea Connector Type: 18-3/4" (476mm) H4 10,000 psi
- Subsea Intervention Lubricator Length: 60ft.

6.4.5.2 Light Well Intervention (LWI) Operational Considerations

With two well barriers in place the tree cap can be recovered. After tree cap recovery the SID will be deployed onto the subsea production tree using a heave compensated crane on the LWI vessel. After deployment of the SID onto the subsea production tree the SID will be pressure tested to Closed-In Tubing Head Pressure (CITHP) plus a margin. SID umbilicals and slickline/wireline will be compensated.

Control of the production tree valves during well entry will be via the SID umbilical system or managed through a lock out interface with FLNG. The LWIV has the necessary tooling for ROV intervention also.

If required, subsea production tree valve cavities and the A-annulus may be flushed/ topped with inhibited MEG from the LWI vessel. This will most likely be completed using a down line from the LWI vessel or via ROV as an alternative.

With sufficient well barriers in place the SID will be placed on the next well or recovered to the LWI vessel. A tree cap will be installed and pressure tested with an ROV.

6.4.6 Potential Light Well Intervention Requirements

Light well interventions required on the Prelude wells, post suspension plug recovery, will in principle be the result of a well integrity issue needing an investigation or repair. These activities may need to be carried out at any point during the life of this EP. Potential well intervention triggers may include:

- Completion tubing leak
- Production packer leak
- Loss of A-annulus integrity
- Subsurface safety valve functionality issues
- Subsea production tree valve leak.

Well interventions most likely require a well entry using slickline/wireline. This can be executed by a vessel with Light Well Intervention capability similar to the LWI vessel used for the planned suspension plug recovery operation. As a result, Section 6.4.5.1 Light Well Intervention (LWI) Vessel Description and all requirements and associated references are also applicable to contingency LWI activities.

Although the in-well activities and objectives are different, the risks and hazards are effectively identical to suspension plug recovery. Hence the Commissioning & LWI Well Integrity Risk Register will apply for these operations.

Below are some of the contingency LWI activities listed which may be applicable from suspension plug recovery through to the commissioning and production (including start-up) activities.

6.4.5.1 Slickline/Wireline interventions

The likely types of slickline/wireline intervention that may be required during the Prelude well life cycle are detailed further in this section.

6.4.6.2 Deep Set Plugs

Setting a deep-set plug would most likely be triggered by a well integrity concern, coming from a tubing or production packer leak into the A-annulus.

If the leak is in the tubing, then the most likely plug will be a slickline conveyed plug set in the nipple profile located in the completion tail pipe.

A leak of the production packer itself will require a high expansion plug set in the 7” (178 mm) liner. This plug will be run on e-line and potentially requires the use of a tractor and setting tool.

6.4.6.3 Sub-Surface Safety Valve Repairs

Sub-surface safety valve functionality issues may also lead to an intervention. The most involved operation that would be attempted would be to run an insert valve. This operation involves four main slick line runs (with possible drift and check runs in between). The operational steps are:

- Run in Hole (RIH) and exercise the sub surface safety valve. This involves shifting the sleeve up and down using a dedicated wireline tool.
- RIH with a lock open tool. This trip involves stroking the sleeve of the sub surface safety valve down and locking it in this position using a dedicated wireline tool.

- RIH with a punch/ communication tool. This dedicated wireline tool will create hydraulic communication with the sub surface safety valve control line.
- RIH with the insert safety valve. The valve is deployed on a lock that sets in the nipple profile above the subsurface safety valve. With the lock set in the profile the valve straddles the punched port allowing the control fluid to reach and function the insert safety valve.

6.4.6.4 Investigation Run

Prior to, for example, rectifying a leak and/or subsurface safety valve issue, it is likely that an investigation tool will be deployed on slickline/wireline to better understand the issue. Typical examples would be:

- RIH and run an acoustic tool to detect the location of a potential tubing leak.
- RIH and run a downhole camera to obtain an imagine of the sub-surface safety valve internal condition.
- RIH and run a calliper or drift run to investigate any changes in well bore internal geometry.

6.4.6.5 Well Surveillance Well Entry

Although not envisaged it is possible that a slickline/wireline run is required for well surveillance purposes e.g.:

- RIH with an expandable gauge carrier to obtain downhole pressure and temperature in case the permanent downhole gauge is not functioning.
- RIH with a drift run to investigate a potential blockage below the completion tail pipe.

6.4.6.6 Well Production Reinstatement

In the unlikely event that sand production becomes an issue, there is the opportunity to run a slickline/wireline deployed sand screen hung off in the nipple profile located in the completion tail pipe.

6.4.7 Isolations from FLNG

With FLNG on location it is imperative that isolations are put in place during a LWI to isolate the wells and the well intervention activities from the production facility and other wells. A number of FLNG Operating Procedures are in place to ensure adequate and tested isolations are in place. These isolations are critical in preparation for handover of the well from the asset to the wells team and vice versa at the start and end of the intervention activities. The specific procedures deal with:

- Prelude Subsea Isolation Strategy
- Lock-Out Tag-Out (LOTO) Manual
- Well Handover Procedure.

6.5 Logistic Support Arrangement

6.5.1 Aviation Support Location

Prelude requires logistics support from the mainland of Australia. The primary means of mobilising personnel to the facility is by helicopter via Broome as the primary helicopter base. Djaradjin (also known as Lombadina) is used as a refuelling point to optimise operational efficiency dependant on environmental conditions. These helicopter bases may change in the future as company requirements may change. However, as the onshore bases are excluded from the scope of this EP, any change to the location of the base does not change the environmental risks from helicopter operations within WA-44-L.

6.5.2 Infield Support Vessel

The Infield Support Vessels (ISVs) support the operations of the Prelude FLNG facility, primarily fulfilling the role of Standby Vessels. Typically, two ISVs are present in the Prelude field area based on a rotation basis.

The ISVs perform the following roles and functions:

- Each ISV is provided with a Fast Rescue Craft (FRC) to facilitate rescue of persons from sea and where necessary the guiding of free floating life rafts.
- In a major emergency, the ISV acts as an emergency evacuation vessel.
- Acting as a place of safety or having the ability to transfer to an alternative vessel offshore or helicopter.
- Firefighting with capability commensurate with notation Fi-Fi 1, with remote operated main water monitors and foam drenching system.
- Ability to provide Tier 1 oil spill response.
- 24/7 security surveillance for other vessels that might pose a threat to Prelude using existing systems (e.g. radar, floodlighting and other means of surveillance).
- Monitoring and maintaining traffic activities in the safety zone.
- Perform side by side berthing and unberthing operations for LNG and LPG Tankers.
- Perform tandem berthing and unberthing, hawser and hose handling operations of offtake Condensate tankers.
- Provide support during offloading of tankers.
- Enable transfer of FLNG TTLS (Pilots) and Service Technicians, Surveyors to the carriers and tankers upon arrival and return to FLNG on departure.
- Pilot transfer from the FLNG is primarily from the Preludes bow catcher located on Preludes Stern with secondary access being at the Port and Starboard doors.
- Perform environmental monitoring (or another similar vessel) if possible.

6.5.3 Supply Vessels

The Shell Marine Logistics Group supports the Prelude FLNG activities through the provision of the following contracted vessels including but not limited to:

- Platform Supply Vessel (PSV) (Figure 11) or Multi-purpose Platform Supply Vessel (MPSV)

- Anchor Handling Tug / Supply (AHTS)
- The scope of work for these dedicated vessels comprises of the following:
  - Port operations (Loading / discharging of cargo and specialist equipment)
  - The safe transportation of cargo / equipment to and from FLNG facility
  - Offshore Installation operations (Discharging / back-loading of cargoes and specialist equipment)
  - Anchor handling / towing operations (AHTS vessels only)
  - Infield emergency response support e.g. oil spill response, helicopter operations standby support.

Shell has contracted supply vessels that will support the Prelude activities. Up to four supply vessels are planned to be utilised during the installation and hook-up activities, and one supply vessel during normal operations. The MPSV can also be called to respond to subsea inspection and intervention requirements. The following is an example to contextualise/visualise.

6.5.4 Accommodation Support Vessels

Potentially during major maintenance activities or shutdowns, an accommodation support vessel (ASV) may be necessary to provide accommodations for additional personnel in excess of the FLNG's capacity.

7.0 Description of the Receiving Environment

As required by regulations 13(2) and 13(3) of the OPGGS(E) Regulations, a description of the receiving environment that may be affected by the activities (both planned and unplanned) covered by this EP is provided in this section. The information contained in this section has been used to inform the assessment of environmental impacts and risks presented in Section 9.3 to Section 9.14.

The spatial extent of the receiving environment encompasses the physical, biological and socio-economic receptors that may be affected by planned and unplanned activities. The majority of the impacts and risks from the activities covered by this EP occur in close proximity to the Prelude FLNG facility (i.e. within the Operational Area around the facility and associated infrastructure), however some impacts and risks may extend further. The credible worst-case hydrocarbon release scenarios determined by modelling studies are predicted to present the greatest spatial extent of all the impacts and risks identified. The outer boundary of the area that may be influenced by the petroleum activities, identified by the modelling and referred to as the Zone of Potential Influence (ZPI), has been used as the outer boundary for the description of the receiving environment. The worst-case hydrocarbon releases during operations have a remote to extremely remote likelihood of occurring, and Shell implements a range of controls to ensure such incidents are prevented, and mitigated to ALARP and Acceptable Levels. The ZPI for the combined worst-case credible hydrocarbon spills from the Prelude FLNG facility and associated petroleum activities is shown in Figure 7-1 and this represents the low exposure thresholds described further in Table 9-78. Refer to Section 9.13 for additional information on hydrocarbon spill modelling and risk management and associated impact thresholds applied for the assessment.

The description of the receiving environment considers environmental receptors that are protected under the EPBC Act, including:

- World heritage and national heritage values
- Ramsar wetlands
- listed threatened species, migratory species and threatened ecological communities
- values and sensitivities within the Commonwealth marine environment.

The EPBC Act Protected Matters Search Tool (PMST) was used to identify environmental receptors protected under the Act. Two EPBC Act PMST reports were generated; one based on the Operational Area and one based on the combined entrained, dissolved and surface ZPI. PMST Reports for both the Operational Area and ZPI are provided in Appendix 14.0.

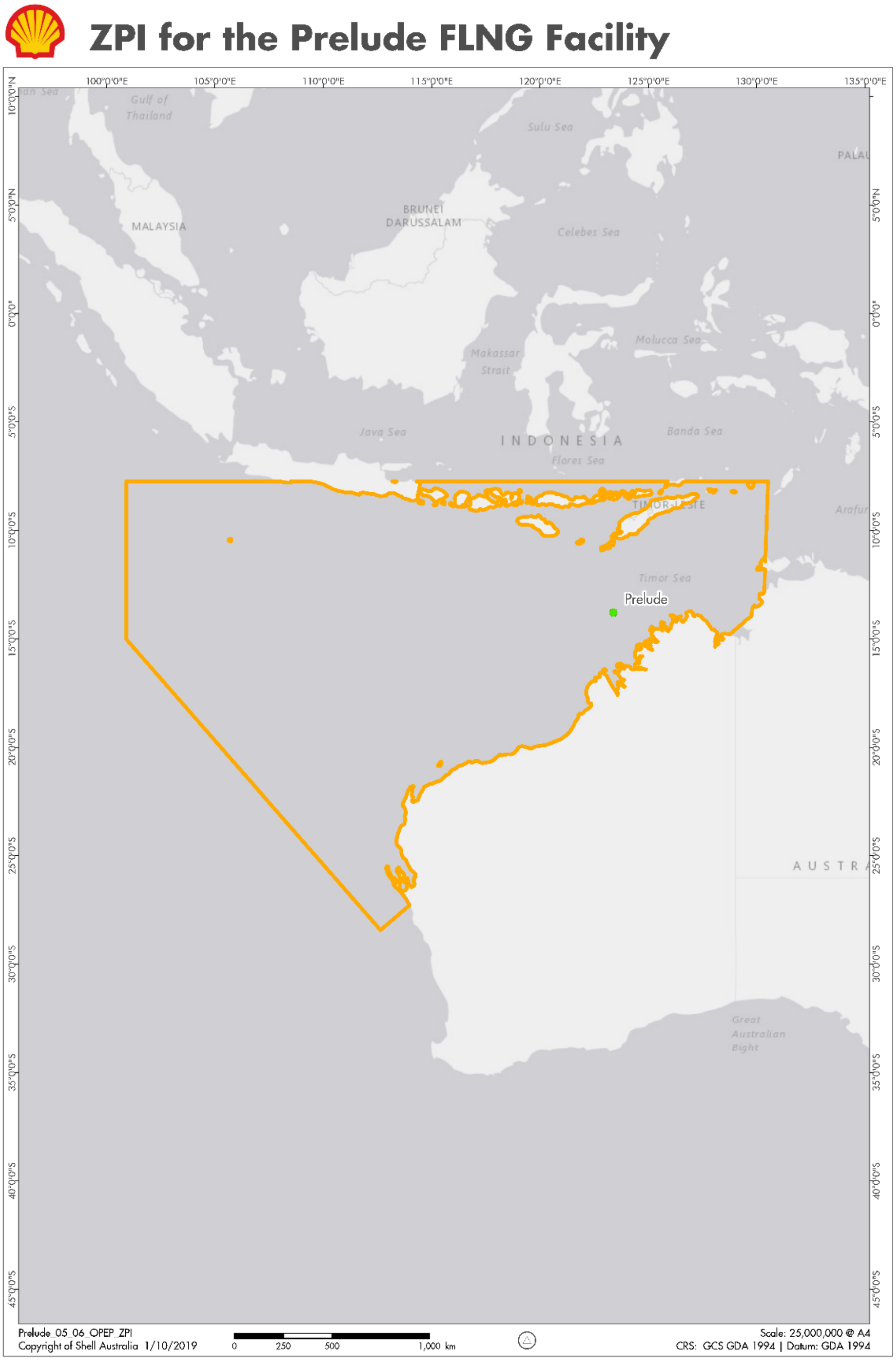


Figure 7-1: ZPI for the Prelude FLNG facility and associated Petroleum Activities

7.1 Physical Environment

7.1.1 Seabed

The Operational Area is located in the Timor Sea on the outer continental slope between 200 and 300 m depth. The seabed within the Operational Area, and within the WA-44-L permit more broadly, is relatively flat and featureless. Baseline environmental study results for the Prelude development show the seabed is characterised by unconsolidated sand, silt and mud (Shell 2009). No reefs or extensive areas of rocky substrate have been observed.

Notable seabed features in the ZPI beyond the Operational Area include the coral reefs and islands that occur throughout the region. The closest of these features, Browse Island, is located some 39 km southeast of Prelude. There are also numerous reefs, banks and shoals throughout the Timor Sea, which host diverse biological communities. Other notable seabed features in the ZPI include Ashore Reef, Cartier Island, Scott Reef, the Rowley Shoals, and numerous reefs, banks and islands off the Kimberley and Pilbara coasts. Refer to Section 7.2 for further discussion of the biological communities associated with these seabed features.

7.1.2 Climate

Prelude is situated in the tropics and experiences a monsoonal climate with two seasons. The Australian northern monsoon generally occurs between December and March (Figure 7-2). It is associated with the inflow of moist west to north-westerly winds into the monsoon trough, producing convective cloud and heavy rainfall over northern Australia. During the cooler months (June - September), the sub-tropical ridge that lies over continental Australia drives stable and persistent easterly winds over the region. The Australian cyclone season officially runs from November to April, although very few storms have occurred in November. The chance of experiencing an intense category 4 or 5 cyclone is highest in March and April. At the start of the cyclone season, the most likely area to be affected is the Kimberley and Pilbara coastline and offshore areas including the Operational Area, with the area threatened later in the season extending further south.

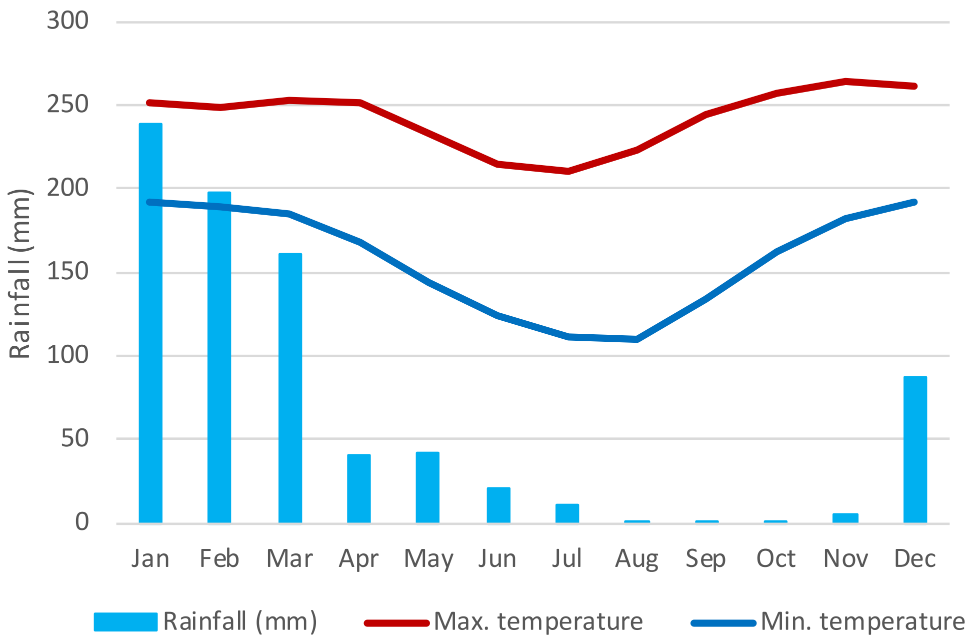


Figure 7-2: Long-term maximum and minimum temperatures and mean rainfall from Cygnet Bay (closest Bureau of Meteorology climate station to Prelude FLNG). Data sourced from Bureau of Meteorology (n.d.)

7.1.3 Oceanography

The regional currents influencing the offshore waters off northern and western Australia are shown in Figure 7-3. The majority of water movement off northern Western Australia is poleward, with the water being relatively warm and low in nutrients (DEWHA 2008). A strong seasonal wind regime is closely associated with seasonality in surface currents in the region, including the seasonal strength of trade winds in the equatorial Pacific Ocean which drive the Indonesian Throughflow (ITF).

The project is located within the North West Marine Region (NWMR)[3] which experiences semi-diurnal tides. Tidal ranges are large - 0.8 m neaps and 5 m springs (RPS 2018) - and strongly influence currents in the region. Notably, tidal amplitudes seem to be retained at large distances offshore and travel initially in a north-east direction in the deeper waters of the region (RPS 2018). The tidal current component is imposed over the synoptic-scale flow.

In addition to synoptic-scale and tidal currents, locally generated wind-driven currents also influence water movement within the Operational Area and ZPI. These are more variable and are superimposed over large-scale flows.

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[3] A series of bioregional plans have been developed by the Commonwealth government. These plans are intended to help improve the way decisions are made under the EPBC Act. The Operational Area (and much of the ZPI) overlaps the area covered in the Marine bioregional plan for the North-west Marine Region: prepared under the Environment Protection and Biodiversity Conservation Act 1999 (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2012a); hence the Operational Area is within the NWMR.

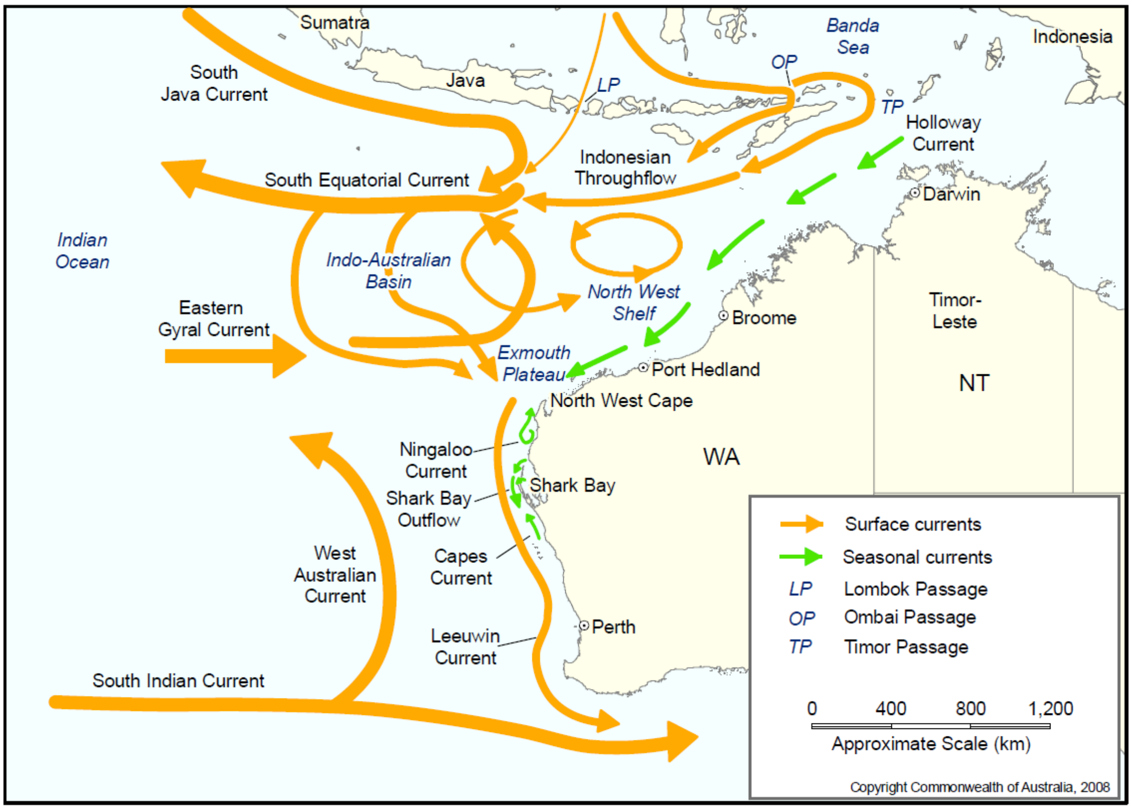


Figure 7-3: Regional synoptic-scale currents off north-western Australia (from DEWHA 2008)

7.1.4 Water Quality

Water quality in the vicinity of Prelude is generally high. A field survey in 2018 was carried out in WA-371-P (including the now WA-44-L) title area, which consisted 40 sampling stations within four identified 'impact' zones (A-D) and an outlying 'reference' zone (R). The positioning and extent of impact zones A-C was determined on the basis of the location of the following main operational areas within the proposed facilities layout:

- The sites for the FLNG facility (Zone B);
- The subsea well structures (Zone C); and
- Proposed site of subsea infrastructure (Zone A).

The fourth impact zone (Zone D) comprised an area encompassing the above three areas, while the reference sites were located outside the external boundaries of Zone D.

Water samples were collected using Niskin water samples at depths of 5 m (surface), 150 m (mid-depth) and 5 m above the seabed (bottom) for in-situ and lab analyses. Additional in-situ samples were taken at each site at depths ranging from 1 m-200 m. Upon surfacing, in-situ measurements were immediately collected using a Hydrolab minisonde 5 probe.

Results from this 2018 baseline water quality survey, in conjunction with the Prelude EIS indicated potential contaminants, such as metals and hydrocarbons, were low and often below the laboratory detection limits (Shell 2009), refer Table 7-1: Water quality for survey results. These results are consistent with other survey results in the Timor

Sea (Ross et al. 2017). Nutrient and turbidity levels in the water column were also low compared to nearshore waters, which is typical for offshore waters and is consistent with other surveys in the region (Ross et al. 2017). The average salinity for the receiving water is approximately 34.5ppt (ERM 2008).

Table 7-1: Water quality

Parameter	Range value (min – max)	Sample location/ condition
pH Range (min-max)	7.15 – 8.21	In-situ measurement collected in and around the development area
Dissolved Oxygen (mg/L)	7.27 - 4.19	DO was found to be same along the sampling point but varied by depth
TSS (mg/l)	Near surface: 3.7 Mid depth: 5.0 Near seabed: 3.8	Data obtained from a study conducted for INPEX in Exploration Permit WA-285-P (RPS, 2007b) located immediately adjacent to WA-371-P
Heavy Metals	Observed little spatial or vertical variation in seawater barium, nickel, iron, zinc and cadmium concentrations	Mean concentration of metals in all sampling zones were below trigger values identified in ANZECC guidelines

Water quality in the immediate vicinity of the Prelude FLNG facility is slightly lower due to routine discharges from the facility (e.g. grey water, sewage, PFW etc.). The area impacted by these discharge streams is localised; refer to Section 9.9 for further information.

7.1.5 Sediment Quality

Sediments at Prelude are described as very soft carbonate silts to a depth of about 10 m below the seabed. A field survey was undertaken within the same spatial extent as described above in Section 7.1.4 for sediment quality testing. Sediment samples were collected using a Van Veen benthic grab sampler with 0.1 m2 sample capacity. The average water depth at each sampling station was approximately 240 m. Baseline studies showed concentrations of potential contaminants, such as hydrocarbons and metals, were typically low and similar to other studies in the region (Ross et al. 2017, Shell 2009), survey results are listed in Table 7-2 and survey locations in relation to the Prelude FLNG are in Figure 7-4.

Table 7-2: Prelude Baseline Sediment quality results

Parameter	Range value (min – max)	Sample location/ condition
Particle size distribution	Samples from Zones A-D were primarily of silt (56.75% ± 9.06) and clay (29.89% ± 4.22)	In-situ measurement collected in and around the development area
Total Organic Carbon (% wt)	0.06 – 2.9	This concentration is considered as a low percentage range of organic material. Also, there was no clear spatial pattern in mean total organic carbon concentrations between sampling zones
Oil & Grease (mg/kg) *	$C_6 – C_9$: 5	Levels of oil and grease above the limits of reporting (200

	$C_{10} – C_{14}$: 114 $C_{15} – C_{28}$: 203 $C_{29} – C_{36}$: 50	mg/kg) were found only in one sample from the site of the FLNG facility (Zone A: 3400 mg/kg) and two samples from the reference zone (Zone R: 530 and 1660 mg/kg). The Prelude turret location is located at the sediment sampling point D5.
Heavy Metals	Barium: 14.2 – 204 Chromium: 11- 16.5 Iron: 3,205 – 5,830 Nickle: 8.9 -11.2	Concentrations of cadmium (Cd), lead (Pb) and mercury (Hg) were below the laboratory detectible level

* mean concentration of all sample points

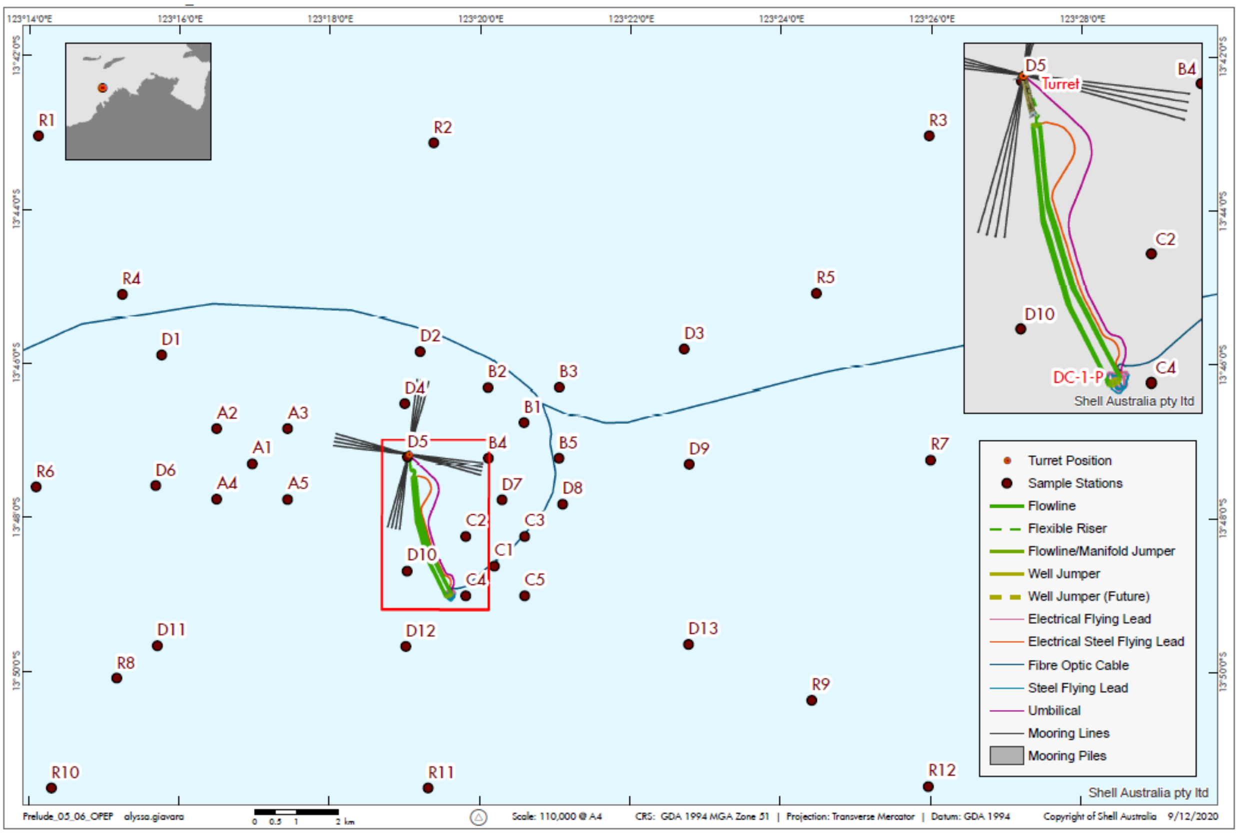


Figure 7-4: Prelude FLNG Baseline Sediment Sampling Locations from 2008.

Installation of subsea facilities (e.g. wells, xmas trees, flowlines and umbilicals) resulted in isolated areas of sediment disturbance. Higher concentrations of potential contaminants from drill cuttings and fluids, such as barite, may occur in the cuttings piles from historical drilling activities. These areas are expected to be highly localised (i.e. within 100’s of metres from wellheads).

7.1.6 Air Quality

No specific information concerning air quality in the local airshed area is available. However, the Operational Area is approximately 200 km from the Kimberley coastline, which itself is a remote and unindustrialised area. Therefore, the air quality is unlikely to be subject to considerable anthropogenic effects with the exception of the Prelude FLNG facility. Emissions from commercial shipping are likely to represent the main source of localised and temporary impacts on air quality. Production facilities in the broader region, such as the Montara FPSO facility (approximately 188 km from the Operational Area), the Ichthys FPSO (approximately 17 km from the Operational Area) and the future Shell Crux normally not manned platform (165 km from the Operational Area), are also expected to incrementally influence local and regional air quality.

In a regional context, the main contributors to particulate levels are ambient wind-borne dust and smoke from seasonal bush fires that are characteristic across the Kimberley regions. International contributors to reduced air quality in the project area may also include the likes of 'slash-and-burn' agricultural methods and other large forest fires in South-East Asian countries (Vadrevu et al. 2014; Kim Oanh et al. 2018).

7.1.7 Underwater Noise

The baseline underwater noise monitoring program in support of the Prelude EIS recorded the following natural and anthropogenic features of:

- several regular fish choruses (i.e. schooling fish calling en masse)
- several great whale calls including humpback whales, pygmy blue whales in late October 2006 and possible minke whale calls
- persistent vessel noise
- seismic survey noise associated with marine seismic survey signals.

The biological noise sources recorded in the nearby Ichthys field were similar and included regular fish choruses, infrequent calls from nearby fish and several whale calls from humpback whales, pygmy blue whales, minke whales and other unidentifiable species (INPEX Browse 2010). Anthropogenic noise sources recorded included low frequency noise from vessels and that generated from seismic surveys being conducted in the region (INPEX Browse 2010).

7.2 Biological Environment

7.2.1 Benthic Communities

7.2.1.1 Bare Sediment

Surveys of benthic habitats within the Operational Area showed low density epibenthic communities of deposit and filter feeders on bare sediments, which is typical of this habitat in the region (Baker et al. 2008). Infauna were dominated by polychaete worms, which accounted for approximately 80% of individual infauna sampled (Shell 2009). This finding is consistent with other studies across the region, which showed infauna communities in similar water depths are dominated by polychaetes and crustaceans (Heyward et al. 1997). Given the water depth within the Operational Area, no benthic primary producers will occur due to the lack of photosynthetically active radiation reaching the seabed.

Bare sediment habitats are also the most common habitat type within the ZPI, although there are discrete areas of other benthic habitat types associated with features such as islands and shoals, such as corals, macroalgae, seagrasses and mangroves (discussed below).

7.2.1.2 Corals

While hard (zooxanthellate) corals are not present within the Operational Area, they are widespread throughout the ZPI in relatively shallow (< 50 m) waters. Much of the open water environment in the ZPI is too deep for growth of hard corals, and coral communities are typically associated with the named islands, shoals, reefs and banks throughout the ZPI, including:

- Browse Island (approximately 39 km from the Operational Area)
- Echuca Shoal (approximately 61 km from the Operational Area)
- Heywood Shoal (approximately 81 km from the Operational Area)
- Cartier Islet (approximately 136 km from the Operational Area)
- Seringapatam Reef (approximately 136 km from the Operational Area)
- Goeree Shoal (approximately 144 km from the Operational Area)
- Vulcan Shoal (approximately 146 km from the Operational Area)
- Scott Reef (approximately 159 km from the Operational Area)
- Ashmore Reef (approximately 169 km from the Operational Area)
- Hibernia Reef (approximately 194 km from the Operational Area).

Coals reef communities are also widespread along the coastlines of Indonesia and Timor-Leste, including:

- Rote Island (approximately 322 km from the Operational Area)
- Timor (approximately 381 km from the Operational Area)
- Sawu Island (approximately 388km from the Operational Area
- Sumba (approximately 494 km from the Operational Area).

Corals, particularly reef-forming corals, form an important component of benthic communities by providing habitat. In turn, this habitat supports relatively diverse associated communities, such as fish assemblages and macroalgal communities. Coral rubble from dead hard coral colonies also results in in-situ sediment production, which may be an important source of biogenic sediments at banks and shoals in the Timor Sea (Heyward et al. 2012).

Corals in the region are thought to spawn seasonally, with two distinct mass spawning events in autumn and spring observed (Gilmour et al. 2009, Rosser and Gilmour 2008). This contrasts with other coral reef communities in the Indo-Pacific, such as the Great Barrier Reef and Ningaloo Reef, which typically exhibit a single annual mass spawning event. Coral reefs in the Timor Sea exhibit recruitment from both local (i.e. self-seeding) and distant (e.g. reefs located 10’s to 100’s of kilometres away) propagules (Gilmour et al. 2013). This has implications for the recovery of coral reefs following disturbance, such as bleaching events or cyclones.

7.2.1.3 Macroalgae & Seagrasses

Like corals, much of the ZPI does not receive sufficient photosynthetically active radiation at the seabed to support macroalgae and seagrass communities. The areas that do are typically associated with physical features such as reefs, banks, shoals, islands and the mainland coasts of Australia, Indonesia and Timor-Leste. Macroalgae and seagrass communities in these areas provide relatively complex habitat structure that supports greater species richness and diversity. Primary productivity from these communities also supports food webs through direct grazing and consumption of detritus.

Macroalgae are an important feature in the seabed communities at several offshore banks and shoals in the ZPI, particularly calcareous green algae in the genus *Halimeda*. Geological coring studies of several Timor Sea banks and shoals indicates extensive deposition of carbonate sediments from *Halimeda* spp. (Heyward et al. 1997), which may account for the creation and maintenance of these geological structures near the sea surface. Seagrasses at banks and shoals tends to be less common and more ephemeral than macroalgae, with surveys showing considerable temporal variability at the scale of years (Heyward et al. 2012).

7.2.1.4 Mangroves

Mangroves are widely distributed along the coastlines within the ZPI, including Indonesia (Timor and Sumba), the Pilbara and the Kimberley coastline. Mangroves habitats are of environmental value due to the shoreline stabilisation and habitat they provide. Many fauna species either complete their life cycles within mangrove habitats, or utilise mangroves during particular life history stages (e.g. nursery habitat for juveniles (Robertson and Duke 1987). The nearest potential mangrove habitat to the Operational Area are the islands and mainland coast of the Kimberley region, over 200 km from the Prelude LNG facility.

7.2.2 Pelagic Communities

7.2.2.1 Plankton

Plankton are organisms, typically small in size, whose movements are determined largely by currents rather than active movement (e.g. swimming). Plankton communities are often categorised into two groups: phytoplankton (drifting plants) and zooplankton (drifting animals).

Surveys in the Operational Area found phytoplankton communities to be highly diverse but low in abundance. Key groups identified include dinoflagellates (Dinophyceae), diatoms (Bacillariophyceae) and Prasinophyceae. The most abundant species included *Prasinophyte* sp. (Prasinophyceae); *Gyrodinium* sp. and *Heterocapsa* sp. (Dinophyceae); *Pseudonitzschia* sp., *Cylindrotheca closterium*, *Chaetoceros* sp., *Thalassionemafrauenfeldii* and *Nitzschia longissima* (Bacillariophyceae) (Shell 2009). Phytoplankton in the wider region is similar to that observed in the project area with relatively high diversity in certain groups recorded such as diatoms, dinoflagellates and coccolithophorids (Hallegraeff and Jeffrey 1984).

Zooplankton samples collected in July 2008 found crustacean assemblages to be primarily dominated by copepod species (Shell 2009). Overall densities of zooplankton assemblages were relatively low and typical of low nutrient open ocean environments in the region. A few samples were dominated by euphausiids or chaetognaths (Shell 2009).

Some fauna groups, such as fish and crustacean species, often have a planktonic larval stage following which they assume a free-swimming or benthic existence. The larval fish community within the Operational Area was relatively diverse and abundant; however, species composition was primarily dominated by neritic species, which have little or no commercial value (Shell 2009). Commercial species identified came from groups typical of a range of marine habitats including pelagic shelf systems and both coastal and deep sea demersal habitats. Larvae were identified from the following groups which have commercially targeted species: Berycidae, Carangidae (trevally and jacks), Lutjanidae (tropical snappers), Serranidae (cods), and Scombridae (mackerels and tunas).

7.2.2.2 Pelagic Fish & Invertebrates

Free swimming pelagic fauna within the Operational Area and ZPI are expected to include pelagic fishes, marine turtles, seasnakes, squid, and cetaceans. Several of these fauna groups (e.g. whale sharks, several cetacean species, marine turtles) are listed threatened and / or migratory under the EPBC Act; these species are considered in Section 7.2.4 Threatened Ecological Communities.

Small pelagic fishes, such as sardines and anchovies, form an important trophic link between microscopic planktonic communities (e.g. zooplankton feeding on phytoplankton) and larger consumers (e.g. tunas). Small pelagic fishes are expected to be broadly distributed throughout the tropical pelagic environment given the relatively homogeneous nature of the open sea, with food availability and predation also influencing the distribution and abundance of these species.

The distribution of larger pelagic fishes (e.g. tunas, bonito, blue sharks etc.) are expected to mirror the distribution of small pelagic fishes, as small pelagic fishes are the primary prey of these larger species. Several pelagic fish species, such as marlin, swordfish and mackerel, are important for commercial and recreational fisheries, although fishing effort in the Operational Area and much of the ZPI is very low. The commercially important southern bluefin tuna is thought to spawn in the north-eastern Indian Ocean, although this species is not fished within the Operational Area or ZPI.

7.2.3 Key Ecological Features

Key Ecological Features (KEFs) are elements of the Commonwealth marine environment that are considered to be of regional importance for either a region’s biodiversity or its ecosystem function and integrity. There are no KEFs present within the Operational Area; several KEFs have been identified within the ZPI. A summary of the KEFs overlapped by the ZPI are shown in Figure 7-5 and listed in Table 7-3.

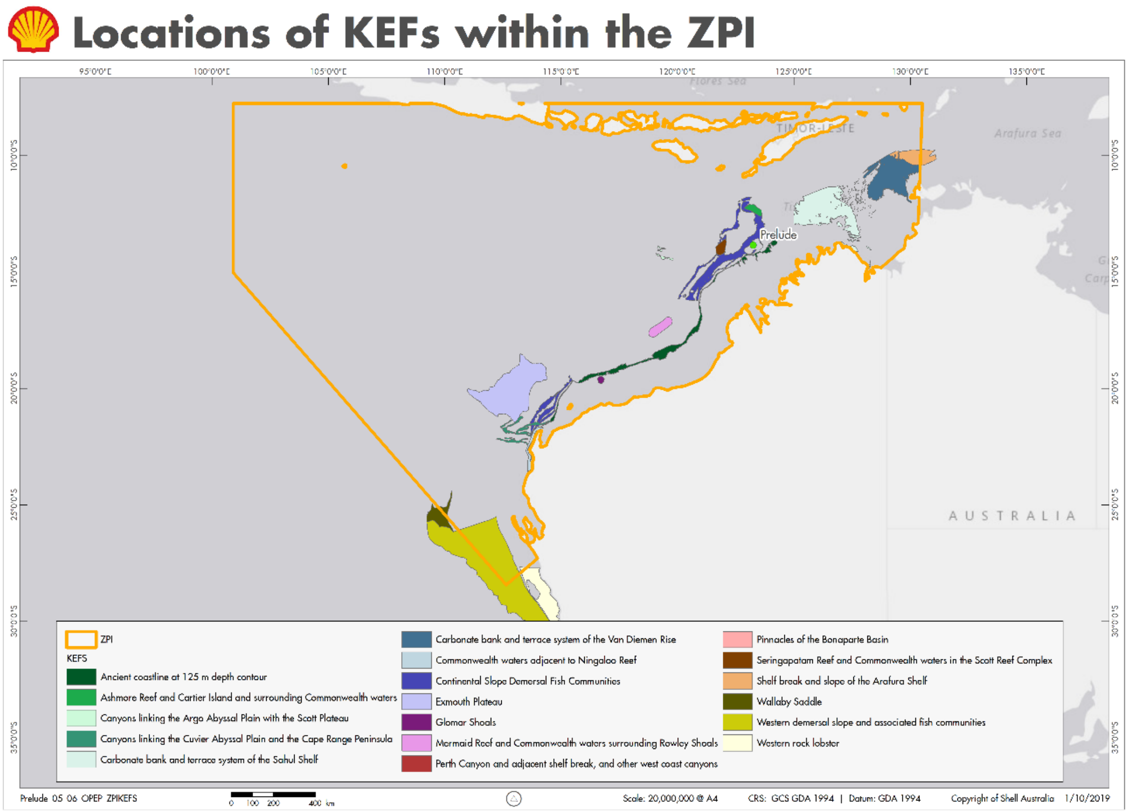


Figure 7-5: Locations of KEFs within the ZPI

Table 7-3: Descriptions of KEFs within the ZPI, including distance from Prelude FLNG

KEF	Distance from Prelude (km)	Description
Continental Slope Demersal Fish Communities	14	***Communities with high species biodiversity and endemism*** There is a high diversity of demersal fish assemblages on the Australian continental slope from the North West Cape to the edge of the NMR. The continental slope between North West Cape and the Montebello Trough has more than 500 fish species, 76 of which are endemic, which makes it the most diverse slope bioregion in the whole of Australia. The KEF covers a vast area of approximately 33,182 km^2.
Ancient coastline at 125 m depth contour	41	***Unique seafloor feature with ecological properties of regional significance*** The areas of hard substrate along this ancient coastline, which follows the 125 m depth contour, are thought to provide biologically important habitats in areas otherwise dominated by soft sediments; thereby providing for higher species diversity and richness relative to the wider region. The topographic complexity of these escarpments may also facilitate vertical mixing of the water column providing a relatively nutrient-rich environment for species present on the

KEF	Distance from Prelude (km)	Description
		escarpment. The KEF encompasses an area of approximately 16,190 km^2.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	131	***High productivity and aggregations of marine life*** The coral communities at Seringapatam and Scott Reefs play a key role in maintaining species richness and aggregations of marine life. The reefs and the waters surrounding them attract aggregations of marine life including migratory cetaceans. Green and hawksbill turtles nest during the summer months on Sandy Islet on South Scott Reef. These species also inter-nest and forage in the surrounding waters. Scott Reef is a particularly biologically diverse system and includes more than 300 species of reef-building corals, approximately 400 mollusc species, 118 crustacean species, 117 echinoderm species, around 720 fish species and several species of sea snakes.
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	134	***High productivity and aggregations of marine life*** Ashmore Reef is the largest of only three emergent oceanic reefs present within the north-eastern Indian Ocean and is the only oceanic reef in the region with vegetated islands. The emergent reefs are known to provide areas of enhanced primary productivity in otherwise oligotrophic environments. Ashmore Reef and Cartier Islands and the surrounding Commonwealth waters are regionally important for feeding and breeding aggregations of seabirds and shorebirds, and other marine life. Ashmore Reef regularly supports more than 40,000 waterbirds (those ecologically dependent on wetlands) and is estimated to support as many as 100,000 seabirds in a twelve month period (Hale and Butcher 2013). The marine habitats supported by the reefs are nationally and internationally significant, providing habitat for diverse and abundant marine reptile (including feeding, nesting and inter-nesting areas for green, hawksbill and loggerhead turtles) and marine mammal populations, including dugongs. Species at Ashmore and Cartier include more than 225 reef-building corals, 433 molluscs, 286 crustaceans, 192 echinoderms, and 709 species of fish. Thirteen species of sea snakes occur in high numbers at Ashmore and Cartier reefs but are thought to be in decline (Threatened Species Scientific Committee 2010a).
Carbonate bank and terrace system of the Sahul Shelf	206	***Unique seafloor feature with ecological properties of regional significance*** While little is known about this KEF, the carbonate banks and terrace system of the Sahul Shelf is considered regionally important because of their role in enhancing biodiversity and local productivity relative to their surrounds, largely due to the presence of elevated hard substrates. The seabed features are thought to create enhanced productivity and biodiversity as a result of upwellings of cold nutrient-rich water at the heads of the channels. The KEF covers an area of approximately 41,158 km^2. The banks rise to depths of 150 m – 300 m and are separated from each other by narrow meandering channels which are up to 150 m deep. The hard substrates of the banks are thought to support a high diversity of benthic organisms.

KEF	Distance from Prelude (km)	Description
Canyons linking the Argo Abyssal Plain with the Scott Plateau	384	***High productivity and aggregations of marine life*** Canyons linking the Argo Abyssal Plain with Scott Plateau covers an area of approximately 836 km^2. The Bowers and Oats canyons are major canyons on the slope between the Argo Abyssal Plain and Scott Plateau and deeply cut into the Scott Plateau at depths of approximately 2,000 m – 3,000 m. The ocean area above the canyons is thought to be an area of moderately enhanced productivity, attracting aggregations of fish, sharks, toothed whales and dolphins.
Pinnacles of the Bonaparte Basin	457	***Unique seafloor feature with ecological properties of regional significance*** The limestone pinnacles in the western Bonaparte Depression are expected to support a diverse community in an otherwise oligotrophic system. More than 110 pinnacles occur in the Bonaparte Depression, covering a total area of more than 520 km^2. The pinnacles are thought to be the eroded remnants of underlying strata and can be up to 50 m high and 50 km–100 km long.
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	523	***High productivity and aggregations of marine life*** The Rowley Shoals consist of three atoll reefs, Clerke, Imperieuse and Mermaid Reef, which support 214 coral species and around 530 species of fish. The steep changes in slope around the reef also attract a range of migratory pelagic species such as dolphins, tuna, billfish and sharks. The coral communities of Mermaid Reef are also an important feature. The enhanced productivity at the shoals is thought to be facilitated by the breaking of internal waves in the waters surrounding the reefs, causing mixing and re-suspension of nutrients from water depths of 500 – 700 m into the photic zone.
Glomar Shoals	941	***High productivity and aggregations of marine life*** The Glomar Shoals (approximately 786 km^2) are a submerged littoral feature located approximately 150 km north of Dampier on the Rowley shelf at depths of 33 m – 77 m. While biological data is limited, the fish of Glomar Shoals are believed to be a subset of reef-dependent species. The shoals are known to be an important area for a number of commercial and recreational fish species such as Rankin cod, brown-striped snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish.
Exmouth Plateau	1,127	***Unique seafloor feature with ecological properties of regional significance*** The Exmouth Plateau is a large, mid-slope, continental margin plateau that ranges in depth from approximately 800 to 3,500 m. The Exmouth Plateau is overlaid by an interface between the ITF and the Indian Ocean Central Water. This interface constitutes a potential shear zone (with associated mixing). The seascape of the Exmouth Plateau is not considered to be unique by Falkner et al. (2009) in their review of KEFs in the northwest marine region, however the geological origin and potential enhanced upwelling due to the Exmouth Plateau may constitute unique environmental values (DSEWPaC 2012a).
Canyons linking the Cuvier Abyssal Plain and the Cape	1,256	***Unique seafloor feature with ecological properties of regional significance*** The Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF lies off the north-west coast of Australia. Interactions

KEF	Distance from Prelude (km)	Description
Range Peninsula		with the Leeuwin current and strong internal tides are thought to result in upwelling at the canyon heads, thus creating conditions for enhanced productivity in the region (Brewer et al. 2007). Note that such upwelling may not result from the presence of the canyons, but from other factors such as local wind stress (e.g. upwelling off the Capes region in south-western Australia) and internal waves (Taylor and Pearce 1999, Woo et al. 2006).
Commonwealth waters adjacent to Ningaloo Reef	1,304	***High productivity and aggregations of marine life*** Ningaloo reef is globally significant as the only extensive coral reef in the world that fringes the west coast of a continent. It is also globally significant as a seasonal aggregation site for whale sharks. The Commonwealth waters adjacent to Ningaloo Reef and associated canyons and plateau are interconnected and support the high productivity and species richness of Ningaloo Reef. The Leeuwin and Ningaloo currents interact on the seaward side of the reef, leading to areas of enhanced productivity (DoEE n.d.).
Demersal slope and associated fish communities of the Central Western Province	1,747	***High levels of biodiversity and endemism*** The Demersal slope and associated fish communities of the Central Western Province provides important habitat for demersal fish communities. In particular, the continental slope of the Central Western provincial bioregion supports demersal fish communities characterised by high diversity compared with other, more intensively sampled, oceanic regions of the world. Its diversity is attributed to the overlap of ancient and extensive Indo-west Pacific and temperate Australasian fauna (Williams et al. 2001).
Western rock lobster	1,862	***Ecological role on the west coast continental shelf*** The Western rock lobster KEF covers a considerable portion (~40,000 km^2) of continental shelf waters on the lower west coast of Western Australia and was established in recognition of the presumed ecological role played by the western rock lobster (*Panulirus cygnus*) in shelf waters (DSEWPaC 2012b).
Wallaby Saddle	1,898	***High productivity and aggregations of marine life*** The Wallaby Saddle is located in water depths ranging from 4,000 to 4,700 m. The Wallaby Saddle is an abyssal geomorphic feature linking the north-west margin of the Wallaby Plateau with the upper continental slope margin of the Carnarvon Basin.
Perth Canyon and adjacent shelf break, and other west coast canyons	1,934	***Higher productivity that attracts feeding aggregations of deep-diving mammals and large predatory fish*** The Perth Canyon is the largest canyon on the Australian margin and, together with numerous smaller submarine canyons that incise the continental slope of southern Western Australia, is expected to have high biodiversity values. The west-coast canyons are believed to be associated with small periodic upwellings that locally increase productivity and attract aggregations of marine life. In the Perth Canyon, interactions between the canyon topography and the Leeuwin Current induce clockwise-rotating eddies that transport nutrients upwards in the water column from greater depths. Due to the canyon's depth and the Leeuwin Current's barrier effect, this remains a subsurface upwelling (depths greater than 400 m), which confers ecological complexity that is typically absent from canyon systems in other areas (Pattiaratchi 2007).

7.2.4 Threatened Ecological Communities

Threatened Ecological Communities (TECs) are protected under Part 3 of the EPBC Act and are MNES. The PMST report for the ZPI indicated that the monsoon vine thickets on the coastal sand dunes of the Dampier Peninsula TEC lies within the ZPI, approximately 285 km from the Operational Area at the closest point.

The identification of this TEC by the PMST report is an artefact of the method used to derive the search area for the PMST. This TEC lies entirely above the high water mark and will not credibly be impacted by a worst-case hydrocarbon spill. Hence, this TEC is not considered further in this EP.

No other TECs were identified that may credibly be affected by the petroleum activities considered in this EP.

7.2.5 Ramsar Wetlands

Sites recognised under the Convention on Wetlands of International Importance (the Ramsar Convention), referred to as Ramsar wetlands, are protected under Part 3 of the EPBC Act and are MNES. Several Ramsar wetlands were identified within the ZPI; the environmental values for these Ramsar wetlands are shown in Figure 7-6 and summarised in Table 7-4.

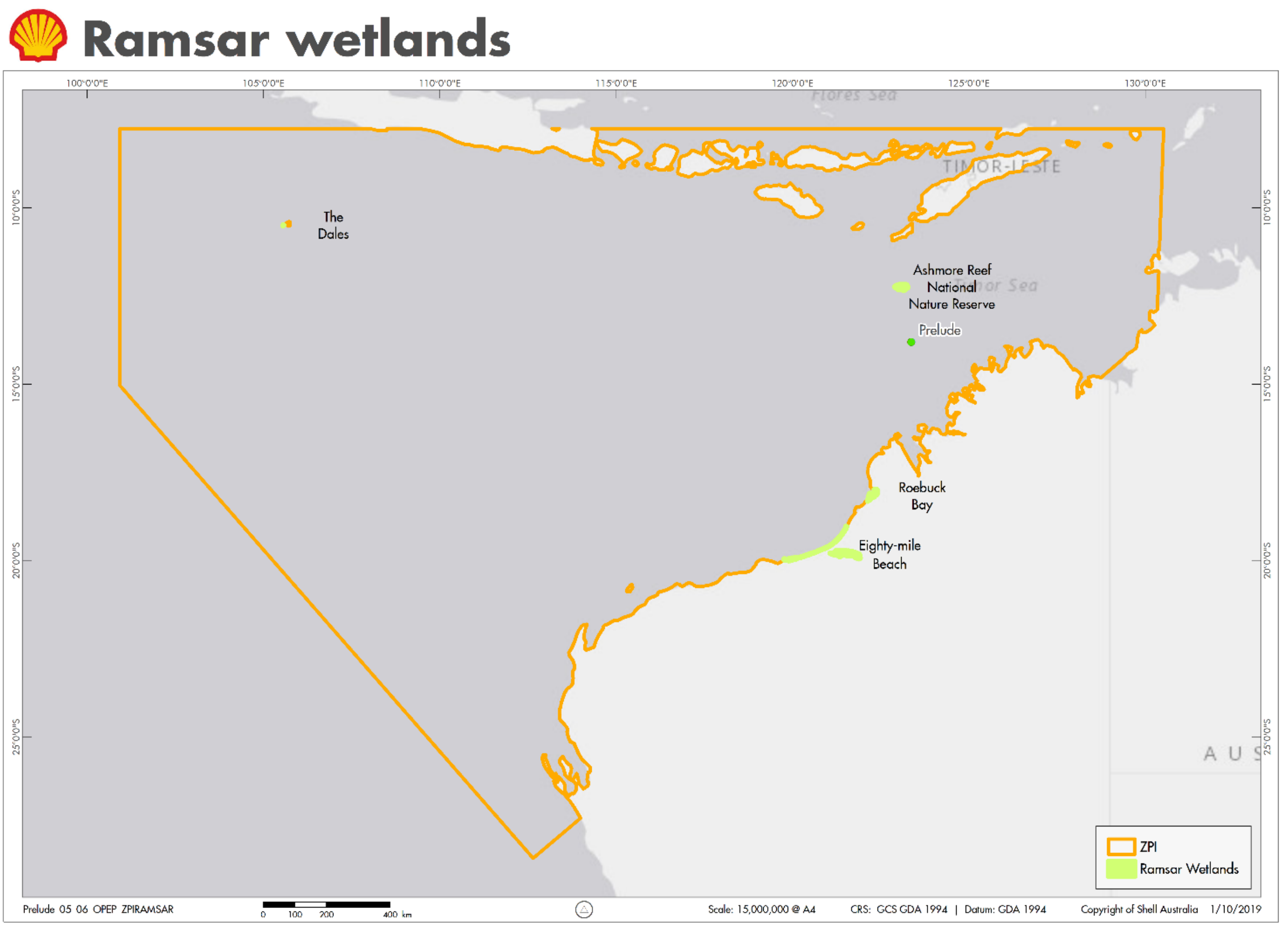


Figure 7-6: Ramsar Wetlands within the ZPI

Table 7-4: Descriptions of Ramsar Wetlands within the ZPI, including distance from Prelude FLNG

Ramsar Wetland	Distance from Prelude (km)	Description
Ashmore reef national nature reserve	162	Ashmore Reef supports an abundance and diversity of birds; 72 species have been recorded at this Ramsar site, with 12 recorded breeding (Hale and Butcher 2013). Ashmore Reef was designated as a Ramsar wetland based on the following characteristics: • Ashmore is the largest of the atolls in the region and has been managed for the purposes of conservation for three decades. • Each of the wetland types is in near natural condition, with low densities of coral predators and disease. • The three islands represent the only vegetated island within the Timor Province bioregion. • It supports 64 threatened species. • It is considered a true 'hotspot' of biological diversity within the Timor Province bioregion and within the broader north-west marine region. • It supports 47 species of waterbird listed as migratory under international treaties and three species of migratory turtle (green, hawksbill and loggerhead). It also supports breeding of green and hawksbill turtles, dugongs and 20 species of waterbird. • It regularly supports over 40,000 waterbirds including large numbers of migratory shorebirds and breeding seabirds (Hale and Butcher 2013). Ashmore Reef is also recognised as a KEF and is within the Ashmore Reef Australian Marine Park (AMP) (refer to 7.2.3).
Roebuck bay	474	The Roebuck Bay Ramsar site is located at Roebuck Bay near Broome in north Western Australia. Roebuck Bay has a very large tidal range which exposes around 160 square kilometres of mudflat, covering most of the Ramsar site. The eastern edge of the site is made up of microscale linear tidal creeks. The intertidal mud and sand flats support a high abundance of bottom dwelling invertebrates, which are a key food source for waterbirds. The site is one of the most important migration stopover areas for shorebirds in Australia and globally. For many shorebirds, Roebuck Bay is the first Australian landfall they reach on the East Asian Australasian Flyway. The total numbers of waders using the site each year is estimated at over 300 000. The northern beaches and Bush Point provide important high tide roost sites.
Eighty-mile beach	610	Eighty-mile Beach Ramsar site, located between Port Hedland and Broome in north Western Australia, is made up of Eighty-mile Beach and, 40 km to the east, Mandora Salt Marsh. Eighty-mile Beach is a 220 km section of coastline and adjacent intertidal mudflats. Eighty-mile Beach is characterised by extensive mudflats supporting an abundance of macroinvertebrates which provide food for large numbers of shorebirds. More than 472,000 migratory waders have been counted on the mudflats during the September to November period.

Ramsar Wetland	Distance from Prelude (km)	Description
		The site is considered to be one of the major arrival and departure areas for migratory shorebirds visiting Australia, particularly on southward migration. It is one of the most important sites in the world for the migration of the Great Knot.
The dales	1,994	The Ramsar site has a near-pristine system of seven watercourses collectively known as The Dales. The Dales includes permanent and perennial streams, permanent springs, and include the majority of surface water on the Island. Most rainfall on Christmas Island filters down through the soil and limestone, and surface runoff only occurs after heavy rain. The Dales contain numerous wetland types including surface and karst features, and inland and coastal wetlands. The Dales support a number of unique ecological and geomorphic features including anchialine cave communities, surface karst including the unique stepped tufa deposits at Hugh's waterfall, a stand of Tahitian chestnuts, a large number of endemic terrestrial species and a significant number of seabirds including Abbott's booby, red-footed booby and the brown booby, all of which breed at the site.

7.2.6 Commonwealth Marine Area

The Operational Area is located within the Commonwealth marine area, which includes any part of the sea, including the waters, seabed and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not state or NT waters. The Commonwealth marine area stretches from three to 200 nm from the coast.

7.2.7 WA Mainland Coastline

The WA mainland coastline lies over 200 km from the Prelude FLNG at the closest point, with several parts of the Kimberley and Pilbara coastlines within the outer edge of the ZPI. These coastlines support a diverse array of coastal and nearshore marine habitats including coral reefs, sandy beaches, rocky shores, seagrass meadows, mangroves, wetlands, estuaries, creeks and rivers. These environments in turn support a number of fauna, including EPBC listed seabirds and migratory shorebirds, turtles, sea snakes, dugongs, cetaceans, fish, sharks and rays (refer to Section 7.2.8).

The WA nearshore and coastal areas provide Indigenous and European heritage value, as well as cultural, social and economic values such as local tourism and recreation (refer to Section 7.3). The nearshore and coastal habitats also support a number of culturally and commercially significant marine fauna species such as marine turtles, dugongs, fish and prawns.

7.2.8 Threatened and Migratory Species

A total of 102 EPBC Act listed species considered to be MNES (46 and 91 listed as threatened or migratory respectively) were identified as potentially occurring within the ZPI, of which a subset of 34 were identified as potentially occurring within the Operational Area (Table 7-5). The full list of marine species identified from the protected matters search is provided in Appendix B: EPBC Act Protected Matters Reports.

Note that a number of MNES that will not credibly be impacted by the petroleum activities considered were identified by the PMST Report for the ZPI (e.g. terrestrial species within the wider ZPI). These PMST report results are an artefact of the method used to generate the area upon which the report is based; this method occasionally overlaps small areas of the terrestrial environment that will not credibly be impacted by the petroleum activity. These have been excluded from further consideration and are not listed in Table 7 3; justifications for these exclusions are provided in Appendix B: EPBC Act Protected Matters Reports.

Table 7-5: EPBC Act listed threatened and migratory fauna potentially occurring within the Operational Area and ZPI identified by the PMST reports that may credibly be impacted by the petroleum activities considered in this EP

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area / ZPI
Mammals				
Balaenoptera borealis	Sei whale	Vulnerable	Migratory	Operational Area
Balaenoptera edeni	Bryde's whale	N/A	Migratory	
Balaenoptera musculus	Blue whale	Endangered	Migratory	
Balaenoptera physalus	Fin whale	Vulnerable	Migratory	
Megaptera novaeangliae	Humpback whale	Vulnerable	Migratory	
Orcinus orca	Killer whale, orca	N/A	Migratory	
Physeter macrocephalus	Sperm whale	N/A	Migratory	
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted bottlenose dolphin (Arafura/Timor Sea populations)	N/A	Migratory	
Balaenoptera bonaerensis	Antarctic Minke Whale, Dark-shoulder Minke Whale	N/A	Migratory	ZPI
Dugong dugong	Dugong	N/A	Migratory	
Eubalaena australis	Southern Right Whale	Endangered	Migratory	
Orcaella heinsohni	Australian snubfin dolphin	N/A	Migratory	
Sousa chinensis (sahulensis)	Indo-Pacific (Australian) humpback dolphin	N/A	Migratory	
Reptiles				
Caretta	Loggerhead turtle	Endangered	Migratory	Operational Area
Chelonia mydas	Green turtle	Vulnerable	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area / ZPI
Dermochelys coriacea	Leatherback turtle, leathery turtle, luth turtle	Endangered	Migratory	
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory	
Lepidochelys olivacea	Olive ridley turtle, pacific ridley turtle	Endangered	Migratory	
Natator depressus	Flatback turtle	Vulnerable	Migratory	
Aipysurus apraefrontalis	Short-nosed seasnake	Critically endangered	N/A	ZPI
Aipysurus foliosquama	Leaf-scaled seasnake	Critically endangered	N/A	
Crocodylus porosus	Salt-water crocodile, estuarine crocodile	N/A	Migratory	
Sharks and Rays				
Anoxypristis cuspidata	Narrow sawfish, knifetooth sawfish	N/A	Migratory	Operational Area
Carcharodon carcharias	White shark, great white shark	Vulnerable	Migratory	
Glyphis garricki	Northern river shark, New Guinea river shark	Endangered	N/A	
Isurus oxyrinchus	Shortfin mako, mako shark	N/A	Migratory	
Isurus paucus	Longfin mako	N/A	Migratory	
Manta birostris	Giant manta ray, chevron manta ray, Pacific manta ray, pelagic manta ray, oceanic manta ray	N/A	Migratory	
Pristis zijsron	Green sawfish, dindagubba, narrowsnout sawfish	Vulnerable	Migratory	
Rhincodon typus	Whale shark	Vulnerable	Migratory	
Carcharias taurus (west coast population)	Grey nurse shark (west coast population)	Vulnerable	N/A	ZPI
Lamna nasus	Porbeagle, Mackerel Shark	N/A	Migratory	
Manta alfredi	Reef manta ray, coastal manta ray, inshore manta ray, Prince Alfred's ray, resident manta ray	N/A	Migratory	
Pristis clavata	Dwarf sawfish, Queensland sawfish	Vulnerable	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area / ZPI
Pristis pristis	Freshwater sawfish, largetooth sawfish, river sawfish, Leichhardt's sawfish, northern sawfish	Vulnerable	Migratory	
Birds				
Actitis hypoleucos	Common sandpiper	N/A	Migratory	Operational Area
Anous stolidus	Common noddy	N/A	Migratory	
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	N/A	
Calidris acuminata	Sharp-tailed sandpiper	N/A	Migratory	
Calidris canutus	Red knot, knot	Endangered	Migratory	
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	
Calidris melanotos	Pectoral sandpiper	N/A	Migratory	
Calonectris leucomelas	Streaked shearwater	N/A	Migratory	
Fregata ariel	Lesser frigatebird, least frigatebird	N/A	Migratory	
Fregata minor	Great frigatebird, greater frigatebird	N/A	Migratory	
Numenius madagascariensis	Eastern curlew, far eastern curlew	Critically endangered	Migratory	
Papasula abbotti	Abbott's booby	Endangered	N/A	
Ardenna carneipes	Flesh-footed shearwater, Fleshy-footed shearwater	N/A	Migratory	ZPI
Ardenna pacifica	Wedge-tailed shearwater	N/A	Migratory	
Arenaria interpres	Ruddy turnstone	N/A	Migratory	
Calidris alba	sanderling	N/A	Migratory	
Calidris ruficollis	Red-necked stint	N/A	Migratory	
Calidris tenuirostris	Great knot	Critically endangered	Migratory	
Charadrius bicinctus	Double-banded plover	N/A	Migratory	
Charadrius leschenaultii	Greater sand plover, large sand plover	Vulnerable	Migratory	
Charadrius mongolus	Lesser sand plover, Mongolian plover	Endangered	Migratory	
Charadrius veredus	Oriental plover, oriental dotterel	N/A	Migratory	

Diomedea amsterdamensis	Amsterdam albatross	Endangered	Migratory	
Diomedea epomophora	Southern royal albatross	Vulnerable	Migratory	
Diomedea exulans	Wandering albatross	Vulnerable	Migratory	
Fregata andrewsi	Christmas Island frigatebird, Andrew's frigatebird	Endangered	Migratory	
Glareola maldivarum	Oriental pratincole	N/A	Migratory	
Hydroprogne caspia	Caspian tern	N/A	Migratory	
Limicola falcinellus	Broad-billed sandpiper	N/A	Migratory	
Limnodromus semipalmatus	Asian dowitcher	N/A	Migratory	
Limosa lapponica	Bar-tailed godwit	N/A	Migratory	
Limosa lapponica baueri	Bar-tailed godwit (baueri), Western Alaskan bar-tailed godwit	Vulnerable	N/A	
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit, bar-tailed godwit (menzbieri)	Critically endangered	N/A	
Limosa limosa	Black-tailed godwit	N/A	Migratory	
Macronectes giganteus	Southern giant-petrel, southern giant petrel	Endangered	Migratory	
Macronectes halli	Northern giant petrel	Vulnerable	Migratory	
Numenius phaeopus	Whimbrel	N/A	Migratory	
Onychoprion anaethetus	Bridled tern	N/A	Migratory	
Pandion haliaetus	Osprey	N/A	Migratory	
Phaethon lepturus	White-tailed tropicbird	N/A	Migratory	
Phaethon lepturus fulvus	Christmas Island white-tailed tropicbird, golden bosunbird	Endangered	N/A	
Phaethon rubricauda	Red-tailed tropicbird	N/A	Migratory	
Philomachus pugnax	Ruff (reeve)	N/A	Migratory	
Pluvialis fulva	Pacific golden plover	N/A	Migratory	
Pluvialis squatarola	Grey plover	N/A	Migratory	
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	N/A	
Rostratula australis	Australian painted-snipe, Australian painted snipe	Endangered	Migratory	

Sterna dougallii	Roseate tern	N/A	Migratory	
Sternula albifrons	Little tern	N/A	Migratory	
Sternula nereis nereis	Australian fairy tern	Vulnerable	N/A	
Sula dactylatra	Masked booby	N/A	Migratory	
Sula leucogaster	Brown booby	N/A	Migratory	
Sula sula	Red-footed booby	N/A	Migratory	
Thalassarche carteri	Indian yellow-nosed albatross	Vulnerable	Migratory	
Thalassarche cauta	Tasmanian shy albatross	Vulnerable	Migratory	
Thalassarche cauta steadi	White-capped albatross	Vulnerable	Migratory	
Thalassarche impavida	Campbell albatross, Campbell black-browed albatross	Vulnerable	Migratory	
Thalassarche melanophris	Black-browed albatross	Vulnerable	Migratory	
Thalassarche steadi	White-capped albatross	Vulnerable	Migratory	
Thalasseus bergii	Crested tern	N/A	Migratory	
Tringa brevipes	Grey-tailed tattler	N/A	Migratory	
Tringa glareola	Wood sandpiper	N/A	Migratory	
Tringa nebularia	Common greenshank, greenshank	N/A	Migratory	
Tringa stagnatilis	Marsh sandpiper, little greenshank	N/A	Migratory	
Tringa totanus	Common redshank, redshank	N/A	Migratory	
Xenus cinereus	Terek sandpiper	N/A	Migratory	

7.2.8.1. Listed Threatened Species Conservation Advice & Species Recovery Plans

The Commonwealth publishes recovery plans and conservation advice for a number of species listed as threatened under the EPBC Act. These documents are intended to assist in preventing the decline, and enhance the recovery, of threatened species. The requirements of the species recovery plans and conservation advice (Table 7-6) for threatened species identified within the ZPI were considered to identify any aspects that may be applicable to the impact and risk assessment (Section 9.3 to Section 9.14).

Table 7-6: Conservation advice for EPBC Act listed threatened species identified within the ZPI considered during environmental risk assessment

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
All Vertebrate Fauna			
All vertebrate fauna	Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia 2018)	Marine debris	No explicit management actions for non-fisheries related industries (note that management actions in the plan relate largely to management of fishing waste (e.g. "ghost" gear), and state and Commonwealth management through regulation.
Mammals			
Sei whale	Approved conservation advice *Balaenoptera borealis* (sei whale) (Threatened Species Scientific Committee 2015a)	Noise interference	Assess and manage acoustic disturbance
		Vessel disturbance	Assess and manage physical disturbance and development activities
Blue whale	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (Commonwealth of Australia 2015a)	Noise interference	Assessing and addressing anthropogenic noise
		Vessel disturbance	Minimising vessel collisions
Fin whale	Approved conservation advice for *Balaenoptera physalus* (fin whale) (Threatened Species Scientific Committee 2015b)	Noise interference	Assessing and addressing anthropogenic noise
		Vessel disturbance	Minimising vessel collisions
Humpback whale	Approved conservation advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee 2015c)	Noise interference	For actions involving acoustic impacts (example pile driving, explosives) on humpback whale calving, resting, feeding areas, or confined migratory pathways site specific acoustic modelling should be undertaken (including cumulative noise impacts)
		Vessel disturbance	Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike
Southern right whale	Conservation management plan for the southern right whale: a recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* 2011-2021 (DSEWPaC 2012c)	Vessel disturbance	Addressing vessel collisions
		Noise interference	Assessing and addressing anthropogenic noise
Reptiles			
		Light pollution	Minimise light pollution

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
Loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle, flatback turtle, olive ridley turtle	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017)	Chemical and terrestrial discharge (oil pollution)	Ensure that spill risk strategies and response programs include management for turtles and their habitats
		Vessel disturbance	Vessel interactions identified as a threat; no specific management actions in relation to vessels prescribed in the plan
		Noise interference	No explicit relevant management actions; noise interference identified as a threat
Leatherback turtle	Approved conservation advice for *Dermochelys coriacea* (Leatherback Turtle) (Threatened Species Scientific Committee 2008a)	Vessel disturbance	No explicit relevant management actions; vessel strikes identified as a threat
Short-nosed seasnake	Approved conservation advice for *Aipysurus apraefrontalis* (short-nosed sea snake) (Threatened Species Scientific Committee 2010a)	No additional threats identified (ex. marine debris)	None applicable
Leaf-scaled seasnake	Approved conservation advice for *Aipysurus foliosquama* (leaf-scaled sea snake) (Threatened Species Scientific Committee 2010b)	No additional threats identified (ex. marine debris)	None applicable
Sharks and Rays			
White shark	Recovery plan for the white shark (*Carcharodon carcharias*) (DSEWPaC 2013)	No additional threats identified (ex. marine debris)	None applicable
Northern river shark	Approved conservation advice for *Glyphis garricki* (northern river shark) (Threatened Species Scientific Committee 2014a)	Habitat degradation / modification	Implement measures to reduce adverse impacts of habitat degradation and/or modification
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks
Green sawfish	Approved conservation advice for green sawfish (Threatened Species Scientific Committee 2008b)	Habitat degradation / modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks
Whale shark	Approved conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee 2015d)	Vessel disturbance	Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations and along the northward migration route that follows the

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
			northern Western Australian coastline along the 200 m isobath
Grey nurse shark (west coast population)	Recovery plan for the grey nurse shark (*Carcharias taurus*) (Department of the Environment 2014)	No additional threats identified (ex. marine debris)	None applicable
Dwarf sawfish	Approved conservation advice for *Pristis clavata* (dwarf sawfish) (Threatened Species Scientific Committee 2009)	Habitat degradation / modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks
Freshwater sawfish	Approved conservation advice for *Pristis pristis* (largetooth sawfish) (Threatened Species Scientific Committee 2014b)	Habitat degradation / modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks
Birds			
Migratory shorebird species[4]	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia 2015c)	Habitat degradation / modification	Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment processes
Albatrosses and giant petrels[5]	National recovery plan for threatened albatrosses and giant petrels (DSEWPaC 2011)	Marine pollution	No explicit relevant management actions; pollution identified as a threat
Australian lesser noddy	Approved Conservation Advice for *Anous tenuirostris melanops* (Australian lesser noddy) (Threatened Species Scientific Committee 2015e)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Red knot, knot	Approved Conservation Advice for *Calidris canutus* (Red knot) (Threatened Species Scientific Committee 2016a)	Pollution / contamination	No explicit relevant management actions; pollution identified as a threat

[4] Red knot, great knot, greater sand plover, lesser sand plover and bar-tailed godwit.

[5] Several albatrosses and giant petrels were identified as potentially occurring: Amsterdam albatross, southern royal albatross, wandering albatross, southern giant-petrel, northern giant petrel, soft-plumaged petrel, Indian yellow-nosed albatross, Tasmanian shy albatross, white-capped albatross, Campbell albatross, black-browed albatross, white-capped albatross.

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
Curlew sandpiper	Conservation advice *Calidris ferruginea* curlew sandpiper (Threatened Species Scientific Committee 2015f)	Pollution / contamination	No explicit relevant management actions; pollution identified as a threat
Eastern curlew	Conservation advice *Numenius madagascariensis* eastern curlew (Threatened Species Scientific Committee 2015g)	Pollution / contamination	No explicit relevant management actions; pollution identified as a threat
Abbott's booby	Approved Conservation Advice for *Papasula abbotti* (Abbott's booby) (Threatened Species Scientific Committee 2015h)	No threats identified	None applicable
Great knot	Conservation advice *Calidris tenuirostris* great knot (Threatened Species Scientific Committee 2016b)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Greater sand plover	Approved Conservation Advice for *Charadrius leschenaultii* (Greater sand plover) (Threatened Species Scientific Committee 2016c)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Lesser sand plover	Approved Conservation Advice for *Charadrius mongolus* (Lesser sand plover) (Threatened Species Scientific Committee 2016d)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Soft-plumaged petrel	Conservation advice *Pterodroma mollis* soft-plumage petrel (Threatened Species Scientific Committee 2015i)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Bar-tailed godwit (baueri)	Approved Conservation Advice for *Limosa lapponica baueri* (Bar-tailed godwit (western Alaskan) (Threatened Species Scientific Committee 2016e)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Australian painted snipe	Approved Conservation Advice on *Rostratula australis* (Australian Painted Snipe) (Threatened Species Scientific Committee 2013)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat

7.2.8.2 Biologically Important Areas & Habitat Critical for the Survival of a Species

The Department of the Environment and Energy (now the Department of Agriculture, Water and the Environment) have established a series of Biologically Important Areas (BIAs) for regionally significant marine species (which are typically listed as threatened under the EPBC Act). BIAs identify areas where biologically significant behaviours may occur, such as nesting, breeding, migrating, foraging or resting. The collection of BIAs were developed by the DAWE during the development of bioregional plans utilising a range of data, such as expert advice and published literature. BIAs are intended to assist decision-making under the EPBC Act.

Habitats critical for the survival of several species of marine turtles were identified in the *Recovery Plan for Marine Turtles in Australia 2017-2027* (Commonwealth of Australia 2017). Like BIAs, these critical habitats identify areas where biologically significant behaviours may occur. Unlike BIAs, habitats critical for the survival of a species receive specific protection under the EPBC Act. While BIAs do not receive specific protection under the EPBC Act, the threatened and migratory species associated with them are MNES and are protected under the EPBC Act.

A review of the Conservation Values Atlas identified that there are no BIAs or critical habitats within the Operational Area. A number of BIAs and critical habitats occur within the ZPI. These BIAs and critical habitats are summarised in Table 7-7. Refer to the species-specific discussions in Sections 7.2.8.4 Marine Mammals, 7.2.8.5 Reptiles, 7.2.8.6 Sharks and Rays, and 7.2.8.7 Birds for further information.

Table 7-7: BIAs and Critical Habitats(*) within the ZPI nearest to Prelude

Common Name	BIA Behaviour	Distance from Prelude (km)
Marine Mammals		
Blue and pygmy blue whales	Migration	78
	Foraging	132
Humpback whale	Migration	145
	Calving	145
	Resting	145
	Nursing	145
	Migration (north and south)	327
Dugong	Foraging (high density seagrass beds)	168
	Foraging	176
	Calving	176
	Breeding	176
	Nursing	176
Australian snubfin dolphin	Foraging	187
	Breeding	190
	Foraging (high density prey)	190
	Calving	190
	Resting	190
Indo-Pacific humpback dolphin	Foraging	190
	Calving	190
	Breeding	190
	Foraging (high density prey)	190
	Significant habitat - unknown behaviour	247
	Calving	190

Common Name	BIA Behaviour	Distance from Prelude (km)
Indo-Pacific/spotted bottlenose dolphin	Foraging	190
	Breeding	239
Reptiles		
Flatback turtle	Inter-nesting buffer	268
	Foraging	344
	Nesting*	302
	Inter-nesting	356
	Mating	1,005
	Migration corridor	1,005
	Aggregation	1,114
Green turtle	Nesting*	43
	Foraging and inter-nesting buffer	23
	Inter-nesting buffer	121
	Inter-nesting	169
	Mating	174
	Migration corridor	1,005
	Aggregation	1,114
	Basking	1,130
Hawksbill turtle	Foraging	141
	Inter-nesting buffer	150
	Nesting	169
	Nesting*	971
	Mating	1,005
	Migration corridor	1,005
	Inter-nesting	1,005
Loggerhead turtle	Foraging	344
	Inter-nesting buffer	986
	Nesting	1,008
	Nesting*	1,285
	Inter-nesting	1,688
Olive ridley turtle	Nesting – critical habitat*	177
	Foraging	344
Sharks and Rays		
Whale shark	Foraging	33
	Foraging (high prey density)	1,329
Dwarf sawfish	Foraging	203
	Nursing	416

Common Name	BIA Behaviour	Distance from Prelude (km)
Freshwater sawfish	Pupping	416
	Foraging	416
	Nursing	433
Green sawfish	Foraging	203
	Pupping	454
	Nursing	769
Birds		
Red-footed booby	Breeding	59
Greater frigatebird	Breeding	59
Lesser frigatebird	Breeding	60
Wedge-tailed shearwater	Breeding	61
	Foraging (in high numbers)	1,747
White-tailed tropicbird	Breeding	68
Brown booby	Breeding	118
Lesser crested tern	Breeding	141
Little tern	Resting	142
	Breeding	245
Roseate tern	Breeding	142
	Resting	571
Fairy tern	Breeding	991
Bridled tern	Foraging (in high numbers)	1,747
Sooty tern	Foraging	1,772
Little shearwater	Foraging (in high numbers)	1,826
White-faced storm petrel	Foraging (in high numbers)	1,837

7.2.8.3 Seasonal Sensitivities of Threatened Species

Periods of the year coinciding with key environmental sensitivities for the Operational Area and the wider regional context (ZPI), including EPBC Act listed threatened and/or migratory species potentially occurring within the Operational Area are presented in Table 7-8. These relate to breeding, foraging or migration of the indicated fauna.

Table 7-8: Key environmental sensitivities and indicative timings for migratory fauna within the Operational Area and ZPI (North-west Marine Region)

Species	January	February	March	April	May	June	July	August	September	October	November	December
Mammals												
Blue whale[1,2]												
Humpback whale[3,4]												
Reptiles												
Loggerhead turtle[5]	H	H	H							N	N	H
Green turtle[6,7]	N,H	N,H	H	H	H							N
Hawksbill turtle[8]	N,H	H	H							N	N	N,H
Olive ridley turtle[9]												
Flatback turtle[10]	N					N	N	N	N	N	N	N
Birds												
Migratory shorebirds[11]												

	Species likely to be present
	Peak period. presence of animals reliable and predictable each year
N	Peak Turtle Species Nesting
H	Peak Turtle Species Hatching
1 - Commonwealth of Australia (2015a), 2 - Double et al. (2014), 3 - Jenner and Jenner (2001), 4 - Double et al. (2012a), 5 - Limpus (2008a), 6 - Limpus (2008b), 7 - Guinea (2010), 8 - Limpus (2009a), 9 - Limpus (2008c), 10 - Limpus (2007), 11 - Rogers et al. (2011)	

7.2.8.4 Marine Mammals

Sei Whale

Sei whales (*Balaenoptera borealis*) have a global distribution. Though sightings are uncommon, the species may be seen in coastal and offshore waters throughout Australia, as well as the waters surrounding Christmas and Cocos Keeling Islands (Bannister et al. 1996, DoEE 2019). The species utilises a range of marine habitats, which has been attributed to a combination of dynamic physical and prey processes (DoEE 2019).

Sei whale migratory movements are well defined (distinctly north-south) with the species moving between polar, temperate and tropical waters for foraging and breeding. The species feeds intensively between the Antarctic and sub-Antarctic boundary on planktonic crustaceans (Bannister et al. 1996, DoEE 2019). The species does not dive, rather it sinks, and tends to swim at shallower depths comparative to other species (DoEE 2019).

There are no mating or calving areas in Australian waters, nor are there any recognised BIAs or critical habitat. Sei whales may occur within the Operational Area and ZPI, but are expected to occur only in low numbers.

Bryde's Whale

The Bryde's whale was identified as potentially occurring within the Operational Area and ZPI. The Bryde's whale occurs in tropical and temperate waters (Bannister et al. 1996). Bryde's whales occur in both oceanic and inshore waters with the only key localities recognised in Western Australia being in the Abrolhos Islands and north of Shark Bay (Bannister et al. 1996). Two forms are recognised: inshore and offshore Bryde's whales. It appears that the offshore form may migrate seasonally, heading towards warmer tropical waters during the winter, however, behaviour of the offshore form in the Indian Ocean is not well documented.

Bryde's whales may occur through a broad area of the continental shelf in the region, including the Operational Area and the ZPI. The noise monitoring study undertaken for the Barossa project detected Bryde's whales in the Timor Sea almost year-round (January to October) (McPherson et al. 2016). Bryde's whales have also been detected on the North West Shelf (south-west of the Operational Area) from mid-December to mid-June, peaking in late February to mid-April (RPS Environment and Planning 2012).

Bryde's whale may be encountered within the Operational Area and ZPI year-round in low numbers, particularly in oceanic and continental slope waters.

Blue Whale

There are two recognised subspecies of blue whale in the Southern Hemisphere, both of which are recorded in Australian waters. These are the southern (or 'true') blue whale (*Balaenoptera musculus*) and the 'pygmy' blue whale (*Balaenoptera musculus brevicauda)* (Commonwealth of Australia 2015a). Both are listed as Endangered under the EPBC Act. In general, southern blue whales occur in waters south of 60 °S and pygmy blue whales occur in waters north of 55 °S (i.e. not in the Antarctic) (Department of the Environment and Heritage 2005). On this basis, nearly all blue whales sighted are likely to be pygmy blue whales. The *Conservation Management Plan for the Blue Whale* (Commonwealth of Australia 2015a) has delineated the distribution area of blue whales in Australian waters and identified a number of BIAs for blue whales for Commonwealth waters (migratory corridor and foraging areas) (Table 7-8).

Recent tagging studies (Double et al. 2014) indicate the general migration pattern, timing and key areas for pygmy blue whales in Commonwealth waters are the Perth Canyon/Naturaliste Plateau and Ningaloo Reef/North West Cape (beyond the ZPI). Satellite tagging of pygmy blue whales off the Perth Canyon confirmed the general distribution of migrating pygmy blue whales was offshore in water depths over 200 m and commonly over 1,000 m (Double et al. 2012b). These data showed that whales tagged during March and April migrated northwards post tag deployment. The tagged whales travelled relatively near to the Australian coastline (100 ± 2 km) until reaching North West Cape after which they travelled offshore (238 ± 14 km). Whales reached the northern terminus of their migration and potential breeding grounds in Indonesian waters by June (Double et al. 2014). The southbound migration is thought to terminate in the Southern Ocean, where the species feeds.

No pygmy blue whale BIAs overlap the Operational Area; two BIAs were identified within the ZPI (Table 7-8). These are:

- A broad migration corridor along the coast of Western Australia, approximately 78 km west of the Prelude FLNG facility; and
- A potential foraging area around Scott Reef, approximately 132 km west of the Prelude FLNG facility.

Based on these tagging studies and the locations of the BIAs relative to the Operational Area, pygmy blue whales are unlikely to occur in the Operational Area due to their preference for deeper waters, but are expected to be seasonally present within the ZPI.

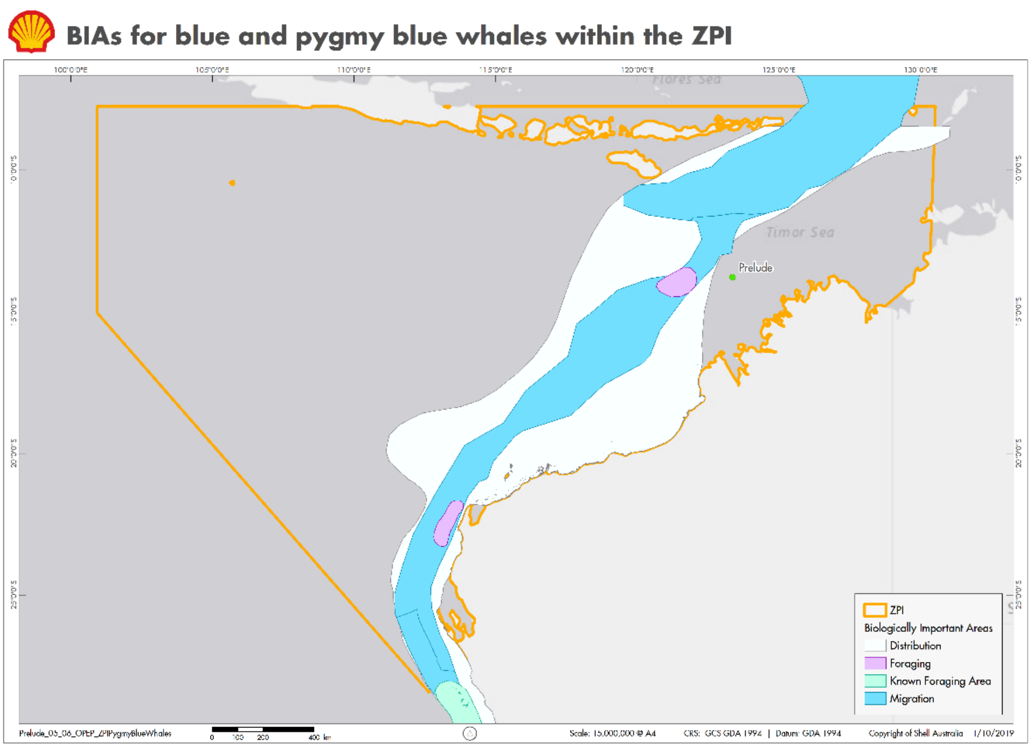


Figure 7-7: BIAs for blue and pygmy blue whales within the ZPI

Fin Whale

Fin whales (*Balaenoptera physalus*) are widely distributed from polar to tropical waters and have been recorded in all Australian states, other than New South Wales and the Northern Territory (Bannister et al. 1996). The species is listed as Vulnerable under the EPBC Act.

Fin whales are rarely observed in inshore waters and displays migratory movements (essentially north-south) between polar, temperate and tropical waters (Bannister et al. 1996). Migration within Australian waters does not appear to follow a clear route and is thought to occur in summer and autumn. Breeding in the Southern hemisphere occurs in tropical and sub-tropical latitudes between May and July.

Fin whales feed on planktonic crustacea, such as Antarctic krill, and primarily forage in high latitudes (Bannister et al. 1996). Within Australian waters, Antarctic waters and the Bonney Upwelling are thought to be important foraging grounds for this species.

There are no recognised BIAs or critical habitats for fin whales within the Operational Area or the ZPI. The species may occur within the Operational Area or ZPI, but is not expected to be particularly abundant.

Humpback Whales

The humpback whale (*Megaptera novaeangliae*) has a wide distribution, with recordings throughout Australian Antarctic waters and offshore from all Australian states (Bannister et al. 1996). Humpback whales are listed as Vulnerable under the EPBC Act.

Humpback whales migrate between summer feeding grounds in Antarctica and winter breeding and calving grounds in the sub-tropical and tropical inshore waters of north-west Australia (Jenner et al. 2001). Humpback whales breed and calve in continental shelf waters off northern Western Australia, with the area between Broome and the northern end of Camden Sound hosting large numbers of humpback whales from June to September each year (Double et al. 2012a, 2010). Camden Sound is considered to be the northern limit of most migrating humpback whales; hence the species is unlikely to occur within the Operational Area but will be seasonally present within the ZPI.

Within the wider ZPI, a BIA area has been identified for the humpback whale. The behaviour of the humpback whale within this BIA, located approximately 145 km south of the Operational Area is resting, calving, migrating and nursing (Figure 7-8).

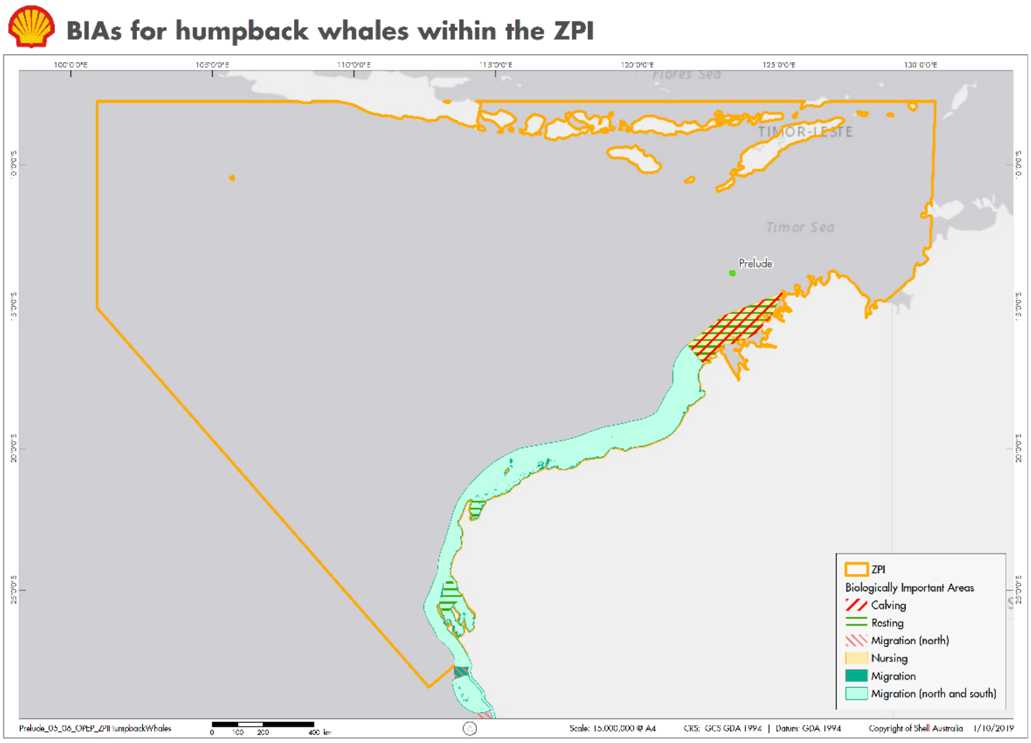


Figure 7-8: BIAs for humpback whales within the ZPI

Killer Whale

Killer whales (*Orcinus orca*) have a global distribution and utilise a wide range of habitats. However, they appear to be primarily concentrated in temperate coastal waters and cooler regions of high productivity (Bannister et al. 1996).

This species is distributed throughout Australian waters, in particular in Tasmanian waters and the waters surrounding Macquarie Island (1,500 km south-south-east of Tasmania) (Bannister et al. 1996). Off Australia, the species is typically observed moving along the continental slope and shelf, and near seal colonies (Bannister et al. 1996). There are no key localities identified within continental Australian waters for this species. Killer whales are carnivores and their diet varies seasonally and regionally (Bannister et al. 1996).

Globally killer whales are known to migrate; however, specific routes and seasonal movement patterns are not known in detail and are thought to relate to prey availability (Bannister et al. 1996). Mating occurs year-round and there are no known calving areas in Australian waters (Bannister et al. 1996).

Based on their known distribution and movements, killer whales may be encountered in within the Operational Area and ZPI in low numbers.

Sperm Whale

Sperm whales (*Physeter microcephalus)* occur in deep waters in all oceans, typically remaining at depths of 200 m or greater, and are known to occur throughout Australian waters (Bannister et al. 1996). Key areas for sperm whales occur in continental shelf waters approximately 20 nautical miles (nm) to 30 nm offshore between Cape Leeuwin and Esperance (Bannister et al. 1996), several thousand kilometres from the ZPI.

Sperm whales have a diverse diet, although they primarily feed on oceanic squid (Bannister et al. 1996). Migration patterns vary between sex. Mature females and juveniles are thought to be resident in tropical and subtropical waters throughout the year, whereas mature males are thought to migrate between the tropics and Antarctic (Bannister et al. 1996).

Considering the known distribution of the species, sperm whales may transit through the Operational Area and ZPI in low numbers.

Spotted Bottlenose Dolphin

The spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*) occurs primarily in continental shelf waters (< 200 m deep), nearshore and in areas with rocky or coral reefs, sandy or soft sediments, or seagrass beds (DSEWPaC 2012d). Small populations also occur in the inshore waters of some oceanic and continental shelf islands, such as the Rowley Shoals and Scott Reef (DSEWPaC 2012d). No BIAs occur within the Operational Area. Several BIAs occur within the ZPI (primarily within the Lalang-garram / Camden Sound Marine Park), including foraging and calving (190 km south of Prelude) and breeding (239 km south of Prelude).

Migration patterns for the species in Australia are variable, including of year-round residency in small areas, long-range movements and migration. Due to their tendency to shallow water areas it is unlikely that the species will occur in the Operational Area, but is likely to occur in coastal waters in the ZPI.

Antarctic Minke Whale

The Antarctic minke whale is distributed worldwide and has been recorded off all Australian states, feeding in cold waters and migrating to warmer waters to breed. It is not expected to occur in the Operational Area, but may occur within the ZPI. It is thought that the Antarctic minke whale migrates up the WA coast to approximately 20°S to feed and possibly breed (Bannister et al. 1996); however, detailed information on timing and location of migrations and breeding grounds is not well known. No critical habitats or BIAs for Antarctic minke whales occur within the Operational Area or ZPI.

Given the wide distribution of Antarctic minke whale, the ZPI is unlikely to represent an important habitat for this species. Antarctic minke whales are not expected to occur within the Operational Area or ZPI in large numbers.

Dugong

Dugongs (*Dugong dugong*) occur in tropical and sub-tropical coastal and island waters broadly coincident with the distribution of seagrasses (Marsh et al. 2002), which typically occur in shallow intertidal zone areas to water depths of around 25 m. Dugong feeding aggregations tend to occur in large seagrass meadows within wide shallow protected bays, shallow mangrove channels and in the lee of large inshore islands. The movements of most individuals are limited to within tens of kilometres within the vicinity of seagrass beds (Marsh et al. 2002). However, some individuals have been observed to travel large distances of up to 600 km over a few days (Marsh et al. 2002).

Dugongs and areas of potential dugong habitat exist along the majority of northern Australian coastline from Shark Bay in Western Australia to Moreton Bay in Queensland. A small population of approximately 50 individuals exists at Ashmore Reef, which is considered to be genetically distinct from other nearby Australian or Indonesian populations (Commonwealth of Australia 2002).

Several BIA's for dugong overlap the ZPI, the nearest of which is the foraging (high density seagrass beds BIA around Cartier Island approximately 168 km north of the

Prelude FLNG facility. Other BIAs for foraging, breeding, calving and nursing occur within the ZPI around Ashmore Reef and the Dampier Peninsula.

Considering the habitat preference of the species, dugongs are very unlikely to occur within the Operational Area but are expected to occur in coastal waters and around islands in the ZPI.

Southern Right Whale

The southern right whale occurs primarily in waters between approximately 20° and 60°S and moves from high latitude feeding grounds in summer to warmer, low latitude, coastal locations in winter (Bannister et al. 1999). These latitudes are far to the south of the Operational Area, which is at approximately 13.7°S. Southern right whales aggregate in calving areas along the south coast of Western Australia, such as Doubtful Island Bay, east of Israelite Bay and to a lesser extent Twilight Cove (DSEWPaC 2012b). During the calving season, between May and November, female southern right whales that are either pregnant or with calf can be present in shallow protected waters along the entire southern Western Australian coast and west up to approximately Two Rocks, north of Perth. Sightings in more northern waters are relatively rare; however, they have been recorded as far north as Exmouth (Bannister et al. 1996). There are no southern right whale BIAs within the Operational Area or ZPI.

Given the species prefers temperate waters and has rarely been recorded north of Exmouth, southern right whales will not occur in the Operational Area and are very unlikely to occur in the ZPI.

Australian Snubfin Dolphin

The Australian snubfin dolphin (*Orcaella heinsohni*, also known as the Irrawaddy dolphin, *O. brevirostris*) shares similar habitat preferences with the Indo-Pacific humpback dolphin, occurring in shallow coastal and estuarine waters (typically less than 20 m deep) (DSEWPaC 2012d). However, as with the Indo-pacific humpback dolphin, the species has also been recorded up to 23 km offshore. In Australia, the species distribution covers the coastal waters of Queensland, the Northern Territory and northern Western Australia. The population in Australian waters is thought to be continuous with the Papua New Guinea species but separate from populations in Asia.

This species is not expected to occur within the Operational Area due to its preference for coastal habitats, but may be present in coastal areas of the ZPI. No BIAs occur within the Operational Area. Several BIAs occur within the ZPI (primarily within the Lalang-garram / Camden Sound Marine Park), including foraging, breeding, resting and calving (190 km south of Prelude).

Indo-Pacific (Australia) Humpback Dolphin

The Indo-Pacific humpback dolphin has been recognised as two distinct species; the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Australian humpback dolphin (*S. sahulensis*) (Jefferson and Rosenbaum 2014). Only the Australian humpback dolphin is considered here. Humpback dolphins inhabit shallow coastal, estuarine habitats in tropical and subtropical regions generally in depths of less than 20 m (Corkeron et al. 1997, Jefferson 2000, Jefferson and Rosenbaum 2014).

The Australian humpback dolphin (*Sousa sahulensis*) occurs along the northern Australian coastline from Exmouth in Western Australia to the Queensland/New South Wales border (Bannister et al. 1996). The species' preferred habitat is shallow (generally < 20 m in depth) coastal, estuarine and riverine (occasional) waters.

However, individuals have been observed in shallow waters up to 55 km offshore (Bannister et al. 1996).

Given the species' preferred habitat is relatively shallow coastal waters, Australian humpback dolphins are very unlikely to occur in the Operational Area, but may be present in coastal areas of the ZPI. There are several BIAs within the ZPI along the Kimberley coast, including foraging, breeding, calving and resting, the closest of which is approximately 190 km from the Prelude FLNG facility.

7.2.8.5 Reptiles

Loggerhead Turtle

The loggerhead turtle (*Caretta caretta*) is distributed throughout tropical and sub-tropical and temperate waters in all ocean basis. In Australia, the species ranges along most of the coastline, but is rare in temperate waters (Commonwealth of Australia 2017). Nesting in Australia is concentrated in southern Queensland and from Shark Bay to the North West Cape in Western Australia. Foraging areas are more widely distributed with the Western Australian stock foraging from Shark Bay through to Arnhem Land, Gove and into the Java Sea of Indonesia (Limpus 2008a). Loggerhead turtles are carnivorous and mainly feed on benthic invertebrates in a wide range of habitats ranging from nearshore to 55 m in depth (Commonwealth of Australia 2017).

Loggerhead turtles may occur within the Operational Area and the ZPI. A foraging BIA for the loggerhead turtle lies within the ZPI approximately 344 km east from the Prelude FLNG facility. The nearest critical habitat for loggerhead turtles defined by the Recovery plan for marine turtles in Australia 2017-2027 (Commonwealth of Australia 2017) is the nesting habitat around North West Cape, approximately 1,285 km south-west from Prelude.

Green Turtle

The green turtle (*Chelonia mydas*) is distributed in tropical and sub-tropical waters in the Pacific, Atlantic and Indian oceans. Within Australian waters, the species is predominately found off the Western Australia, Northern Territory and Queensland coastlines (Commonwealth of Australia 2017). The population at Ashmore Reef and Cartier Island is thought to nest year-round, with a peak in nesting during December and January; hatchling emergence is thought to be highest during May (Limpus 2008b).

The species is primarily herbivorous and forages on algae, seagrass and mangroves, including where these habitats exist at offshore coral reef habitats (Commonwealth of Australia 2017). Tagging studies have shown that green turtles can move considerable distances between nesting, with movements of 100's to 1,000's of kilometres recorded (Limpus 2008b).

No BIAs or habitats critical for the survival of green turtles overlap the Operational Area. The nearest habitat critical for the survival of green turtles is the nesting habitat around Browse Island; this habitat lies approximately 23 km south-east of the Prelude FLNG facility at the closest point. Other critical nesting habitat within the ZPI is distributed around offshore islands in the Timor Sea and along the Kimberley coast (Figure 7-9). There are also a number of BIAs for green turtles within the ZPI, none of which overlap the Operational Area:

- Foraging and inter-nesting buffer (23 km south-east of Prelude)
- Inter-nesting buffer (121 km north of Prelude)

- Nesting (141 km north of Prelude FLNG facility)
- Inter-nesting (169 km west of Prelude FLNG facility)
- Mating (174 km north of Prelude FLNG facility).

Green turtles may occur throughout the Operational Area, but would only be expected to occur in low numbers due to the absence of foraging or nesting habitat. Green turtles may be present throughout the ZPI, and are likely to be more abundant around nesting beaches and shallow foraging habitats.

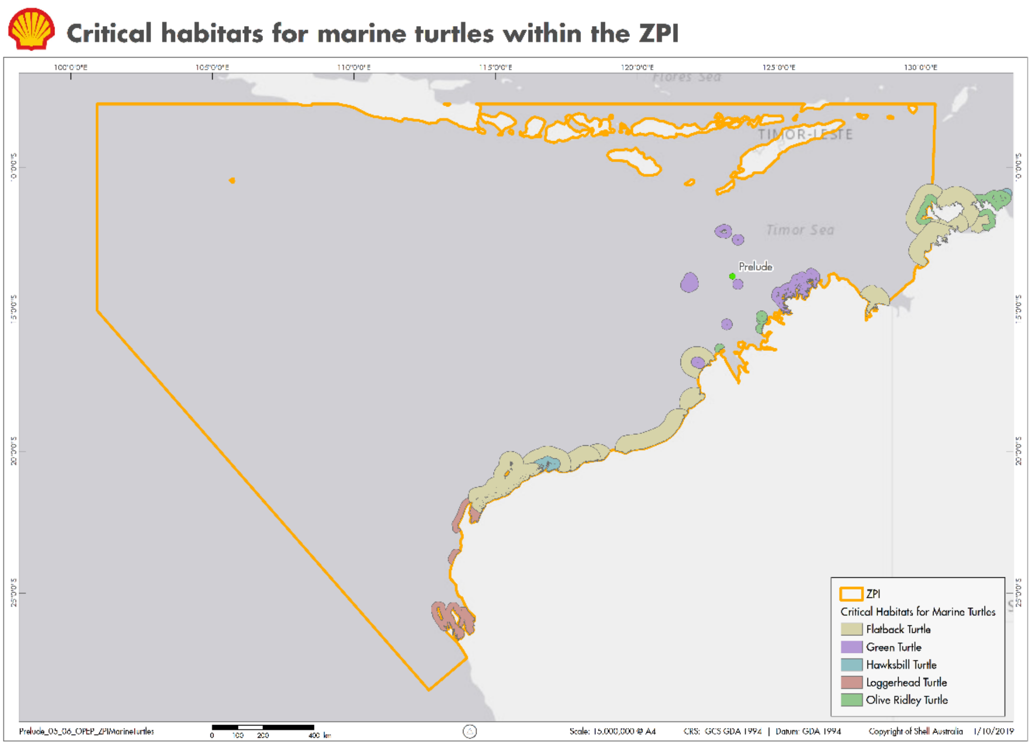


Figure 7-9: Critical habitats for marine turtles within the ZPI

Leatherback Turtle

The leatherback turtle (*Dermochelys coriacea*) is distributed in tropical and temperate oceans worldwide. The species is known to forage and migrate throughout the open offshore waters of Australia, with a distribution that extends further south into temperate waters than other marine turtle species (Limpus 2009b). Records of leatherback turtle nesting in Australia are sparse and limited to the Cobourg Peninsula and Queensland coast (Limpus 2009b). There have been no confirmed accounts of nesting on beaches along Western Australia’s coastline. Leatherback turtles eat almost exclusively jellyfish and are pelagic throughout their life in oceanic waters around Australia (Limpus 2009b).

There are no BIAs or habitats critical for the survival of leatherback turtles within the Operational Area and ZPI. Leatherback turtles may occur within the Operational Area and ZPI in low numbers throughout the year.

Hawksbill Turtle

The hawksbill turtle (*Eretmochelys imbricata*) has a worldwide distribution in tropical and sub-tropical waters. In Australia, hawksbill turtles predominately occur along the northern Western Australia, Northern Territory and northern Queensland coastlines (Limpus 2009a).

This species is typically associated with rocky and coral reef habitats and is expected to be found foraging within these habitats along the Western Australian coastline, from Shark Bay to the northern extent of the North West Marine Region (Commonwealth of Australia 2017a). Hawksbill turtles are omnivorous and feed on algae, sponges, soft corals and soft bodied-invertebrates.

The population in Western Australia is thought to nest primarily between October and January, while there is evidence of year-round breeding and nesting in the Northern Territory and northern Queensland stocks (Limpus 2009a).

There are no habitats critical for the survival of hawksbill turtles within the Operational Area or the ZPI. There are a number of BIAs for hawksbill turtles within the ZPI:

- Foraging (141 km north of Prelude FLNG facility)
- Inter-nesting buffer (150 km west of Prelude FLNG facility)
- Nesting (169 km west of Prelude FLNG facility).

Hawksbill turtles may occur throughout the Operational Area, but would only be expected to occur in low numbers due to the absence of foraging or nesting habitat. Hawksbill turtles may be present throughout the ZPI, and are likely to be more abundant around nesting beaches and shallow foraging habitats.

Olive Ridley Turtle

The olive ridley turtle (*Lepidochelys olivacea*) has worldwide tropical and sub-tropical distribution. In Australia, the species primarily occurs primary in the Northern Territory and Queensland; the component of the Australian population in Western Australian waters is relatively small (Limpus 2008c).

The olive ridley turtle is primarily carnivorous and feed predominantly on soft-bodied invertebrates (Commonwealth of Australia 2017). The species is known to feed in water depths between 15 m and 200 m, and may make movements > 1,000 km between their nesting and foraging grounds (Whiting et al. 2007).

Nesting is known to occur in the Northern Territory and on western Cape York (Queensland) (Commonwealth of Australia 2017, Limpus 2008c); low density nesting has also been described on the Kimberley coast (Limpus 2008c).

No BIAs or habitats critical for the survival of the olive ridley turtle occur within the Operational Area. Nesting habitat critical for the survival of the olive ridley turtle does occur within the ZPI (Figure 7-9), centred on several islands along the Kimberley coastline, the nearest of which is approximately 177 km south of Prelude. The nearest olive ridley BIA to the Prelude FLNG facility is a foraging BIA, which lies approximately 344 km to the east.

Olive ridley turtles may occur within the Operational Area and the ZPI, but are only expected to be present in low numbers.

Flatback Turtle

The flatback turtle (*Natator depressus*) is known to occur along the Western Australia, Northern Territory and Queensland coastlines, and forages widely across the Australian continental shelf and into the continental waters off Indonesia and Papua New Guinea (Commonwealth of Australia 2017). Unlike other species of marine turtle, the flatback turtle does not have a global tropical distribution, with all recorded nesting beaches within Australian waters (Limpus 2007).

Flatback turtles nest throughout tropical Australia, although there are several distinct populations (Limpus 2007). The northerly populations in Queensland and the Northern Territory nest year-round with a peak during winter months. Populations at higher latitudes off central Queensland and Western Australia's Pilbara coast tend to have a nesting peak in summer (Limpus 2007).

Flatback turtles are primarily carnivorous and feed predominantly on soft-bodied invertebrates in relatively shallow waters (Limpus 2007). Their distribution is largely restricted to continental shelf waters (< 200 m).

There are no BIAs or habitats critical for the survival of flatback turtles within the Operational Area. Habitat critical for the survival of flatback turtles does occur within the ZPI, the closest of which is the inter-nesting habitat on the western Dampier Peninsula, approximately 302 km south of the Prelude FLNG facility. There are several BIAs within the ZPI, including:

- Inter-nesting buffer (268 km south of the Prelude FLNG facility)
- Foraging (344 km east of the Prelude FLNG facility)
- Inter-nesting (360 km south of the Prelude FLNG facility)
- Nesting (360 km south of the Prelude FLNG facility).

Flatback turtles are unlikely to occur within the Operational Area, but are expected to occur within the ZPI, particularly in suitable foraging habitat in coastal waters and around nesting beaches.

Short-nosed Seasnake

The short-nosed seasnake (*Aipysurus apraefrontalis*) is a slender marine snake with a small head and pointed snout. This species has primarily been recorded at Ashmore Reef and Cartier Island on the Sahul Shelf, which lie approximately 169 km north of the Prelude FLNG facility. The species has also been recorded along the Pilbara coast between Exmouth Gulf and Broome (Threatened Species Scientific Committee 2010a).

Like all seasnakes, the short-nosed seasnake must come to the surface to breathe at intervals anywhere between 30 minutes and two hours. The species has been recorded primarily in reef flats or in shallow waters (< 10 m). The short-nosed seasnake has apparently experienced a decline in numbers, with recent surveys of Ashmore Reef failing to observe the species (Threatened Species Scientific Committee 2010a).

The short-nosed seasnake is unlikely to occur within the Operational Area, but may occur within shallow reef habitat within the ZPI.

Leaf-scaled Seasnake

The leaf-scaled seasnake (*Aipysurus foliosquama*) is a slender marine snake growing up to 60 cm in total length with some specimens found up to 90 cm. Like the short-nosed seasnake, the leaf-scaled seasnake is thought to be largely restricted to the reefs of the Sahul Shelf in Western Australia, especially on Ashmore and Hibernia Reefs (Threatened Species Scientific Committee 2010b).

The short-nosed seasnake is unlikely to occur within the Operational Area, but may occur within shallow reef habitat within the ZPI.

Saltwater Crocodile

The salt-water crocodile occurs within the nearshore marine and estuarine waters throughout southern Asia and Northern Australia. Large populations within the major river systems of the Kimberley occur in the rivers draining into the Cambridge Gulf, the Prince Regent and Roe River systems of the east and northwest Kimberley. There are no BIAs for the species within the Operational Area or ZPI. Saltwater crocodiles are very unlikely to occur in the Operational Area, but may be present within the coastal waters, estuaries and tidal creeks of the Kimberley region within the ZPI.

7.2.8.6 Sharks and Rays

Narrow Sawfish

The narrow sawfish is widely distributed throughout the Indo-Pacific region, with records spanning from the Arabian Gulf to Japan. In Australia, the species may have a broad tropical distribution from approximately North West Cape in Western Australia to southern Queensland. Like other sawfish species, the narrow sawfish has experienced considerable decline in numbers due to human activities, including fishing and habitat loss / damage (Cavanagh et al. 2003).

Like other sawfish in the family Pristidae, the narrow sawfish prefers shallow coastal, estuarine and riverine habitats, although may occur in waters up to 40 m deep (D'Anastasi et al. 2013). There are no BIAs for this species within the Operational Area or the ZPI. Given the water depth (>230 m) and distance from preferred habitats, narrow sawfish are not expected to occur within the Operational Area. However, the species may be found in shallow coastal waters and estuaries within the ZPI.

White Shark

The white shark (*Carcharodon carcharias*) has a circumglobal distribution primarily in temperate waters. In Australian waters, the species typically occurs in temperate and sub-tropical waters between the shore and the 100 m depth contour; however, adults and juveniles have been recorded diving to depths of 1,000 m (Bruce 2008, Bruce et al. 2006). Tagging studies indicate white sharks may move as far north as Rockhampton on the Queensland coast, however they are thought to be very uncommon in tropical waters (Bruce et al. 2006), such as the Timor Sea.

There are no BIAs for white sharks within the Operational Area or ZPI; given the anti-tropical distribution of this species, white sharks are unlikely to occur in the Operational Area or ZPI.

Northern River Shark

The northern river shark (*Glyphis garricki*) is a medium-sized shark which can tolerate both marine and freshwater. The species has a tropical distribution and is believed to be endemic to northern Australia and southern New Guinea (Stevens et al. 2005). In Western Australia, the majority of records of the species are from King Sound. The species is most commonly encountered in tidal creeks and estuaries (Morgan et al. 2010), hence it is unlikely to occur within the Operational Area but may be present in

Kimberley coastal waters in the ZPI. There are no BIAs for this species within the Operational Area or ZPI.

Shortfin Mako

The shortfin mako shark is a pelagic species with a circumglobal, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al. 2000). The shortfin mako is commonly found in water with temperatures greater than 16 °C. Tagging studies indicate shortfin makos spend most of their time in water less than 50 m deep but with occasional dives up to 880 m (Abascal et al. 2011, Stevens et al. 2010).

The species can grow to almost 4 m in length. Females mature later (19 to 21 years) than males (7 to 9 years) and adults have moderate longevity estimates of 28 to 29 years (Bishop et al. 2006).

The shortfin mako shark is an apex and generalist predator that feeds on a variety of prey, such as teleost fish, other sharks, marine mammals and marine turtles (Campana et al. 2005). Little is known about the population size and distribution of shortfin mako sharks in Western Australia; they may occur in both the Operational Area and ZPI.

Longfin Mako

The longfin mako is a widely distributed, but rarely encountered, oceanic shark species. The species can grow to just over 4 m long and is found in northern Australian waters, from Geraldton in Western Australia to at least Port Stephens in New South Wales and is uncommon in Australian waters relative to the shortfin mako (Bruce 2013, Department of the Environment, Water, Heritage and the Arts 2010).

There is very little information about these sharks in Australia, with no available population estimates or distribution trends. A study from southern California documented juvenile longfin mako sharks remaining near surface waters, while larger adults were frequently observed at greater maximum depths of about 200 m (Sepulveda et al. 2004).

Longfin mako may occur in the Operational Area and ZPI, but given their widespread distribution and apparent low density they are likely to be uncommon.

Giant Manta Ray

The giant manta ray is broadly distributed in tropical waters of Australia. The species primarily inhabits near-shore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al. 2011). Giant manta rays have been recorded regularly off the Ningaloo Coast (Preen et al. 1997), well beyond the ZPI.

The Operational Area is not located in, or adjacent to, any known aggregation areas for the species (e.g. feeding or breeding). Occurrence of giant manta rays within the Operational Area is likely to be infrequent, and restricted to individuals transiting the area.

Green Sawfish

The green sawfish (*Pristis zijsron*) were once widely distributed in coastal waters along the northern Indian Ocean, although it is believed that northern Australia may be the last region where significant populations exist (Stevens et al. 2005). Within Australia, green sawfish are currently distributed from about Cairns in Queensland across northern Australian waters to Broome in Western Australia (Threatened Species Scientific Committee 2008b).

Despite records of the species in deeper offshore waters, green sawfish typically occur in the inshore fringe with a strong associated with mangroves and adjacent mudflat habitats (Commonwealth of Australia 2015b, Stevens et al. 2005). Movements within these preferred habitats is correlated with tidal movements (Stevens et al. 2008).

No BIAs for the green sawfish overlap the Operational Area. BIAs in the ZPI include foraging (203 km south of Prelude) and pupping (294 km south of Prelude) BIAs along the Kimberley coast to the south of the Operational Area. Given the habitat preferences of the green sawfish, the species is unlikely to occur within the Operational Area, but is likely to occur with the ZPI along nearshore waters and tidal creeks of the Kimberley coastline.

Whale Shark

The whale shark (*Rhincodon typus*) is globally distributed in tropical and warm temperate waters, and it is thought individuals form a single genetic population (Castro et al. 2007). The species is an epipelagic filter feeder; their diet typically consists of planktonic and nektonic species, including small crustaceans and smaller schooling fish species.

Key areas of concentration within Australian waters include the Ningaloo coast (March – July), Christmas Island (December – January) and the Coral Sea (November – December), with the timing of the aggregations thought to be linked to seasonal fluctuations in prey abundance (Threatened Species Scientific Committee 2015d). Tagging, aerial and vessel surveys of whale sharks aggregating off the Ningaloo Coast suggest that the group disperses widely. Satellite tracking has shown that the sharks may follow three migration routes from Ningaloo (Meekan & Radford 2010, Wilson et al. 2006):

- north-west, into the Indian Ocean
- directly north, towards Sumatra and Java
- north-east, passing through the NWS Province travelling along the shelf break and continental slope.

These large scale movements are consistent with observations in other parts of the world. Tagging studies in other parts of the world have recorded whale shark movements > 13,000 km (Eckert and Stewart 2001).

Based on tagging studies, a foraging BIA has been defined for whale sharks which extends along the continental slope between the Ningaloo Coast and the Timor Sea (Figure 7-10). While listed as a foraging BIA, it is more likely to represent a migration corridor for individual whale sharks moving between Indonesia and the Ningaloo Coast. This BIA does not overlap the Operational Area, but does extend through the ZPI. The whale shark is known to occur within the Operational Area, with crew onboard the Prelude FLNG facility having observed the species. Whales sharks will also occur within the ZPI.

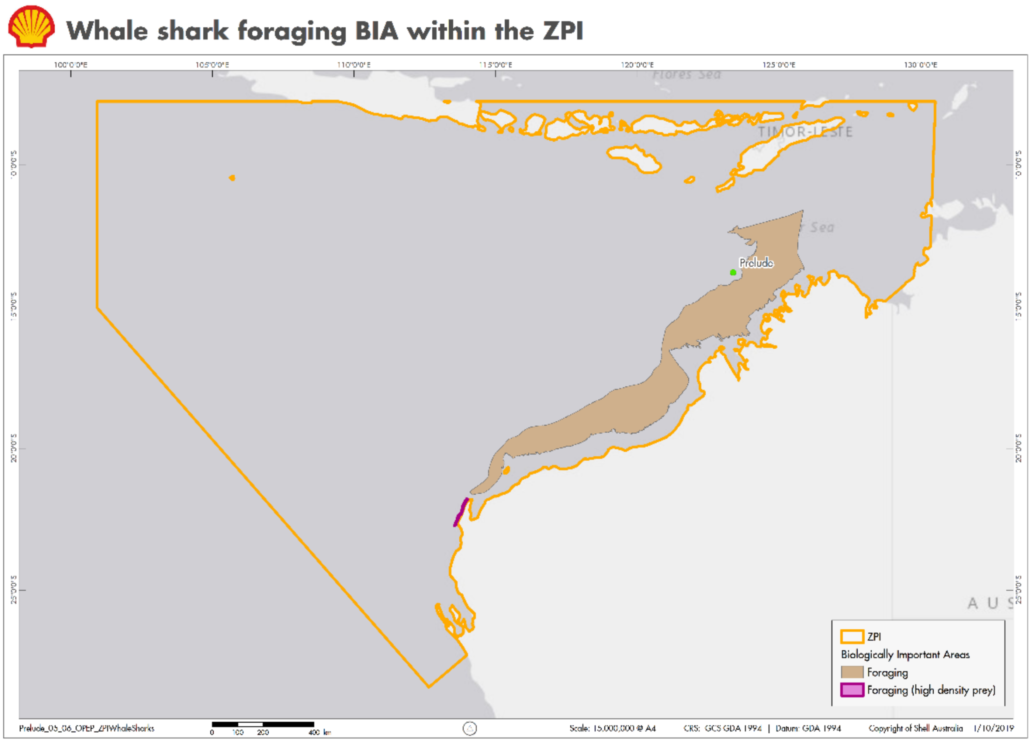


Figure 7-10: Whale shark foraging BIA within the ZPI

Grey Nurse Shark (West Coast Population)

The grey nurse shark (*Carcharus taurus*) has a broad distribution in inner continental shelf waters, primarily in sub-tropical to cool temperate waters. The species occurs primarily in south-west coastal waters between 20 and 140 m depth off Western Australia (Chidlow et al. 2006). Grey nurse sharks have been documented as aggregating in specific areas (typically reefs), however no clear aggregation sites have been identified off Western Australia (Chidlow et al. 2006).

No BIAs for grey nurse sharks occur within the Operational Area or the ZPI. Given the species' preference for temperate waters, it is unlikely to occur within the Operational Area or ZPI.

Porbeagle

The porbeagle is a species of lamnid shark found in temperate, sub-Arctic and sub-Antarctic waters worldwide. The species can thermos-regulate physiologically, allowing it to occupy cooler waters than other shark species. The porbeagle has a wide vertical range within the water column, with tagging studies recording the species between the surface and > 700 m water depth (Saunders et al. 2011). Given its preference for cooler waters (Bruce 2013), the porbeagle is unlikely to be encountered within the Operational Area, but may occur in the southern portion of the ZPI. There are no critical habitats or BIAs for the porbeagle in the Operational Area or ZPI.

Reef Manta Ray

The taxonomy of the reef manta ray (*Manta alfredi*) was revised relatively recently, with this species being recognised as distinct from the giant manta ray (*M. birostris*) (Marshall et al. 2009). The species is occurs in inshore waters, but also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al. 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest that this species is more resident in tropical waters and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations than the giant manta ray (Deakos et al. 2011, Marshall et al. 2009). A resident population of reef manta rays has been recorded at Ningaloo Reef, and the species has been shown to have both resident and migratory tendencies in eastern Australia (Couturier et al. 2011).

Reef manta rays may occur in the Operational Area, but is only expected to occur in low numbers. The species is likely to be present in the ZPI where suitable habitat is available (e.g. coastal waters and offshore reefs).

Dwarf Sawfish

The dwarf sawfish (*Pristis clavata*) is found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland to the Pilbara coast (Kyne et al. 2013).

Dwarf sawfish typically inhabit shallow (2 to 3 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al. 2008). Juvenile dwarf sawfish utilise estuarine habitats in north-western Western Australia as nursery areas and migrate to deeper waters as adults (Thorburn et al. 2008, Threatened Species Scientific Committee 2009). The majority of capture locations for the species in Western Australia waters have occurred within King Sound (beyond the ZPI) and the lower reaches of the major rivers that enter the sound, including the Fitzroy, Mary and Robinson rivers (Morgan et al. 2010). Individuals have also been recorded from Eighty Mile Beach, and occasional individuals have also been taken from considerably deeper water by trawl fishers (Morgan et al. 2010).

Dwarf sawfish are very unlikely to occur within the Operational Area, but may be present in coastal waters within the ZPI.

Freshwater Sawfish

The freshwater sawfish (*Pristis pristis*) inhabits both riverine and marine environments in northern Australia. While primarily associated with rivers, tidal creeks and estuaries, the freshwater sawfish has been recorded up to 100 km offshore (Commonwealth of Australia 2015b).

In Western Australia, the species is known from riverine and coastal environments in the Kimberley region. Riverine habitats are particularly important as pupping habitats.

The freshwater sawfish is very unlikely to occur within the Operational Area, but may occur in coastal waters, estuaries and tidal creeks along the Kimberley coastline within the ZPI.

7.2.8.7 Birds

The Operational Area may be visited by migratory and oceanic birds but does not contain any emergent land that could be utilised as roosting or nesting habitat and contains no known critical habitats (including feeding) for any species. Observations onboard the Prelude FLNG facility indicate that seabirds and migratory shorebirds opportunistically roost onboard the facility.

Threatened and migratory bird species that may occur within the Operational Area and ZPI can broadly be classified into two groups – seabirds and migratory shorebirds. The descriptions below of the species in Table 7-5 have been based on these groups.

Seabirds

Seabirds are birds that are highly adapted to the marine environment. Characteristics of many seabird species include webbed feet, dense water-resistant plumage that protects birds from becoming soaked, a diet comprising marine biota (typically fish), and nesting on offshore islands or inaccessible coastlines. Many seabird species spend relatively little time on land and forage at sea for extended periods. Some species may undertake long migrations; however, unlike migratory shorebirds, they do not typically follow the East Asian-Australasian flyway.

Seabirds that may occur within the Operational Area and ZPI (Table 7-5) include:

- noddies:
  - common noddy
  - Australian lesser noddy.
- shearwaters:
  - streaked shearwater
  - flesh-footed shearwater
  - wedge-tailed shearwater.
- terns:
  - Caspian tern
  - bridled tern
  - roseate tern
  - little tern
  - Australian fairy tern
  - crested tern.
- frigatebirds:
  - lesser frigatebird
  - great frigatebird
  - Christmas island frigatebird.
- tropicbirds:
  - white-tailed tropicbird
  - Christmas Island white-tailed tropicbird
  - red-tailed tropicbird.
- petrels:
  - southern giant-petrel
  - northern giant petrel
  - soft-plumaged petrel.
- albatrosses:
  - Amsterdam albatross
  - southern royal albatross
  - wandering albatross

  - Indian yellow-nosed albatross
  - Tasmanian shy albatross
  - white-capped albatross
  - Campbell albatross
  - black-browed albatross
  - white-capped albatross.
- boobies:
  - Abbott's booby
  - masked booby
  - brown booby
  - red-footed booby.
- ospreys.

Many of the seabird groups listed, such as noddies, terns, frigatebirds, tropicbirds and boobies above are typically found in tropical areas. These species may transiently occur within the Operational Area, however they are more likely to occur in the vicinity of offshore islands in the ZPI, such as Browse Island and Ashmore Reef, particularly during breeding seasons.

Many of the seabird groups listed above have temperate or sub-Antarctic distributions, such as shearwaters, petrels and albatrosses. These species are very unlikely to occur within the Operational Area, although may be present in the southern portion of the ZPI.

Migratory Shorebirds

Migratory shorebirds and wading birds include many species of birds that breed in northern Asia during the northern hemisphere summer (particularly eastern Russia and China) and migrate to Australasia during the southern hemisphere summer to feed. Many of these species follow the East Asian-Australasian flyway and are protected by migratory bird agreements between counties along this route, including Australia.

Migratory shorebirds typically do not nest within Australia, but do make extensive use of wetland and coastal habitats as feeding and resting areas during their migration. Several of these areas are listed under the Ramsar Convention and are protected under the EPBC Act (Section 7.2.5).

Migratory shorebirds that may occur within the Operational Area and ZPI include:

- sandpipers, curlews, stints, knots and turnstones (genus Calidris):
  - common sandpiper
  - sharp-tailed sandpiper
  - curlew sandpiper
  - pectoral sandpiper
  - broad-billed sandpiper
  - wood sandpiper
  - marsh sandpiper

  - Terek sandpiper
  - eastern curlew
  - whimbrel
  - ruddy turnstone
  - sanderling
  - ruff (reeve)
  - red-necked stint
  - red knot
  - great knot.
- shanks and tattlers:
  - grey-tailed tattler
  - common greenshank
  - common redshank.
- plovers:
  - double-banded plover
  - greater sand plover
  - lesser sand plover
  - oriental plover
  - pacific golden plover
  - grey plover.
- godwits:
  - bar-tailed godwit
  - bar-tailed godwit (baueri)
  - Northern Siberian bar-tailed godwit
  - Black-tailed godwit.
- Oriental Pratincole
- Asian Dowitcher
- Australian Painted-snipe.

Many of the species listed above are closely related and within the family Scolopacidae, and share very similar life histories. All of these migratory shorebird species may transit through the Operational Area during migration. They are likely to occur seasonally along coastlines, in estuaries and wetlands throughout the ZPI, particularly Ramsar sites (Section 7.2.5).

7.3 Socio-Economic Environment

7.3.1 Heritage

7.3.1.1 World Heritage Properties

There are no World Heritage properties within the Operational Area. Two World Heritage properties occur within the far southern portion of the ZPI:

- the Ningaloo Coast (approximately 1,283 km south of Prelude)
- Shark Bay, Western Australia (approximately 1,651 km south of Prelude).

The Ningaloo Coast

The Ningaloo Coast World Heritage Area (WHA) includes North West Cape and the Muiron Islands, and was inscribed, under criteria (vii) and criteria (x) by the World Heritage Committee onto the World Heritage Register in June 2011. The statement of Outstanding Universal Value for the Ningaloo coast was based on the natural criteria and recognised the following:

- Criterion (vii): The landscapes and seascapes of the property are comprised of mostly intact and large-scale marine, coastal and terrestrial environments. The lush and colourful underwater scenery provides a stark and spectacular contrast with the arid and rugged land. The property supports rare and large aggregations of whale sharks (*Rhincodon typus*) along with important aggregations of other fish species and marine mammals. The aggregations in Ningaloo following the mass coral spawning and seasonal nutrient upwelling cause a peak in productivity that leads approximately 300-500 whale sharks to gather, making this the largest documented aggregation in the world.
- Criterion (x): In addition to the remarkable aggregations of whale sharks the Ningaloo Reef harbours a high marine diversity of more than 300 documented coral species, over 700 reef fish species, roughly 650 mollusc species, as well as around 600 crustacean species and more than 1000 species of marine algae. The high numbers of 155 sponge species and 25 new species of echinoderms add to the significance of the area. On the ecotone, between tropical and temperate waters, the Ningaloo Coast hosts an unusual diversity of marine turtle species with an estimated 10,000 nests deposited along the coast annually.

The dominant feature of the Ningaloo Coast WHA is Ningaloo Reef, the largest fringing reef in Australia. Ningaloo Reef supports both tropical and temperate species of marine fauna and flora and more than 300 species of coral (Department of Conservation and Land Management 2005).

The Ningaloo Coast WHA is entirely overlapped by the Commonwealth Ningaloo Australian Marine Park and State Ningaloo Marine Park and Muiron Islands Marine Management Area; refer to Section 7.3.2 for further information on these marine protected areas.

Shark Bay, Western Australia

The Shark Bay WHA includes Bernier Island, Dorre Island and Dirk Hartog's landing site. Shark Bay was inscribed under all four natural criteria (criterion vii, viii, ix, and x) by the World Heritage Committee onto the World Heritage Register in 1991. The statement of Outstanding Universal Value for the Shark Bay WHA was based on natural criteria and recognised the following:

- Stromatolites, in the hypersaline Hamelin Pool, which represent the oldest form of life on earth and are comparable to living fossils.
- One of the few marine areas in the world dominated by carbonates not associated with reef building corals.
- One of the largest seagrass meadows in the world, covering 103,000 ha, with the most seagrass species recorded in one area.
- Marine fauna such as dugong, dolphins, sharks, rays, turtles, fish, and migratory seabirds which occur in great numbers.
- The hydrologic structure of Shark Bay, altered by the formation of the Faure Sill and a high evaporation, has produced a basin where marine waters are hypersaline (almost twice that of seawater) and contributed to extensive beaches consisting entirely of shells.
- The Wooramel Seagrass Bank is also of great geological interest due to the extensive deposit of limestone sands associated with the bank, formed by the precipitation of calcium carbonate from hypersaline waters.

The Shark Bay WHA is partially overlapped by the State Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve.

7.3.1.2 Commonwealth Heritage Places

The Commonwealth Heritage List is a list of Indigenous, historic and natural heritage places owned or controlled by the Australian Government. The Operational Area is not located in, or in the immediate surrounds of, any Commonwealth Heritage places. There are a number of Commonwealth Heritage Places within the ZPI. These are listed in Table 7-9, with a supporting summary of their key values as Commonwealth Heritage Places.

Table 7-9: Commonwealth Heritage Places within the ZPI

Commonwealth Heritage Place	Approximate Distance from Prelude (km)	Description
Scott Reef and surrounds	155	Scott Reef is considered regionally important for the following features: • high diversity of marine fauna, including corals, fish and marine invertebrates; • physical characteristics of the reefs create environmental conditions which are rare for shelf atolls, including clear deep oceanic water and large tidal ranges that provide a high physical energy input to the marine ecosystem; • high representation of species not found in coastal waters off WA and for the unusual nature of their fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific, as well as the reefs of the Indonesian region; and • important for scientific research and benchmark studies into long term geomorphological and reef formation processes due to the age of the reef and the documentation of its geophysical and physical environmental characteristics.

Commonwealth Heritage Place	Approximate Distance from Prelude (km)	Description
Ashmore Reef National Nature Reserve	162	The Ashmore Reef National Nature Reserve protects Ashmore Reef, a large platform reef with coral reefs, sand flats and three vegetated islands. Specific values of this site include: • breeding and foraging habitat for marine turtles • considered to have the world's greatest abundance and diversity of sea snakes • habitat for 569 species of fish, 255 species of corals and 433 species of mollusc, as well as species not previously recorded or rarely recorded in Australia • an important seabird rookery and provides an important staging/feeding area for many seabirds and migratory shorebirds (Environment Australia 2002) • breeding and feeding habitat for a small dugong population (< 50 individuals).
Mermaid Reef – Rowley Shoals	535	Mermaid Reef is one of three reef systems, located 30 – 40 km apart, which make up the Rowley Shoals. The shoal consists of a reef flat roughly 500 to 800 m wide, shallow back reefs and a large lagoon. The Rowley Shoals have been described as the most perfectly formed shelf atolls in Australian waters, and the clear, deep water and large tidal range of the atolls are considered rare environmental conditions for shoals. The specific values of Mermaid Reef include: • high diversity of marine reef fauna, including corals, fish and marine invertebrates • important area for sharks, marine turtles and toothed whales, dolphins, tuna and billfish • important resting and feeding site for migratory seabirds • regionally significant due to the presence of many species not found in inshore tropical waters of Northern Australia, and species that are close to their geographical ranges. Includes 216 species of fish, 39 species of mollusc and seven species of echinoderms • considered a genetic stepping stone between the Indonesian archipelago and reefs to the south.
Ningaloo Marine Area - Commonwealth Waters	1,304	The Ningaloo Marine Area – Commonwealth Waters lies within the Commonwealth waters section of the Ningaloo Coast World Heritage Property – refer to Section 7.3.1.1 World Heritage Properties for further information about the environmental values within the Ningaloo Marine Area – Commonwealth Waters.
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,877	The HMAS Sydney II and HSK Kormoran Shipwreck Sites Commonwealth Heritage Place covers the historic wrecks that resulted from a battle during the Second World War. Both wrecks are located in over 2,000 m of water. The battle between HMAS Sydney and HSK Kormoran resulted in the largest single loss of life in Australian naval history.

7.3.1.3 National Heritage Places

The National Heritage List is Australia's list of natural, historic and Indigenous places of outstanding significance to the nation. There are no National Heritage properties in, or in the immediate surrounds of, the Operational Area. National Heritage Places in the ZPI are described in Table 7-10.

Table 7-10: National Heritage Places within the ZPI

National Heritage Place	Approximate Distance from Prelude (km)	Description
The West Kimberley	171	The West Kimberley is known for its ancient geology, Aboriginal culture, stunning landscapes, and biological richness. The West Kimberley coastline includes a range of landforms, including cliffs, rocky headlands, sandy beaches, rivers, waterfalls and numerous islands located off the coast. The West Kimberley holds extensive history of Aboriginal people who have lived in the area for at least 40,000 years. The West Kimberley also provides remnant habitats for many native animals and plants which are now absent elsewhere in Australia. Many of the national heritage values of the West Kimberley are located away from the coastline will not credibly be affected by the petroleum activities considered in this EP.
Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves	1,097	Barrow Island and the Montebello / Barrow Islands Marine Conservation Reserves are of national and international significance as a diverse region of high conservation value terrestrial and aquatic habitats, and high species diversity and endemism. Barrow Island hosts a range of terrestrial and subterranean species that are unique, including species that are extinct, or threatened with extinction, on mainland Australia. The marine environment within the reserves has complex bathymetry with many reefs and a diverse assemblage of corals. Significant marine turtle nesting activity occurs on sandy beaches throughout the reserves, including significant flatback and green turtle rookeries.
The Ningaloo Coast	1,283	Refer to The Ningaloo Coast World Heritage Area description in Section 7.3.1.1 World Heritage Properties
Shark Bay, Western Australia	1,651	Refer to Shark Bay, Western Australia World Heritage Area description in Section 7.3.1.1 World Heritage Properties
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,877	Refer to HMAS Sydney II and HSK Kormoran Shipwreck Sites description in Section 7.3.1.3 National Heritage Places

7.3.1.4 Cultural Heritage

There are no known sites of Indigenous or European cultural significance within the Operational Area. The Australian coastline and nearshore islands have a long history of Indigenous occupation and host many culturally significant sites. The ZPI partially overlaps parts of the Kimberley, Pilbara and Gascoyne coastlines, which host numerous culturally significant sites, including sites that contribute to the national heritage value of the West Kimberley National Heritage Place.

7.3.1.5 Underwater Cultural Heritage

Information on underwater cultural heritage, including historic shipwrecks, is maintained in the Australasian Underwater Cultural Heritage Database, a searchable database of records provided by the Australian DAWE. A search of the database revealed no known shipwrecks or other underwater cultural heritage sites within the Operational Area. The nearest historic shipwreck is the wreck of the sailing vessel Berteaux, which lies approximately 18 km south-east of the Prelude FLNG facility.

7.3.2 Marine Protected Areas

The Operational Area does not overlap any Marine Protected Areas (MPAs), such as Commonwealth Australian Marine Parks (AMPs) or state marine parks. There are a number of Commonwealth AMPs and Western Australian MPAs in the ZPI (Figure 7-11) Each of these MPAs is described in Table 7-11.

All AMPs and many state MPAs have management plans in place, which outline the objectives for the management of the protected area. These objectives have been considered where applicable in the environmental impact and risk assessment in Section 9.13.

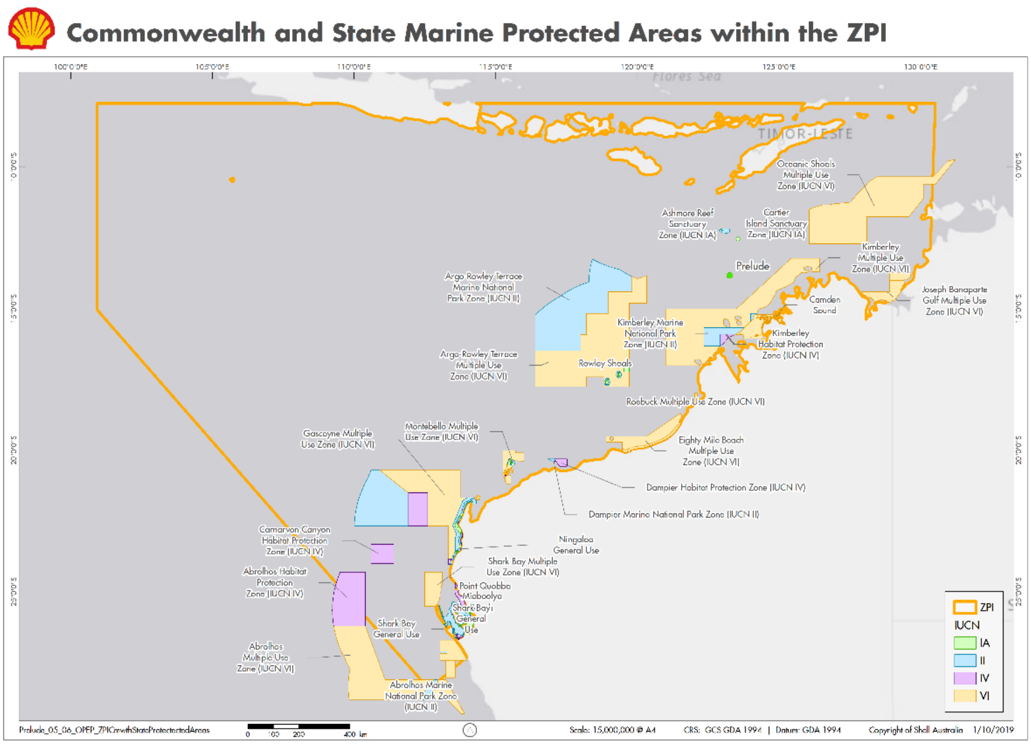


Figure 7-11: Commonwealth and State Marine Protected Areas within the ZPI

Table 7-11: MPAs within the ZPI

<table>
<tr><th>Marine Protected</th><th>Distance from Prelude (km)</th><th>Description</th></tr>
<tr><td colspan="3">Commonwealth AMPs</td></tr>
<tr><td>Kimberley</td><td>111</td><td>The Kimberley AMP covers approximately 74,469 km^2 and ranges in water depth from less than 15 m to approximately 800 m. The AMP lies from the Lacepede Islands in the north to the Holothuria Banks offshore from Cape Bougainville. The Kimberley AMP contains the following conservation values (Director of National Parks 2018a):
• Important foraging areas for migratory seabirds, dugongs, dolphins and marine turtles
• Important migration pathway and nursery areas for the humpback whale
• Adjacent to important foraging and pupping areas for sawfish and important nesting sites for green turtles
• Features such as the continental shelf, slope, plateau, pinnacles, terraces, banks and shoals and deep holes/valleys
• Examples of the communities and seafloor habitats of the Northwest Shelf Transition, North West Shelf province and Timor Province provincial bioregions along with the Kimberley, Canning, Northwest Shelf and Oceanic Shoals meso-scale bioregions.
The AMP provides protection for two KEFs; an ancient coastline (a unique seafloor feature that provides areas of enhanced productivity) and continental slope demersal fish communities (the second richest area for demersal fish species in Australia), refer to Section 7.2.3. The Kimberley meso-scale bioregion in particular has been reported to be one of the most diverse coral areas in WA. In addition, the reserve is adjacent to the listed West Kimberley National Heritage place and Western Australian Lalang-garram / Camden Sound Marine Park.</td></tr>
<tr><td>Cartier Island</td><td>134</td><td>Cartier Island AMP is considered to be a biodiversity hotspot (like nearby Ashmore Reef) and is thought to be a source of larvae of marine biota such as corals which are transported south by the Leeuwin Current. The AMP covers an area of approximately 172 km^2. Key conservation values include (Director of National Parks 2018a):
• An unvegetated sand island
• High diversity and abundance of hard and soft corals, gorgonians, sponges and a range of encrusting organisms
• Algae and seagrasses
• Important breeding and foraging habitat for seabirds
• Foraging habitat for whale sharks
• Nesting, inter-nesting and foraging habitat for marine turtles
• High diversity and abundance of seasnakes.</td></tr>
<tr><td>Ashmore Reef</td><td>162</td><td>The Ashmore Reef AMP covers an area of 583 km^2 and is a designated Ramsar Wetland (Section 7.2.5). Key conservation values of the AMP include (Director of National Parks 2018a):</td></tr>
</table>

Marine Protected	Distance from Prelude (km)	Description
		• Regionally significant as contains ecosystems, habitat and communities representative of the NWS, Timor Province and emergent oceanic reefs • Biologically rich habitat including primary producer habitat (mangroves, seagrass beds and coral reefs) and their associated benthic communities, fishes and other biota • Regionally important nesting, inter-nesting, foraging areas for marine turtles (particularly green but also hawksbill and loggerhead turtles). An estimated 11,000 marine turtles feed in the area throughout the year • Isolated, small dugong population of less than 50 individuals that breeds and feeds around the reef. This population is thought to be genetically distinct from other Australian populations • Important seabird rookeries and staging points/feeding areas for migratory sea/shorebirds including colonies of bridled terns, common noddies, brown boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, crested terns and lesser crested terns • International significance for seasnake abundance and diversity • Importance cultural and heritage sites: Indonesian artefacts and grave sites.
Oceanic Shoals	321	The Oceanic Shoals AMP comprises a 71,743 km^2 area, with a large proportion (39,964 km^2) designated as Multiple Use Zone (IUCN Category VI). There are smaller areas designated for National Park Zone (Category II, 406 km^2), Habitat Protection Zone (Category IV, 6,929 km^2), and Special Purpose Zone for Trawling (Category VI, 10,461 km^2). The AMP has several conservation values (Director of National Parks 2018a): • important inter-nesting area for the flatback and olive ridley turtles • an important foraging area for loggerhead and olive ridley turtles • examples of the ecosystems of both the Northwest Shelf Transition and Timor Transition provinces. KEFs represented in the reserve are carbonate banks, pinnacles and the shelf break and slope of the Arafura Shelf. (Refer to Section 7.2.3.)
Argo-Rowley Terrace	323	The Argo-Rowley Terrace AMP covers 146,099 km^2 of the MPA network, including the Commonwealth waters surrounding the Rowley Shoals (each reef managed as separate state and Commonwealth marine parks). The Argo-Rowley Terrace Commonwealth Marine Park encompasses water depths from approximately 220–6000 m. The ecological and conservation values include (Director of National Parks 2018a): • Important foraging areas for migratory seabirds and, reportedly, the loggerhead turtle • Support for relatively large populations of sharks (compared with other areas in the region) • A range of seafloor features such as canyons, continental rise and the terrace, among others • Connectivity between the reefs of the Rowley Shoals

Marine Protected	Distance from Prelude (km)	Description
		• Linkage of the Argo Abyssal Plain with the Scott Plateau through canyons. The AMP is contiguous with the Western Australian Rowley Shoals Marine Park.
Roebuck	480	The Roebuck Marine Park is located approximately 12 km offshore of Broome, and is adjacent to the Western Australian Yawuru Nagulagun/Roebuck Bay Marine Park. The Marine Park covers an area of 304 km² and a water depth range of less than 15 m to 70 m. The ecological and conservation values include (Director of National Parks 2018a): • The park is adjacent to the Eighty Mile Beach Ramsar wetland • Representative ecosystems of the Northwest Shelf Province • Breeding and resting habitat for seabirds • foraging and inter-nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat for dugong.
Mermaid Reef	523	The Mermaid Reef Commonwealth Marine Park encompasses Mermaid Reef and covers 540 km^2; it is classified as an IUCN protected area category 1a, Sanctuary Zone (Strict Nature Reserve). Mermaid Reef is one of the best geological examples of a shelf-edge reef in Australian waters (one of three oceanic reefs that form the Rowley Shoals). It is the only reef of the Rowley Shoals located entirely in Commonwealth waters. Mermaid Reef supports (Director of National Parks 2018a): • rich coral communities (216 species of hard coral, 12 genera of soft corals) • a high diversity of associated sessile and mobile invertebrates (echinoderms, molluscs and crustaceans) • more than 390 reef and pelagic fish species • a variety of sharks that frequent the reef habitats. The Mermaid Reef AMP also includes the Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals KEF (Table 7-3).
Joseph Bonaparte Gulf	604	The Joseph Bonaparte Gulf Marine Park is located approximately 15 km west of Wadeye, Northern Territory, and approximately 90 km north of Wyndham, Western Australia, in the Joseph Bonaparte Gulf. It is adjacent to the Western Australian North Kimberley Marine Park. The Marine Park covers an area of 8,597 km² and water depth ranges between less than 15 m and 100 m (Director of National Parks 2018b). Environmental values within the Park include (Director of National Parks 2018b): • species and communities associated with the Northwest Shelf Transition bioregion

Marine Protected	Distance from Prelude (km)	Description
		• carbonate bank and terrace system of the Sahul Shelf KEF • prominent shallow seafloor features, including emergent reef, shoals and sand banks • biologically important areas including foraging habitat or marine turtles and the Australian snubfin dolphin.
Eighty Mile Beach	788	Eighty Mile Beach AMP comprises a 10,785 km^2 Multiple Use Zone. Environmental values within the AMP include (Director of National Parks 2018a): • examples of ecosystems representative of the Northwest Shelf Province • diverse benthic and pelagic fish communities • and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales • a range of fauna threatened, migratory, marine and cetacean under the EPBC Act. The AMP is adjacent to the Eighty Mile Beach Ramsar wetland (which is beyond the ZPI).
Dampier	950	The Dampier Marine Park is located approximately 10 km north-east of Cape Lambert and 40 km from Dampier extending from the Western Australian state water boundary. The Marine Park covers an area of 1,252 km^2 and a water depth range between less than 15 m and 70 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • representative ecosystems and communities of the Northwest Shelf Province • breeding and foraging habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales.
Montebello	1,047	The Montebello Marine Park is located offshore of Barrow Island and 80 km west of Dampier extending from the Western Australian state water boundary, and is adjacent to the Western Australian Barrow Island and Montebello Islands Marine Parks. The Marine Park covers an area of 3,413 km^2 and water depths from less than 15 m to 150 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • habitats, species and ecological communities associated with the Northwest Shelf Province • ancient coastline at the 125 m depth contour KEF • breeding habitat for seabirds • inter-nesting, foraging, mating and nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat for whale sharks.

Marine Protected	Distance from Prelude (km)	Description
Gascoyne	1,277	The Gascoyne Marine Park is located approximately 20 km off the west coast of the Cape Range Peninsula, adjacent to the Ningaloo Reef Marine Park and the Western Australian Ningaloo Marine Park, and extends to the limit of Australia's exclusive economic zone. The Marine Park covers an area of 81,766 km² and water depths between 15 m and 6,000 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • four KEFs: - canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula - Commonwealth waters adjacent to Ningaloo Reef - continental slope demersal fish communities - the Exmouth Plateau. • diverse continental slope habitats • breeding habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat and migratory pathway for pygmy blue whales.
Ningaloo	1,304	The Ningaloo Marine Park stretches approximately 300 km along the west coast of the Cape Range Peninsula, and is adjacent to the Western Australian Ningaloo Marine Park and Gascoyne Marine Park. The Marine Park covers an area of 2,435 km² and a water depth range of 30 m to more than 500 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • representative ecosystems of the: - Central Western Shelf Transition - Central Western Transition - Northwest Province - Northwest Shelf Province. • KEFs: - canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula - Commonwealth waters adjacent to Ningaloo Reef - continental slope demersal fish communities • breeding habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat and migratory pathway for pygmy blue whales • breeding, calving, foraging and nursing habitat for dugong

Marine Protected	Distance from Prelude (km)	Description
		• foraging habitat for whale sharks.
Shark Bay	1,588	The Shark Bay Marine Park is located approximately 60 km offshore of Carnarvon, adjacent to the Shark Bay world heritage property and national heritage place. The Marine Park covers an area of 7,443 km², extending from the Western Australian state water boundary, and a water depth range between 15 m and 220 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • representative ecosystems of the Central Western Shelf and Central Western Transition bioregions • connectivity between deeper Commonwealth waters and inshore waters of Shark Bay • breeding habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales. The Park is adjacent to the Shark Bay World Heritage Area.
Abrolhos	1,781	The Abrolhos Marine Park is located adjacent to the Western Australian Houtman Abrolhos Islands, covering a large offshore area extending from the Western Australian state water boundary to the edge of Australia's exclusive economic zone. It is located approximately 27 km south-west of Geraldton and extends north to approximately 330 km west of Carnarvon. The northernmost part of the shelf component of the Marine Park, north of Kalbarri, is adjacent to the Shark Bay World Heritage Area. The Marine Park covers an area of 88,060 km² and a water depth range between less than 15 m and 6,000 m (Director of National Parks 2018c). Environmental values within the Park include (Director of National Parks 2018c): • KEFs: - Commonwealth marine environment surrounding the Houtman Abrolhos Islands - demersal slope and associated fish communities of the Central Western Province - mesoscale eddies - Perth Canyon and adjacent shelf break, and other west-coast canyons - western rock lobster - ancient coastline between 90 m and 120 m depth - Wallaby Saddle. • high biodiversity due to the southwards flowing Leeuwin Current supplying tropical species • foraging and breeding habitat for seabirds • foraging habitat for Australian sea lions and white sharks • migratory pathway for humpback and pygmy blue whales.

Marine Protected	Distance from Prelude (km)	Description
		The Marine Park is adjacent to the northernmost Australian sea lion breeding colony in Australia on the Houtman Abrolhos Islands.
Western Australian Marine Parks		
Lalang-garram / Camden Sound	182	The Lalang-garram / Camden Sound Marine Park provides protection for a large, biologically diverse part of the Kimberley coastal waters. The park is contiguous with the Commonwealth Kimberley AMP, which is described above. The environmental and social values within the park include: • habitat for a range of marine species, including marine turtles, coastal dolphins and dugong • important calving and resting areas for humpback whales • sanctuary zones which prohibit most activities, including fishing • important cultural heritage sites for the traditional owners. The Lalang-garram / Camden Sound Marine Park is jointly managed by WA government agencies and the traditional owners of the land.
North Kimberley	188	The North Kimberley Marine Park covers an area of approximately 1,845,000 hectares, which is currently zoned as IUCN Category VI – multiple use. The park is remote and contains a range of outstanding natural and cultural values, such as a complex coastline with many small islands and cultural heritage sites for Aboriginal saltwater people. The Marine Park contains habitats such as coral reefs, seagrasses and mangroves. Fauna include dugong, birds, marine turtles, fishes, cetaceans and saltwater crocodiles.
Rowley Shoals	567	The Rowley Shoals Marine Park protects two of the three oceanic shoals (Clerke Reef and Imperieuse Reef) that constitute the Rowley Shoals. The third shoal (Mermaid Reef) is protected by the Argo-Rowley Terrace AMP. The Rowley Shoals Marine Park is characterised by intertidal and subtidal coral reefs, with rich and diverse marine fauna and high water quality. The reefs within the park may act as a source of recruits for habitats further south, via the Leeuwin Current, and hence are considered to be regionally significant (MPRA 2007).
Eighty Mile Beach Marine Park	612	Eighty Mile Beach is an extensive stretch of remote and remarkable coastal country located between Port Hedland and Broome, stretching for some 220 km from Cape Missiessy to Cape Keraudren. The marine park includes Eighty Mile Beach, Cape Keraudren and the diverse marine environments west of Cape Keraudren to Mulla Down Creek. it is jointly managed with the traditional owners of the area (Department of Parks and Wildlife 2014). The marine park contains vast intertidal sand and mudflats that extend up to 4 km wide at low tide and provide a rich source of food for many species. Eighty Mile Beach is one of the world's most important feeding grounds for migratory shorebirds and is a major nesting site for flatback turtles, which are only found in northern Australia. Both are critical components of the Eighty Mile Beach Ramsar site, and the management plan seeks to maintain its ecological character (Department of Parks and Wildlife 2014).

Marine Protected	Distance from Prelude (km)	Description
		The Park is adjacent to the Commonwealth Eighty Mile Beach AMP.
Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area	1,097	The Montebello Islands Marine Park, Barrow Island Marine Park and Barrow Island Marine Management Area are jointly managed and cover a combined area of 1,770 km^2, located approximately 170 km from the Operational Area at the closest point. A sanctuary zone covers the entire 4,100 ha Barrow Island Marine Park. The Barrow Island Marine Management Area covers 114,500 ha and includes most of the waters surrounding Barrow Island and Lowendal Islands, except for the port areas around Barrow and Varanus Islands. Key conservation and environmental values within the reserves include (Department of Environment and Conservation 2007): • a complex seabed and island topography consisting of subtidal and intertidal reefs, sheltered lagoons, channels, beaches, cliffs and rocky shores • pristine sediment and water quality, supporting a healthy marine ecosystem • undisturbed intertidal and subtidal coral reefs and bommies with a high diversity of hard corals • important mangrove communities, particularly along the Montebello Islands, which are considered globally unique as they occur in offshore lagoons • extensive subtidal macroalgal and seagrass communities • important habitat for cetaceans and dugongs • nesting habitat for marine turtles • important feeding, staging and nesting areas for seabirds and migratory shorebirds • rich finfish fauna with at least 456 species • historical culture of the pearl oyster (Pinctada maxima) in the reserves produces some of the highest quality pearls in the world. These islands support significant colonies of wedge-tailed shearwaters and bridled terns. The Montebello Islands support the biggest breeding population of roseate terns in Western Australia. Ospreys, white-bellied sea-eagles, eastern reef egrets, Caspian terns, and lesser crested terns also breed in this area. The Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area is contiguous with the Montebello Commonwealth Marine Park.
Muiron Islands Marine Management Area and Ningaloo Marine Park	1,283	The Ningaloo Marine Park (State waters) was established in 1987 and stretches 300 m from the North West Cape to Red Bluff. It encompasses the State waters covering the Ningaloo Reef system and a 40 m strip along the upper shore. The Muiron Islands Marine Management Area is managed under the same management plan as for the Ningaloo State Marine Park (Department of Conservation and Land Management 2005). The Ningaloo Marine Park is part of the Ningaloo Coast WHA. Ecological and conservation values of the Ningaloo Marine Park and Muiron Islands are summarised below. The ecological and conservation values include (Department of Conservation and Land Management 2005): • Unique geomorphology, which has resulted in a high habitat and species diversity

Marine Protected	Distance from Prelude (km)	Description
		• High sediment and water quality • Subtidal and intertidal coral reef communities providing food, settlement substrate and shelter for marine flora and fauna • Filter feeding communities (sponge gardens) in the northern part of the North West Cape and the Muiron and Sunday Islands • Soft sediment communities found in deeper waters, characterised by a surface film of microorganisms that provide a rich source of food for invertebrates • Macroalgae and seagrass communities, which are an important primary producer providing habitat for vertebrate and invertebrate fauna • Diverse fish fauna (approximately 460 species) • Foreshores and nearshore reefs of the Ningaloo coast and Muiron/Sunday islands provide inter-nesting, nesting and hatchling habitat for several species of marine turtles including the loggerhead, green, flatback and hawksbill turtles • Whale sharks aggregate annually to feed in the waters around Ningaloo Reef • Nesting and foraging habitat for seabirds and shorebirds.
Shark Bay Marine Park	1,691	The Shark Bay Marine Park was gazetted in 1990 as an A Class Marine Park Reserve and encompasses and area of 7,487 km^2. The values of the Marine Park are consistent with those of the World Heritage Area, which are described in Section 7.3.1.1 World Heritage Properties.

7.3.3 Fishing Industry

7.3.3.1 Traditional Fishing

In 1974, Australia recognised access rights for traditional Indonesian fishers in shared waters to the north of Australia, granting long-term fishing rights in recognition of the long history of traditional Indonesian fishing in the area. A Memorandum of Understanding (MOU) between the Governments of Australia and Indonesia enables Indonesian traditional fishers to continue their customary practices. This area is known as the 'MOU Box' and the Operational Area lies within it.

This MOU box covers Scott Reef and surrounds, Seringapatam Reef, Browse Island, Ashmore Reef and Cartier Island, representing an area of approximately 50,000 km^2. Trochus, sea cucumbers (holothurians), abalone, green snail, sponges, giant clams and finfish, including sharks, are targeted by the fishers. Given the shallow water target species, these traditional Indonesian fishermen are only likely to be found in deep water areas during transit to and from the reef locations.

7.3.3.2 Recreational Fishing

Currently, there are no known recreational fishing activities in the Operational Area as the site is too far from shore to be accessed by recreational fishermen in small boats. Even at relatively high speed (30 km/hour), it would take at least fifteen hours for a recreational boat to reach the project area from the nearest port of Broome.

Recreational fishing, particularly boat-based angling, occurs throughout the ZPI. Recreational angling is expected to be centred around access nodes, such as marinas and boat launching facilities, found at towns across the Kimberley region. Recreational anglers typically target demersal and pelagic fish species for consumption and sport.

7.3.3.3 Commonwealth Fisheries

Commonwealth fisheries that overlap the Operational Area and ZPI are described in Table 7-12.

Table 7-12: Commonwealth fisheries within the ZPI

Fishery Name	Distance from Prelude (km)	Description
North-west slope trawl fishery	0	The North West Slope Trawl Fishery extends from 114°E to 125°E, from the 200 m isobath to the outer limit of the Australian exclusive economic zone (EEZ). The fishery traditionally targets scampi and deep-water prawns. Fishing for scampi occurs over soft, muddy sediments or sandy habitats, typically at depths of 200–400 m using demersal trawl gear on the continental slope. Activity in the fishery commenced in 1985, peaking at 21 active vessels in 1986-87 (Woodhams and Bath 2017). There are currently very few licence holders active in the fishery and fishing activity has steadily declined since establishment of the fishery. Two vessels operated in the fishery in the 2016-17 season, which is the same as the 2015-16 season. The total area of waters fished in 2016-17 did not include the Operational Area.
Southern bluefin tuna fishery	0	The Southern Bluefin Tuna Fishery is not active within Operational Area or the ZPI; all activity in this fishery occurs well south of the ZPI, primarily off South Australia. As such, the Southern Bluefin Tuna Fishery is not discussed further.
Western tuna and billfish fishery	0	The West Tuna and Billfish Fishery is currently active, running throughout the year. The fishery zoning extends to the Australian EEZ boundary in the Indian Ocean, overlapping the Operational Area. The fishery targets four pelagic species, which are all highly mobile: • broadbill swordfish (*Xiphias gladius*) • bigeye tuna (*Thunnus obesus*) • yellowfin tuna (*T. albacares*) • albacore tuna (*T. alalunga*). The methods used by the fishery are mainly pelagic longline and some minor-line. The number of vessels operating in the fishery has declined in recent years, with less than five vessels operating in the fishery since 2005 (Williams et al. 2017). Effort data shows fishing effort is concentrated off south-west Western Australia and South Australia (Williams et al. 2017).
Skipjack fishery	0	The combined western and eastern skipjack tuna (*Katsuwonus pelamis*) fisheries encompass the entire EEZ, including the Operational Area. The target species has historically been used for canning, and with the closure of canneries at Eden and Port Lincoln effort in the fishery has declined and there have been no active vessels operating since 2009 (Patterson & Bath 2017).

		Given the fishery has been inactive for a number of years and given the distribution of fishing effort when the fishery was active, fishing for skipjack tuna in the Operational Area is highly unlikely. Should the fishery commence efforts in the area in the future, fishing effort in the Operational Area is unlikely given the historical fishery was concentrated off southern Australia.
Northern prawn fishery	395	The Northern Prawn Fishery is located off Australia's northern coast from Cape York, Queensland to Cape Londonderry, Western Australia. It is Australia's second most valuable Commonwealth fishery. The fishery targets six species of prawn: • Red-legged banana prawn (*Penaeus indicus* and *P. merguiensis*) • White banana prawn (*Fenneropenaeus merguiensis*) • Brown tiger prawn (*P. esculentus*) • Grooved tiger prawn (*P. semisulcatus*) • Blue endeavour prawn (*Metapenaeus endeavouri*) • Red endeavour prawn (*M. ensis*). The fishery method is bottom trawling during two seasons – April to June and August to November, with the season end dates depending on the catch rates. In 2017, there were 52 vessels with fishing rights, which is the maximum number of vessels active at one time. The Northern Prawn Fishery management area is located approximately 433 km from the Operational Area.
Western deepwater trawl fishery	1,072	The Western Deepwater Trawl Fishery is permitted to operate only in deep waters from the 200 m isobath, as far north as the North West Cape. This fishery targets a number of deep water demersal finfish and crustacean species. The nominated fishing grounds are extensive. However, most of the fishing effort is south and offshore of the North West Cape, with areas of medium and high-density fishing activity located to the south of Ningaloo Reef and west of Shark Bay. No vessels were active in the fishery in 2014-15 or 2015-16 seasons (Woodhams and Bath 2017).

7.3.3.4 Western Australian Managed Fisheries

State-based Western Australian commercial fisheries that overlap the ZPI are described in Table 7-13.

Table 7-13: Western Australia fisheries within the ZPI

Fishery Name	Distance from Prelude (km)	Description
Mackerel Fishery	0	The Mackerel Managed Fishery targets Spanish mackerel (*Scomberomorus commerson*) using near-surface trawling gear from small vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture grey mackerel (*S. semifasciatus*) (Molony et al. 2015). The commercial fishery extends from Geraldton to the Northern Territory border. There are three managed fishing areas: Kimberley (Area 1), Pilbara (Area 2), and Gascoyne and West Coast (Area 3). The majority of the catch is taken from waters off the Kimberley coasts (Lewis and Jones 2017), reflecting the tropical distribution of mackerel species (Molony et al. 2015). The majority of fishing activity occurs around the coastal reefs of the Dampier Archipelago and Port Hedland area, with the seasonal appearance of mackerel in shallower coastal waters most likely associated with feeding and gonad development prior to spawning (Mackie et al. 2003).
West Coast Deep Sea Crustacean	0	The West Coast Deep Sea Crustacean Managed Fishery extends north from Cape Leeuwin to the WA/NT border in water depths great than 150 m within the Australian Fishing Zone, including the Operational Area. The fishery targets deep water crustaceans, with the vast majority (>99%) of the catch landed in 2015 comprised of crystal crabs (How and Yerman 2017). Two vessels operated in the fishery in 2015, using baited pots operated in a longline formation in the shelf edge waters mostly in depths between 500 and 800 m (How and Yerman 2017). Fishing effort was concentrated between Fremantle and Carnarvon.
South West Coast Salmon	0	The South West Coast Salmon Managed Fishery operates on various beaches south of the metropolitan area and includes all Western Australian waters north of Cape Beaufort except Geographe Bay. No fishing takes place north of the Perth metropolitan area (well beyond the ZPI), despite the managed fishery boundary extending to Cape Beaufort (Western Australia / Northern Territory border).
Northern Demersal Scalefish	0	The Northern Demersal Scalefish Managed Fishery operates off the northwest coast of Western Australia in the waters east of 120°E longitude. The permitted means of operation within the fishery include handline, dropline and fish traps; since

Fishery Name	Distance from Prelude (km)	Description
		2002 it has essentially been a trap-based fishery. Gear restrictions and spatial zones as the primary management measures. The main species landed by this fishery are red emperor and goldband snapper (Newman et al. 2017b). In 2015, there were 7 vessels with fishing rights (Newman et al. 2017b). The Northern Demersal Scalefish Managed Fishery overlaps the Operational Area.
Marine Aquarium and Specimen Shell	28	The Marine Aquarium and Specimen Shell managed fisheries are largely diver-based, with effort concentrated around the Capes region, Perth, Geraldton, Exmouth and Dampier. Effort in these fisheries is relatively low and spread over a large geographic area. Given the nature of the fisheries, effort is expected to be largely restricted to coastal waters < 30 m water depth.
Abalone	28	The Western Australian abalone fishery includes all coastal waters from the Western Australian and South Australian border to the Western Australian and Northern Territory border. The fishery is concentrated on the south coast (greenlip and brownlip abalone) and the west coast (Roe's abalone). Abalone are harvested by divers, limiting the fishery to shallow waters (typically < 30 m). No commercial fishing for abalone north of Moore River (zone 8 of the managed fishery) has taken place since 2011/2012 (Strain et al. 2017).
Broome Prawn	28	The Broome Prawn Managed Fishery is one of the four northern managed prawn fisheries (the others are the Kimberley, Nickol Bay and Onslow prawn managed fisheries). It is the least active of these four fisheries, with 0.3 tonnes of western king prawns and 0.8 tonnes of coral prawns landed in 2015 (Sporer et al. 2017). The extent of the Broome Prawn Managed Fishery is approximately 28 km from the Operational Area.
Kimberley Prawn	47	The Kimberley Prawn Managed Fishery operates between Koolan Island and Cape Londonderry. Its target catch is banana prawns (*Penaeus merguiensis*) but also catches tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus endeavouri*) and western king prawns (*Penaeus latisulcatus*). Landings in 2016 (Sporer et al. 2017) season were 155 tonnes. The catch season is from early April to late November. The extent of the Kimberley Prawn Managed Fishery is located approximately 47 km from the Operational Area.
Kimberley Gillnet and Barramundi	213	The limited entry Kimberley Gillnet and Barramundi Fishery operates from the Western Australian/Northern Territory border to the northern end of Eighty Mile Beach in the nearshore and estuarine zones. The managed fishery boundary extends approximately 3 nm from the shoreline. In 2013, six vessels fished in the Kimberley Gillnet and Barramundi Fishery. The fishery targets barramundi (*Lates calcarifer*), blue threadfin (*Polydactylus macrochir*) and king threadfin (*Eleutheronema*

Fishery Name	Distance from Prelude (km)	Description
		tetradactylum) (Newman et al. 2017a). The extent of the fishery is located approximately 213 km to the east (near to the shoreline) of the Operational Area.
Pearl Oyster Fishery	0	The Western Australian Pearl Oyster Fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. Pearl oysters (Pinctada maxima) are collected by divers in shallow coastal waters along the Northwest Shelf and Kimberley, which are mainly for use in the culture of pearls. The fishery is separated into four management zones; the Prelude FLNG facility lies within management zone 3, however the Operational Area is much deeper than safe diving depths in which pearl oyster fishing occurs. Most pearl fishing occurs in inner continental shelf waters (< 30 m) along the Kimberley and Pilbara coastlines. Given the fishery is diver-based (i.e. restricted to safe diving depths) interaction with fishery participants from the operation of the Prelude FLNG facility are very unlikely.
Pilbara Trap	477	The Pilbara Trap Managed Fishery is one of three fisheries (Pilbara Fish Trawl (Interim) Managed Fishery, Pilbara Line Fishery) that make up the Pilbara Demersal Scalefish Fisheries. The main species that are caught in this subregion are bluespotted emperor (*Anax nigrofasciatus*), red emperor (*Lutjanus seba)* and rankin cod (*Epinephelus multinotatus*). There are six licences in the Pilbara Trap Managed Fishery that are operated across three vessels. Fishing in this area is not restricted by seasons. The extent of the Pilbara Trap Managed Fishery is located approximately 477 km south-west of the Operational Area.
Pilbara Fish Trawl	560	The Pilbara Fish Trawl (Interim) Managed Fishery is one of three fisheries (Pilbara Trap Managed Fishery and Pilbara Line Fishery) that make up the Pilbara Demersal Scalefish Fisheries. The main species that are caught in this subregion are bluespotted emperor (*Anax nigrofasciatus*), red emperor (*Lutjanus seba)* and rankin cod (*Epinephelus multinotatus*). The fishery is restricted to less than approximately 2% of the North West Shelf. The trawling method uses a single net with extension sweeps. The extent of the Pilbara Fish Trawl (Interim) Managed Fishery is located approximately 560 km south-west of the Operational Area.
Nickol Bay Prawn	560	The Nickol Bay Prawn Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear. The target species typically inhabits sandy and muddy substrate in < 45 m water depth. Landings in the fishery in 2015 were approximately 87 tonnes, comprised largely of banana prawns (Sporer et al. 2017). The annual landing in 2015 was approximately 87 tonnes. The catch effort from the 2016 season was 17 tonnes. The extent of the Nickol Bay Prawn Managed Fishery is approximately 560 km from the Operational Area.

Fishery Name	Distance from Prelude (km)	Description
Onslow Prawn	920	The Onslow Prawn Managed Fishery is one of five prawn fisheries that are collectively referred to as the North Coast Prawn Managed Fisheries. The North Coast Prawn Managed Fisheries produced approximately 200-300 t annually. These fisheries all use low opening, otter prawn trawl systems. The catch effort from the 2016 season was negligible; only one boat fished in the Onslow Prawn Managed Fishery area in 2016. The extent of the fishery is located approximately 920 km south-west of the Operational Area.
Exmouth Gulf Prawn	1,263	The Exmouth Gulf Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear within Exmouth Gulf. The target species typically inhabits sandy and muddy substrate in < 45 m water depth. The fishery is of high value, with approximately 1,067 tonnes landed in 2015, with the town of Exmouth the main port for participants in the fishery. The fishery is managed based on input controls, temporal closures and spatial closures (Kangas et al. 2017c).
West Coast Rock Lobster	1,272	The West Coast Rock Lobster Fishery targets the western rock lobster (*Panulirus cygnus*) from Shark Bay south to Cape Leeuwin using baited traps (pots). In 2008, it was determined that the allocated shares of the West Coast Rock Lobster resource would be 95% for the commercial sector, 5% to the recreational sector, and one tonne to customary fishers. The commercial fishery has been Australia's most valuable single-species wild capture fishery. In 2010/2011, the fishery moved to an individually transferable quota fishery. The fishery is managed using zones, seasons and total allowable catch. Landings in 2015 were 6,416 tonnes (de Lestang and Rossbach 2017).
Gascoyne Demersal Scalefish	1,470	The Gascoyne Demersal Scalefish Fishery comprises commercial and recreational fishing for demersal scalefish in the continental waters of the Gascoyne Coast Bioregion. The fishery is located between the southern Ningaloo coast to south of Shark Bay with a closure area from Point Maud to Tantabiddi. Commercial vessels have traditionally targeted the oceanic stocks of pink snapper (*Pagrus auratus*) during the winter months (fishing spawning aggregations in peak season of June to July). The present fishery also targets other demersal species including the goldband snapper (*Pristipomoides* spp.), red emperor (*Lutjanus sebae*), other emperors and cod.
Shark Bay Scallop	1,512	The Shark Bay Scallop Managed Fishery targets saucer scallops (*Ylistrum balloti*) using otter trawls. The stock is currently recovering after sustained poor recruitment since 2010 (Kangas et al. 2017a). Annual catches in the fishery are highly variable due to recruitment. Scallops occur on sandy and muddy sediments, which may also host commercially exploited prawns; a number of vessels participate in both the Shark Bay Scallop Managed Fishery and the Shark Bay Prawn Managed Fishery (Kangas et al. 2017a).

Fishery Name	Distance from Prelude (km)	Description
Shark Bay Prawn	1,512	The Shark Bay Prawn Managed Fishery is the highest producing Western Australian fishery for prawns. It targets the western king prawn (*Penaeus latisulcatus*) and brown tiger prawn (*P. esculentus*) and takes a variety of smaller prawn species including endeavour prawns (*Metapenaeus* spp.) and coral prawns (various species). Prawns are caught using otter trawls over sandy or muddy substrates, with over 2,000 tonnes landed in 2015 (Kangas et al. 2017b). A number of vessels active in the Shark Bay Prawn Managed Fishery also fish in the Shark Bay Scallop Managed Fishery.
Shark Bay Crab	1,670	The blue swimmer crab (*Portunus armatus*) resource in Shark Bay is harvested commercially by the Shark Bay crab trap, prawn trawl and scallop trawl fisheries. Commercial fishing for blue swimmer crabs in Shark Bay was voluntarily halted by industry in April 2012 to facilitate stock rebuilding. The fishery was reopened in 2013/14, with a 450 tonne catch limit instituted for the 2015 season.
Shark Bay Beach Seine and Mesh Net	1,685	The Shark Bay Seine and Mesh Net Managed Fishery operates from Denham and used a combination of beach seine and mesh net gears to mainly take four species/groups including whiting (mostly yellowfin with some goldenline), sea mullet (*Mugil cephalus*), tailor (*Pomatomus saltatrix*) and western yellowfin bream (*Acanthopagrus morrisoni*). This fishery is managed by limited entry, gear restrictions (e.g. vessel size, net length and mesh size) and permanently closed waters (e.g. Hamelin Pool, Big Lagoon, Denham foreshore).
West Coast Demersal Scalefish	1,765	The West Coast Demersal Scalefish Fishery comprises inshore and offshore suites of demersal scalefish species that are exploited by different commercial fisheries, recreational and charter fishers operating in the West Coast Bioregion. The West Coast Inshore Demersal suite occurs in waters < 250 m deep and is comprised of approximately 100 different species, the most important of which are West Australian dhufish (*Glaucosoma hebraicum*) and pink snapper (*Pagrus auratus*). Less important species include redthroat emperor (*Lethrinus miniatus*), bight redfish (*Centroberyx gerrardi*) and baldchin groper (*Choerodon rubescens*). The West Coast Offshore Demersal suite occurs in waters < 250 m deep and includes eightbar groper (*Hyporthodus octofasciatus*), hapuka (*Polyprion oxygeneios*), blue-eye trevalla (*Hyperoglyphe antactica*) and ruby snapper (*Etelis carbunculus*). Access to the fishery is limited. Gear and other restrictions apply in the form of maximum number of lines and hooks and arrangements regulating the carriage of lines and fish.

7.3.3.5 Northern Territory Managed Fisheries

Northern Territory-based commercial fisheries that overlap the ZPI are described in Table 7-14.

Table 7-14: Northern Territory fisheries within the ZPI

Fishery Name	Distance from Prelude (km)	Description
Aquarium Fishery	537	The Northern Territory Aquarium Fishery targets a range of marine, estuarine and freshwater species for the aquarium trade, including finfish (e.g. freshwater rainbowfish), invertebrates (e.g. hermit crabs) and plants. Fishing is typically either from boat or shore by diving, nets and hand collection. These methods restrict fishing activity in shallow coastal, estuarine and riverine waters. There are approximately 11 licences and three boats active in the fishery each year. The managed fishery area extends to the edge of the Australian fishing zone (200 NM from the coast) and is partially overlapped by the ZPI. Given activity in the fishery is restricted to coastal waters, the operation of the Prelude FLNG facility is unlikely to impact upon the fishery.
Offshore Net and Line Fishery	537	The Offshore Net and Line Fishery covers an area of over 522,000 km^2 and extends from the NT high water mark to the boundary of the Australian fishing zone (NT Government 2017). The fishery permits both pelagic gillnets and longline gear and targets Australian and common blacktip sharks, spottail sharks and grey mackerel; however, longlines have not been used since 2013 due to a drop in shark fin price (NT Government 2017). The majority of the fishing effort is in the coastal zone (within 12 NM of the coast) and immediately offshore in the Gulf of Carpentaria (NT Government 2017). Effort beyond 12 NM from shore is typically very low The number of licences for the fishery is restricted to 17 and generally 11 licences are active in any given year (NT Government 2017).
Spanish Mackerel Fishery	537	The fishery extends from the NT high water mark to the outer limit of the Australian fishing zone (NT Government 2017). The fishery employs troll lines, floating handlines and rods. The majority of the fishing effort occurs in the vicinity of reefs, headlands and shoals and includes waters near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt and the Sir Edward Pellew Group of islands (NT Government 2017). The target species of the fishery is the narrow-barred Spanish mackerel, however a small number of other mackerels are also taken.

Fishery Name	Distance from Prelude (km)	Description
Demersal Fishery	540	The Demersal Fishery boundary extends from 15 nautical miles from the NT coastal waters mark to the outer limit of the Australian fishing zone, excluding the area of the Timor Reef Fishery. The fishery employs trawl, hand and drop lines, and trap fishing methods. The main target species of the fishery are red snappers, goldband snappers, saddletail, and crimson snapper. There are currently 18 licences issued for the fishery (NT Government 2017).
Timor Reef Fishery	569	The Timor Reef Fishery operates in remote offshore waters in the Timor Sea in a defined area approximately 370 km north-west of Darwin. The fishery extends north-west of Darwin to the WA-NT border and to the outer limit of the AFZ and covers an area of ~28,811 km^2 (NT Government 2017). The target species is goldband snapper, with other tropical snappers such as crimson snapper and saddletail snapper also consisting part of the catch. The majority of the fishing effort is undertaken using drop-lines and occurs primarily in the 100 – 200 m depth range.
Pearl Oyster Fishery	537	The Northern Territory pearl oyster fishery is currently a small diver-based fishery collecting pearl shell for mother-of-pearl. Most pearl oysters used in aquaculture in the Northern Territory are reared from hatchery stock, which are grown at farms locations are in waters around Darwin and East Arnhem Land (beyond the ZPI). Fishing for pearl oysters is diver-based, with five licences currently issued to fishers. The managed fishery area extends from the Australian coastline to the edge of the Australian fishing zone. As the fishery is diver-based, fishing activity is likely to be restricted to occupational diving depths (< 30 m). Hence, fishing activity may only occur in a very limited part of the managed fishery area. Given activity in the fishery is restricted to coastal waters, the operation of the Prelude FLNG facility is unlikely to impact upon the fishery.
Coastal Line Fishery	618	The Coastal Line fishery extends 15 nautical miles from the low water mark around the entire NT coastline. The fishery is divided into two zones, which divide the coastline at Vashon Head on the Cobourg Peninsula (NT Government 2017). The majority of fishing effort is focused around rocky reefs within 150 km of Darwin where Black Jewfish are targeted using mainly hook and line gear (NT Government 2017). Fish traps and droplines are also permitted beyond 2 NM from the coastline in the Eastern Zone of the fishery, and gillnets with a maximum drop of 5 m are also permitted (NT Government 2017). Catch from droplines and traps account for less than 7% of the total reported catch (NT Government 2017).

7.3.3.6 Aquaculture

There are no aquaculture operations within the Operational Area; aquaculture is typically restricted to shallow coastal waters. Aquaculture in the region consists primarily of culturing hatchery reared and wild caught oysters (*Pinctada maxima*) for pearl production, which is primary centred around Broome and the Dampier Peninsula. Leases typically occur in shallow coastal waters at depths of less than 20 m (Fletcher et al. 2006).

7.3.4 Tourism and Recreation

No tourism activities are known to occur within the Operational Area, but tourism activities occur widely in the ZPI. Most tourism in the ZPI is nature-based and hence is typically associated with outstanding natural features such as the Kimberley coastline and the offshore reefs and islands (e.g. Rowley Shoals). The remoteness of the region results in most offshore tourism activities being conducted from organised expeditions based on larger vessels.

Tourism makes a significant contribution to the regional economy, with the town of Broome (beyond the ZPI) providing a central node for many tourism-related activities in the region.

7.3.5 Defence

There are no defence exercise areas within the Operational Area or the ZPI, but defence activities may occur within the ZPI.

7.3.6 Shipping

Shipping activity in the vicinity of the Operational Area is considered high. However, almost all vessel activities in the Operational Area are associated with the operation of the Prelude FLNG facility and Ichthys facilities (e.g. offtake tankers, support vessels etc.).

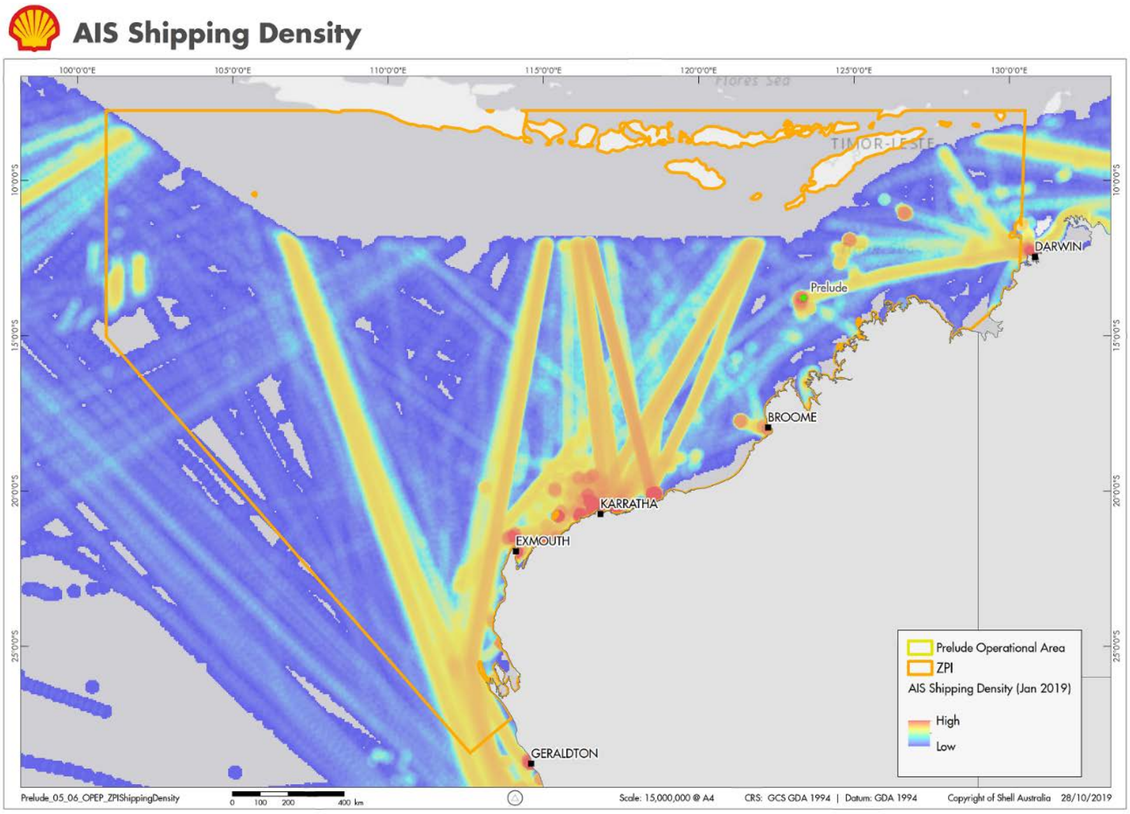


Figure 7-12: Shipping levels within the operational area and broader ZPI

7.3.7 Indonesian Coastline

The Indonesian is located over 300 km north of the Operational Area at the closest point, near the limits of the ZPI.

Indonesia is the world's largest archipelagic state and Indonesian waters play an important role in the global water mass transport system (Asian Development Bank ADB] et al. 2014). Indonesia has some of the most biologically rich coral reefs in the world with over 590 coral species having been identified. Coastal reefs are a primary source of food and income for coastal communities, as well as forming an integral part of the countries tourism industry (ADB et al. 2014). Coastal areas also support aquaculture production of algae, finfish and crustaceans. In addition to coral reefs, coastal habitats include sandy beaches, rocky shorelines, seagrass meadows, and mangroves.

7.3.8 Oil and Gas Industry

Oil exploration activities in the Timor Sea commenced in the late 1960s. Since this time numerous wells have been drilled throughout the region. Petroleum exploration has been active in the Browse Basin since the 1980s, with several commercial discoveries since that time. It is expected that petroleum exploration and development activities will continue in the region into the future.

There are several operating petroleum production facilities in the vicinity of the Prelude FLNG facility. The Ichthys facilities are the closest, situated approximately 20 km south of the Operational Area. The Montara facility is located approximately 188 km north-east of the Operational Area.

8.0 Acceptable Levels of Impact and Risk for the Petroleum Activities

The OPGGS (E) Regulations require the titleholder include an evaluation of all the impacts and risks that determined whether these will be of an 'acceptable' or 'unacceptable' level. To this end, Shell has determined acceptable levels of impact to the environmental receptors that may credibly be impacted by the petroleum activities considered within this EP. The process by which Shell has determined the acceptability of risks and impacts is detailed below.

8.1 Considerations in Developing Defined Acceptable Levels of Impact and Risk

Shell has established defined acceptable levels of impacts and risks for the petroleum activities considered in this EP relating to all the environmental receptors that were identified as being credibly impacted, or at risk of being impacted. The outcomes of the evaluation of environmental impacts and risks were assessed against these defined acceptable levels to determine if the impacts or risks were acceptable.

The following were considered when establishing the acceptable levels of impacts and risks:

- The principles of ESD
- Other requirements applicable to the Prelude project (e.g. laws, policies, standards, conventions etc.)
- Significant impacts[6] to MNES
- Internal context and
- External context.

Each of these considerations are elaborated on below.

8.1.1 Principles of Ecologically Sustainable Development

Shell has considered the principles of ESD in defining acceptable levels of impacts and risks, as defined in Section 3A of the EPBC Act 1999. The principles of ESD are summarised as:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

[6] Significant impacts refer specifically to the levels of impacts defined in the Matters of National Environmental Significance - Significant impact guidelines 1.1. Any subsequent reference in this EP to significant impacts refers to these levels unless stated otherwise.

- The principles of inter-generational equity – that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
- Improved valuation, pricing and incentive mechanisms should be promoted.

8.1.2 Other Relevant Requirements

Shell considered other relevant requirements that apply to the environmental management of the petroleum activities considered in this EP, including legislation, policies, standards and guidelines in establishing acceptable levels of impacts and risks (Refer to Section 3.0).

8.1.3 Significant Impacts to MNES

Given this EP forms the basis for NOPSEMA's assessment of matters protected under Part 3 of the EPBC Act in Commonwealth waters, Shell has given specific attention to the acceptability of impacts and risks to MNES. Where a potential interaction between the relevant MNES and an aspect of the petroleum activities covered by this EP was identified, the criteria provided are listed in Table 8-1.

Potential impacts and risks to MNES from aspects of the petroleum activities were deemed inherently acceptable if:

- The significant impact criteria in relation to the MNES are not anticipated to be exceeded
- The management of the aspect is aligned with published guidance material from the DAWE, including threat abatement plans, recovery plans and conservation advice.

Additionally, the Prelude FLNG project was assessed under the EPBC Act as an Environmental Impact Statement; and a series of conditions were applied to the project as a result of this assessment. These conditions are summarised in Table 3-2 which includes cross-references to the relevant sections within the EP and supporting documentation demonstrating how the requirements have been met.

Table 8-1: MNES Significant impact criteria applied to the petroleum activities considered in this EP

Category	Significant Impact Criteria
Listed Critically Endangered and Endangered species	An action is likely to have a significant impact on critically endangered or endangered species if there is likelihood that it will: • Lead to a long-term decrease in the size of a population • Reduce the area of occupancy of the species • Fragment an existing population • Adversely affect habitat critical to the survival of a species • Disrupt the breeding cycle of a population • Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat • Introduce disease that may cause the species to decline, or • interfere with the recovery of the species.

Category	Significant Impact Criteria
Listed Vulnerable Species	An action is likely to have a significant impact on vulnerable species if there is a likelihood that it will: • Lead to a long-term decrease in the size of an important population • Reduce the area of occupancy of and important population • Fragment an existing important population into two or more populations • Adversely affect habitat critical to the survival of a species • Disrupt the breeding cycle of a population • Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat • Introduce disease that may cause the species to decline, or • Interfere substantially with the recovery of the species.
Listed Migratory Species	An action is likely to have a significant impact on migratory species if there is likelihood that it will: • Substantially modify, destroy or isolate an area of important habitat for a migratory species • Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or • Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species.
Wetlands of International Importance	An action is likely to have a significant impact on a wetland of international importance if there is likelihood that it will result in: • Areas of wetland being destroyed or substantially modified • A substantial and measurable change in the hydrological regime of the wetland • The habitat or lifecycle of native species dependent upon the wetland being seriously affected • A substantial and measurable change in the water quality of the wetland which may adversely impact on the biodiversity, ecological integrity, social amenity or human health, or • An invasive species that is harmful to the ecological character of the wetland being established in the wetland.
Commonwealth Marine Area	An action is likely to have a significant impact on the environment in a Commonwealth Marine Area if there is likelihood that it will: • Result in a known or potential pest species becoming established in the Commonwealth marine area • Modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity on a Commonwealth marine area results • Have a substantial adverse effect on a population of a marine species or cetacean including its life cycle and spatial distribution • Result in a substantial change in air quality or water quality which may adversely impact on biodiversity, ecological integrity[7], social amenity or human health

[7] In the context of the Prelude FLNG, a change to ecological integrity is considered to take into account broadscale, long term impacts to the ecosystem. With regards to the Commonwealth marine environment, the operational area is located in open offshore waters and the seabed is generally characterised by soft sediments. These characteristics are typical of the offshore Browse Basin."

Category	Significant Impact Criteria
	• Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity[2], social amenity or human health may be adversely affected, or • Have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck.

8.1.4 Internal Context

Shell considered its internal requirements when establishing acceptable levels of impacts and risks. This context included Shell's environment policy, environmental risk management framework, internal standards, procedures, technical guidance material and opinions of internal stakeholders.

The following outlines Shell's internal impact and risk assessment defined acceptable levels:

- Residual planned impacts that are ranked as minor or less (i.e. minor, slight, no effect or positive effect) and residual risks for unplanned events ranked light or dark blue, are inherently 'acceptable', if they meet legislative and Shell requirements and the established acceptable levels of impacts and risks.
- Moderate residual impacts, and yellow and red residual risks, are 'acceptable' with appropriate controls in place and if good industry practice can be demonstrated.
- Major and massive residual impacts from planned activities, and massive residual risks from unplanned activities, are 'unacceptable'. The activity (or element of) should not be undertaken as the impact or risk is serious and does not meet the principles of ESD, legal requirements, Shell requirements or regulator and stakeholder expectations. The activity requires further assessment to reduce the risk to an acceptable level.

Table 8-2 provides a summary of the acceptability statements, as correlated to the rankings presented in the environmental impact and risk assessments in Section 9.0

Table 8-2: Acceptability Categories

Acceptability Statement	Residual Impact (Planned)	Residual Risk (Unplanned)
Inherently acceptable - Manage for continuous improvement through effective implementation of the HSSE and SP management system	• Positive Impact Consequence • No Impact Consequence • Slight Impact Consequence • Minor Impact Consequence	• Light Blue • Dark Blue
Acceptable with controls - Apply the hierarchy of control to reduce the risks to ALARP	• Moderate Impact Consequence	• Yellow • Red
Unacceptable	• Major Impact Consequence • Massive Impact Consequence	• Red - X

8.1.5 External Content

Shell also considered the external context when establishing acceptable levels of impacts and risks. This includes information provided by stakeholders during the preparation of the EP and the Prelude FLNG EIS. Shell routinely implements an ongoing stakeholder engagement program managed by Shell's EGR team. Reference is made to Section 5.0 for further information on the stakeholder engagement process and a summary of responses and objections/claims made by Relevant Persons is included in Table 5-3 and Table 5-4 which have informed the defined acceptable levels of impact.

8.1.6 Defined Acceptable Levels of Impact and Risk

The acceptable levels of impacts and risks to environmental receptors from the petroleum activities considered in this EP are summarised in Table 8-3.

Table 8-3: Summary of acceptable levels of impact for environmental receptors that may be affected by the petroleum activities considered in this EP

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
Physical Environment	**Water quality**	Limited environmental impact to water quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	As the larger impact footprint compared to support vessels there are routine planned liquid discharges from the facility. This may result in localised water quality impacts in the immediate vicinity. Modelling studies indicate the impacts will be localised around the facility which is characterised as open offshore waters; typical of and well represented within the Browse Basin. Liquid discharges from the FLNG cannot be avoided. However, the area influenced from routine operational discharges is expected to be limited to within 1 km of the liquid discharge locations. The potential magnitude of impacts to marine ecosystems is slight. Given the offshore location and absence of particularly sensitive marine ecosystems at the FLNG location and immediate surrounds, potential impacts within 1 km of the FLNG are considered acceptable.
	Sediment quality	Limited environmental impact to sediment quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	The liquid discharges from the facility (e.g. PFW, drainage water) may increase the concentration of potential contaminants within sediments around Prelude following settlement, precipitation and/or adsorption to particulates. This slight elevation in contaminant levels above background concentrations is anticipated to occur over decades as described further in Section 9.9. Sediment quality in the vicinity of the FLNG and Operational Area is characteristic of the conditions of the offshore region and well represented within the Browse Basin. Impacts to sediment quality from the project cannot be completely avoided. However, the area influenced is expected to be limited to within 1 km of sources of potential sediment contamination (e.g., a result of discharges from the FLNG). The potential magnitude of impacts to marine ecosystems is slight. These impacts are considered to be acceptable when

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
			considering the seabed is smooth and bare of hard substrates, with predominantly sandy sediments observed.
	Air quality	Limited environmental impact to air quality. Defined as no substantial change in air quality which may adversely impact on biodiversity, ecological integrity social amenity or human health. No significant impacts to air quality during the project.	The Operational Area is located in the open ocean and is far-removed from the nearest residential or sensitive populations of the WA coast, with limited interaction with regional airsheds. It should be noted that risks and impacts to the workforce associated with this petroleum activity are addressed in the corresponding Safety Case and are not addressed in this EP. The MNES Significant Impact Guidelines 1.1 under the EPBC Act 1999 (DoE 2013) define significant impact to air quality as ‘substantial change in air quality which may adversely impact on biodiversity, ecological integrity; social amenity or human health’. There is no definition of the term ‘substantial’ however the above definition highlights that the main concerns are impacts on biodiversity, ecological integrity, social amenity or human health. Due to the lack of background air quality, the National Environment Protection Measures (NEPM) Air Quality and Air Toxics guidelines will be used to judge acceptability of impact on air quality. This is deemed acceptable as the air quality criteria are already conservatively set to afford protection for the health of the general population including its most vulnerable groups such as children and the elderly.
Biological Environment	**Benthic communities**	Limited environmental impact which directly impacts bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities which adversely effects biological diversity or ecological integrity. Limited environmental impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.	Benthic habitats and communities within the Operational Area are widely represented in the Browse Basin, with millions of hectares of similar broad-scale soft benthic habitats occurring in the region and they are not considered of high environmental value. Given there are no named banks, shoals, reefs or islands located within the Operational Area, direct disturbance to benthic habitats contained within the Operational Area are deemed acceptable. Sensitive benthic receptors (corals, macroalgae, seagrasses and mangroves) associated with shoals, banks, reefs and islands of the Browse Basin and Timor Sea, are considered of high environmental value. Shell considers direct impacts to these receptors as unacceptable. Given the separation distance from the FLNG, these receptors would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. Shell considers any large-scale hydrocarbon spill to be unacceptable.

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
	Pelagic communities (Non-Threatened or Migratory)	Limited environmental impact leading to adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	The waters surrounding the facility are characterised as open offshore waters, typical of the offshore Browse Basin. Resident and transient pelagic species and associated habitat within the Operational Area are not specifically protected or unique and are not considered of high environmental value. Species are regionally well represented and considered typical of the Browse Basin and Timor Sea.
	Key Ecological Features (KEFs)	Limited impact to environmental values of KEFs	KEFs in the Browse Basin are largely geomorphic features that provide important ecosystem services primarily as a result of their unique physical features (e.g. provision of hard substrates, facilitation of upwelling etc.). These are geographically diverse features that cover a large extent. Given there are no planned impacts to KEFs from the Prelude project, any impacts to KEFs will be below the significant impact threshold. Shell considers any impacts to KEFs to be unacceptable.
	Threatened Species and Ecological Communities	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations. Management of aspects of the project must be aligned to conservation advice, recovery plans and threat abatement plans, including for bird and marine turtle species.	Threatened ecological communities – Refer to Section 7.2.4. The waters surrounding the FLNG facility are characterised as open offshore waters, typical of the offshore Browse Basin. Resident and transient species and associated habitat within the Operational Area are not specifically protected or unique and are not considered of high environmental value. Species are regionally well represented and considered typically of the Browse Basin and Timor Sea.
	Ramsar Wetlands	Limited environmental impacts to ecological values of Ramsar wetlands	Ramsar wetlands would only be impacted by a large-scale hydrocarbon spill., such as a well blowout. In a regional environmental context, the nearest Ramsar wetland is 169 km away (Ashmore Reef). Shell considers any large-scale hydrocarbon spill to be unacceptable.
	Threatened and Migratory Species	Limited environmental impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations (Refer to Table 8-1).	Shell considers significant impacts to MNES to be unacceptable. Impacts that are below the significant impact threshold defined in Table 8-1 are considered as acceptable.

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
	Commonwealth Marine Area	Limited environmental impacts to the Commonwealth Marine Area (Refer to Table 8-1).	Shell considers significant impacts to MNES to be unacceptable. Impacts that are below the significant impact threshold defined in Table 8-1 are considered as acceptable.
	WA Mainland Coastline	Limited environmental impacts to mainland coastline.	The WA mainland coastline would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. Shell considers any large-scale hydrocarbon spill to be unacceptable.
Socio-economic and Cultural Environment	**Heritage**	Limited environmental impacts to defined heritage values	Listed heritage values would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. In a regional environmental context, the nearest heritage place is 155 km away and the nearest named shipwreck is 18 km away (Refer to Section 7.3.1). Shell considers any large-scale hydrocarbon spill to be unacceptable.
	Marine Protected Areas	Limited environmental impacts to ecological values of Marine Protected Areas	Marine Protected Areas would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. In a regional environmental context, the nearest marine protected area is the Commonwealth Kimberley AMP (approximately 111 km from the FLNG). Shell considers any large-scale hydrocarbon spill to be unacceptable.
	Fishing Industry	No interference with fishing to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Impacts or restricted access to targeted fish stocks may measurably reduce the potential revenue for commercial fishers, charter operators or other benefits provided to traditional fishers. Shell considers this to be unacceptable. In a regional context, commercial, recreational and traditional fishing is typically concentrated mostly in coastal/shallow waters and minimum fishing effort is known to occur within the vicinity of the Operational Area, given its remoteness offshore. Shell considers the displacement of other users (e.g. commercial, recreational and traditional fishers) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective.
	Tourism and Recreation	No negative impacts to nature-based tourism resources resulting in demonstrated loss of income.	Impacts to nature-based tourism resources may deprive the tourism industry of revenue. Shell considers this to be unacceptable. In a regional context, there are no known tourist attractions or destinations within the Operational Area or nearby surrounds, however charter vessels may transit the broader regional waters. Shell considers the displacement of other users (e.g. tourism operators) from the Operational Area, which is a relatively small area of the open ocean environment where existing tourism and recreation use is very low, to be acceptable and

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
			necessary from a safety and security perspective.
	Defence	No interference with defence activities as directed by the Department of Defence.	Shell considers the displacement of other users (e.g. defence vessels and aircraft) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective. In a regional context, there are no designated military/defence exercise areas in the facility area and surrounds, however there are regional defence exercise areas with large geographic extents.
	Shipping	No interference with navigation to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Shell considers the displacement of other users (e.g. commercial shipping) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective. In a regional context, the major shipping routes traversing the Operational Area are associated with the Prelude FLNG and Ichthys facilities.
	Oil and Gas Industry	No interference with other titleholders to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out the petroleum activities	Shell considers the displacement of other users (e.g. petroleum exploration and operations) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective. In a regional context, the nearest facility/field to the Prelude FLNG is the Ichthys development which lies approximately 17 km south of the Operational Area.
	Indonesian and Timor-Leste Coastlines	No impacts to Indonesian or Timor-Leste coastlines or nearshore environments are acceptable.	The Indonesian and Timor-Leste coastlines could only be impacted by a large-scale hydrocarbon spill., such as a well blowout. Shell considers any large-scale hydrocarbon spill to be unacceptable.

9.0 Evaluation of Environmental Impacts and Risks

9.1 Introduction

This section documents the process that identifies and evaluates potential environmental impacts and risks and develops means of mitigating the effects of planned activities and the likelihood of unplanned activities of the petroleum activity on the environment, including socio-economic and cultural impacts. It describes the approach undertaken to evaluate the magnitude and severity of impact to environmental and social receptors from activities associated with the petroleum activities. The resulting proposed management controls form the basis of the Implementation Strategy (refer Section 10.0) which will be implemented during the petroleum activity.

9.1.1 Shell Company Approach to Risk Management

At a corporate level, Shell has a standardised Hazards and Effects Management Process (HEMP), as the process by which Shell identifies and assesses hazards and implements measures to manage them. This process is consistent with the principles outlined in the Australian Standard AS/NZS ISO 31000:2009 Risk Management and Handbook 203:2006 Environmental Risk Management (Figure 9-1). HEMP is a fundamental element of the Shell Group HSSE and SP Control Framework and is a process that is applied at every phase of projects and operations.

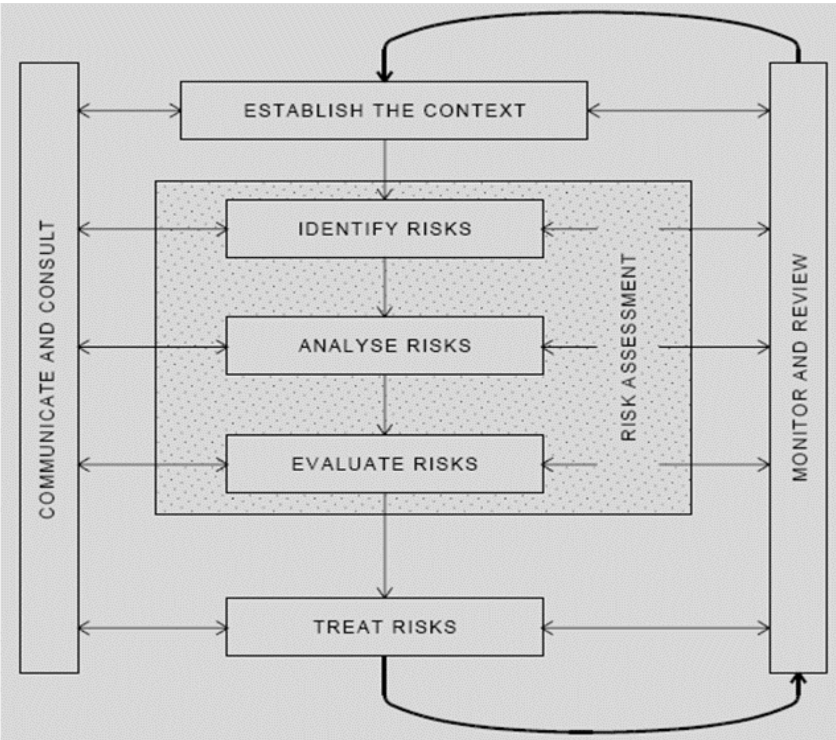


Figure 9-1: Risk Management Framework (AS/NZS 4360:2004 Risk Management

Shell's HSSE and SP Management System is a system that is continually improving due to incorporation of legislative requirements, changing community expectations, improved available technology, ongoing stakeholder engagement, learning from incidents industry wide and within Shell, and regular management review. Assurance that the HSSE and SP Management System is working, continually improving and that each Shell company is correctly applying new Shell standards occurs via local self-assurance and the Shell Global auditing process, which is ongoing and serves to identify gaps and drive gap closure.

Company standards are at least equal to, but in many cases, more stringent than local legislation, and aligned with global good industry practice benchmarks such as those published by the IFC and World Bank. Both legislation and company standards are continually being updated and requiring a higher level of performance over time. Concurrently, new technologies are becoming available and making improved performance possible and more affordable. This continual improvement is reflected in more challenging ALARP and acceptability benchmarks, leading to better environmental outcomes over time.

The OPGGS (E) Regulations 13(5)(b) requires that the EP includes 'an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk'. This is further clarified by Reg. 13(6) which states that: 'To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all environmental impacts and risks arising directly or indirectly from (a) all operations of the activity; and (b) potential emergency conditions, whether resulting from accident or any other reason.' Based on this, Shell has chosen to present ALARP demonstrations for all identified impacts and risks, regardless of their ranking.

The succeeding sections detail the environmental impacts and risks of operations associated with the Prelude FLNG petroleum activities on the local and wider environment, including socio-economic considerations. Activities are described in terms of magnitude/sensitivity and ranking of planned impacts and unplanned risks. A description of management actions proposed to reduce any effect on the environment to ALARP is also presented.

In preparation of this EP, from June through September 2019, a detailed desktop review of the impact and risks assessments were carried out by various environment professionals (Prelude Environment Lead, Shell Australia Environment Lead for Approvals and GHG, and environmental consultants). The review included the alignment with previous environmental MoCs for the in-force EP, followed by a detailed desktop assessment, and subsequent peer review of others work to ensure consistency was applied across the impact and risk assessment review. Throughout the desktop assessment additional supporting information such as current forecasts from Shell's business planning processes were also used to provide input to the impact assessment.

9.2 Impact Assessment Methodology

This section describes the approach adopted for identifying and assessing impacts on the environment as relevant to the petroleum activities. Planned activities give rise to environmental impacts, while unplanned and accidental events pose a risk of environmental impact, if they occur. The risk ranking of environmental impacts resulting from unplanned or accidental events is evaluated by identifying the worst-case credible consequence (without controls) and then assessing the likelihood for the event occurring (with confirmed controls in place).

The approach aligns with Shell's methodology that enables a balanced assessment of planned impacts and unplanned risks, noting that there are some difficulties in relying solely on the corporate Shell Risk Assessment Matrix (RAM) for assessment of planned environmental impacts. Therefore, an adapted methodology has been developed by Shell (United Kingdom), for use across Shell Group companies, that ties together both potential 'Magnitude' of a predicted impact and the 'Receptor Sensitivity' as shown in a summary impact ranking matrix (see Section 9.2.2). The matrix is used for the assessment of impacts consequences for both planned and unplanned events. However, for the assessment of unplanned events, the additional likelihood of occurrence of an event is considered to determine the risk ranking (See Section 9.2.3).

For the purpose of this assessment, key terminology is defined in Table 9-1.

Table 9-1: Definition of Key Terminology for Impact Assessment

Term	Definition
Acceptable	The level of impact and risk to the environment that may be considered broadly acceptable regarding all relevant considerations.
Activity	Components or elements of work associated with the project. All activities associated with the project have been considered at a broad level (as outlined in Section 6).
ALARP	The point at which the cost (in time, money and effort) of further Risk or Impact reduction is grossly disproportionate to the Risk or Impact reduction achieved
Aspect	Elements of the proponent's activities or products or services that can interact with the environment. These include planned and unplanned (including those associated with emergency conditions) activities.
Control	A measure which prevents and/or mitigates risk by reducing the overall likelihood of a worst-case credible consequence occurring. Controls include existing controls (i.e. Company management controls or industry standards) or additional controls (i.e. additional measures identified during the risk assessment processes).
Event	An occurrence of a particular set of circumstances. An event can be one or more occurrences and can have several initiating causes.
Factor	Relevant physical, biological, socio-economic and cultural features of the environment. These are also referred to as values, sensitivities and/or receptors.
Hazard	A substance, situation, process or activity that has the ability to cause harm to the environment.
Impact	Any change to the environment from a planned activity, whether adverse or beneficial, wholly or partially resulting from a proponent's environmental aspects.
Impact Consequence	The outcome of a planned or unplanned event, which can lead to a range of worst case, credible consequences. A consequence can be certain or uncertain and can have positive or negative effects. Consequences can be expressed qualitatively or quantitatively.
Inherent risk	The potential exposure defined as the plausible worst-case event in the absence of controls
Likelihood	Description of probability or frequency of a consequence occurring with controls in place.
Residual risk	The level of risk remaining after risk treatment, i.e. application of controls (inclusive of unidentified risk).
Residual Impact	The level of impact remaining after impact treatment, i.e. application of controls (inclusive of unidentified impact).

9.2.1 Aspects and Impact/Risk Identification

The initial identification of aspects and potentially associated impacts/risks is carried out prior to any detailed assessment of the relative importance of each issue, the sensitivity of the existing environmental and/or socio-economic values, or the magnitude of the potential impact, and does not consider potential control measures.

The key aspects arising from the Prelude petroleum activities have been identified as:

- Physical presence
- Lighting
- Underwater noise
- Seabed disturbance
- Vessel movements (unplanned)
- Liquid discharges
- Atmospheric emissions
- Greenhouse gas emissions
- Waste (unplanned)
- IMS (unplanned)
- Loss of containment (including unplanned spills).

9.2.2 Evaluation of Impacts

Impact Consequence Assessment

The ranking of environmental impact consequence is assessed in terms of:

- magnitude based on the size, extent and duration/frequency of the impact; and
- the sensitivity of the receiving receptors.

These are described further below.

Magnitude

Levels of magnitude of environmental impacts are outlined in Table 9-2. The magnitude of an impact or predicted change takes into account the following (shown descriptively in Figure 9-2):

- nature of the impact and its reversibility
- duration and frequency of an impact
- extent of the change
- potential for cumulative impacts.

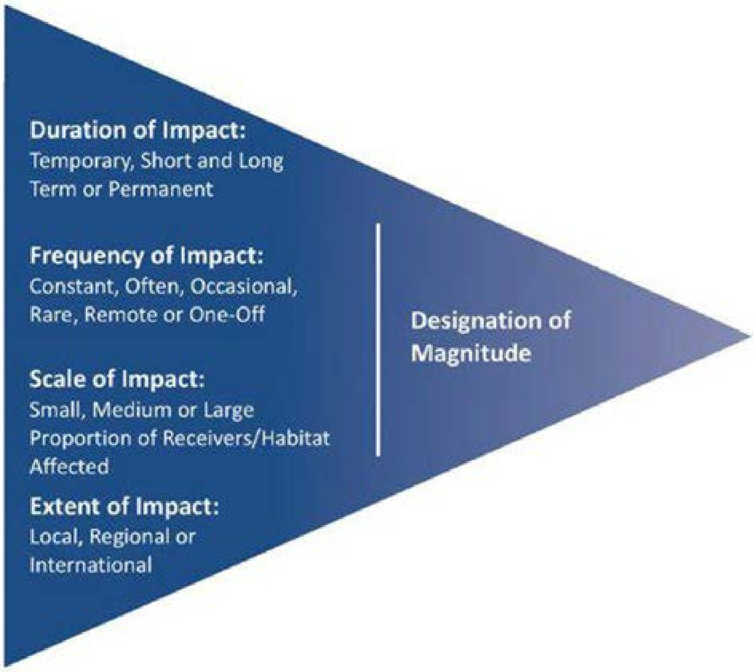


Figure 9-2: Definition of Magnitude in the Context of Impact Identification and Classification

The impact magnitude is defined differently according to the type of impact. For readily quantifiable impacts, such as noise or liquid discharge plume extent, numerical values can be used while for other topics (e.g. communities and habitats) a more qualitative definition is applicable. These criteria capture high level definitions, adapted as appropriate to the offshore context of the Prelude project.

Table 9-2: Magnitude Criteria

+1	• Net positive effect arising from a proposed aspect of the petroleum activity
0	• No environmental damage or effects
-1	• Slight environmental damage contained within the Operational Area • Effects unlikely to be discernible or measurable • No contribution to trans-boundary or cumulative effects • Short-term or localised decrease in the availability or quality of a resource, not effecting usage
-2	• Minor environmental damage, no lasting effects or persistent effects are highly localised • Minor change in habitats or species • Unlikely to contribute to trans-boundary or cumulative effects • Short-term or localised decrease in the availability or quality of a resource, likely to be noticed by users
-3	• Moderate environmental damage that will persist or require cleaning up • Widespread change in habitats or species beyond natural variability • Observed off-site effects or damage, e.g. fish kill or damaged habitats • Decrease in the short-term (1–2 years) availability or quality of a resource affecting usage • Local or regional stakeholders' concerns leading to complaints

	• Minor trans-boundary and cumulative effects
-4	• Severe environmental damage that will require extensive measures to restore beneficial uses of the environment • Widespread degradation to the quality or availability of habitats and/or wildlife requiring significant long-term restoration effort • Major oil spill over a wide area leading to campaigns and major stakeholders' concerns • Trans-boundary effects or major contribution to cumulative effects • Mid-term (2–5 year) decrease in the availability or quality of a resource affecting usage • National stakeholders' concern leading to campaigns affecting Company's reputation
-5	• Persistent severe environmental damage that will lead to loss of use or loss of natural resources over a wide area • Widespread long-term degradation to the quality or availability of habitats that cannot be readily rectified • Major impact on the conservation objectives of internationally/nationally protected sites • Major trans-boundary or cumulative effects • Long-term (> 5 year) decrease in the availability or quality of a resource affecting usage • International public concern

Receptor Sensitivity

For this EP, receptors are grouped into the following primary categories (as described further in Section 7.0 and further broken down into sub-categories):

- Physical environment
- Biological environment
- Socio-economic and cultural environment.

Receptor sensitivity criteria are based on the following key factors:

- Importance of the receptor at local, national or international level – for instance, a receptor will be of high importance at international level if it is categorised as a designated protected area (such as a Ramsar site). Areas that may potentially contain high value habitats are of medium importance if their presence/extent have not yet been confirmed.
- Sensitivity/vulnerability of a receptor and its ability to recovery – for instance, certain species could adapt to changes easily or recover from an impact within a short period of time. As part of the receptor sensitivity criteria (Table 9-3) professional judgement considers recovery time of a receptor from identified impacts. This also considers if the receptor is under stress already.
- Sensitivity of the receptor to certain impacts – for instance, flaring emissions will potentially cause air quality impacts and do not affect other receptors such as seabed.

Table 9-3: Receptor Sensitivity Criteria

Sensitivity	Environmental Impact
L	Receptor with low value or importance attached to them, e.g. habitat or species which is abundant and not of conservation significance, or immediate to short-term recovery and easily adaptable to changes.
M	Receptor of Medium importance, e.g. recognised as an area/species of potential conservation significance for example, KEF or listed threatened species, or Recovery within 1–2 years following cessation of activities, or localised medium-term degradation with recovery in 2–5 years.
H	Receptor of High importance, e.g. recognised as an area/species of potential conservation significance with development restrictions for example marine parks or conservation reserves, or habitat critical to the survival of a species, or Recovery not expected for an extended period (> 5 years following cessation of activity) or that cannot be readily rectified.

Impact Consequence Ranking

The magnitude of the impact and sensitivity of receptor are then combined to determine the impact consequence ranking in accordance with Table 9-4 below. Key management controls are subsequently identified to reduce the magnitude for such an event occurring in order to determine the final residual impact ranking.

Table 9-4: Impact Consequence Ranking Matrix

		Sensitivity		
		L	M	H
Magnitude	+1			
	0			
	-1			
	-2			
	-3			
	-4			
	-5			

Residual Impact Consequence Ranking	Residual Impact Acceptability Categories
Positive Impact Consequence	Inherently acceptable - Manage for continuous improvement through effective implementation of the HSSE and SP management system
No Impact Consequence	
Slight Impact Consequence	
Minor Impact Consequence	
Moderate Impact Consequence	Acceptable with controls - Apply the hierarchy of control to reduce the risks to ALARP
Major Impact Consequence	Unacceptable
Massive Impact Consequence	

Unplanned Risks (Addition of Likelihood Criteria)

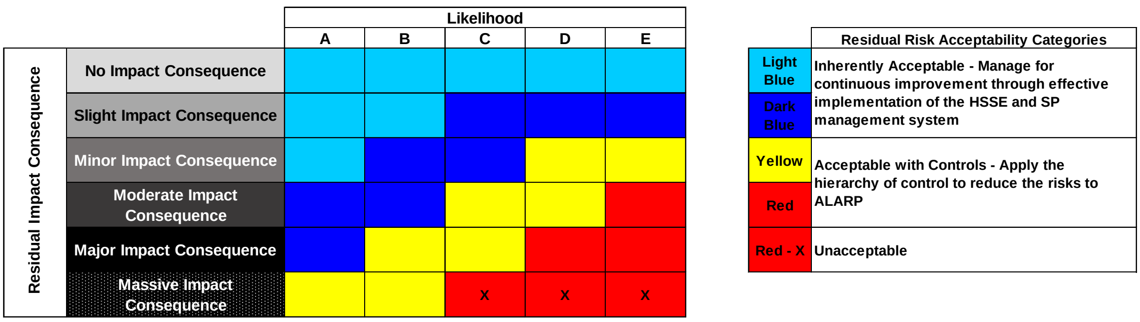
For unplanned/emergency events, the likelihood of such an event occurring also requires assessment in association with the impact consequence to determine the risk ranking. For example, based on magnitude and sensitivity alone, a hydrocarbon spill associated with a long-term well blowout would be classed as having a major impact ; However, the likelihood of an event occurring would typically be in the range of unlikely to remote. In addition, the mitigation measures for such impacts focusses on reducing the likelihood of the impact occurring as opposed to reducing the magnitude of the impact itself. Unplanned events also require assessment in terms of residual risk.

As with planned activities, the potential impacts of unplanned events are initially identified, and the impact consequence ranking is determined, which inherently takes into account the magnitude of the event and sensitivity of the relevant receptor(s). The impact consequence ranking is then combined with the likelihood of the event occurring (Table 9-5) in order to determine the overall environmental risk ranking via Table 9-6. Controls are then identified to reduce the risk of such an event occurring in order to determine residual risk.

Table 9-5: Likelihood Criteria

A	• Never heard of in the industry – **extremely remote** • < 10^{-5} per year • Has never occurred within the industry or similar industry but theoretically possible
B	• Heard of in the industry – **remote** • 10^{-5} – 10^{-3} per year • Similar event has occurred somewhere in the industry or similar industry but not likely to occur with current practices and procedures
C	• Has happened in the Company or more than once per year in the industry – **unlikely** • 10^{-3} – 10^{-2} per year • Event could occur within lifetime of similar facilities. Has occurred at similar facilities
D	• Has happened at the location or more than once per year in the Company – **possible** • 10^{-2} – 10^{-1} per year • Could occur within the lifetime of the development
E	• Has happened more than once per year at the location – **likely** • 10^{-1} – > 1 per year • Event likely to occur more than once at the facility

Table 9-6: Environmental Risk Matrix (Unplanned Events)



For the purpose of the Prelude petroleum activities risk review, the following key risks were assessed in accordance with the risk-based approach summarised in this section:

- Vessel movements, in the context of unplanned interactions with marine fauna
- IMS
- Atmospheric emissions
- Greenhouse gas emissions
- Unplanned release of wastes
- Unplanned (spill) events.

9.2.3 Assessment of Residual Impacts and Risks

The risk assessment methodology applied ensured the following key steps were completed throughout scenario development:

1. hazards identified
2. initiating causes determined
3. worst case credible scenarios agreed (without controls in place)
4. release of hazards understood (i.e. top events)
5. preventative controls listed
6. mitigative controls listed
7. likelihood determined (with confirmed controls in place)
8. risk ranking attributed.

In the evaluation of residual impacts and risks, all controls are assumed to be implemented effectively and functioning as intended.

The residual impacts and risks detailed in Sections 9.3-9.14 represent a discussion of the various sub-category environmental value/receptor rankings as determined. The residual rankings displayed in the summary tables in the respective sections represents the highest residual impact or risk for each primary receptor category where relevant (i.e. physical environment, biological environment, and socio-economic/cultural environment), and therefore can be considered a conservative assessment for some individual environmental values/sensitivities. These residual impacts and risks are then compared to the acceptability categories outlined in Section 8.0, Table 9-4 and Table 9-6 to determine a final ALARP and acceptability statement.

Cumulative environmental impacts and risks are also considered and discussed where relevant through the impact and risk assessment process taking into account current and foreseeable pressures on the environment including other petroleum activities, other marine industries and users, and other ecosystem pressures.

9.2.4 ALARP Assessment

ALARP for Shell means, the point at which the cost (in time, money and effort) of further risk or impact reduction is grossly disproportionate to the risk or impact reduction achieved.

ALARP can be demonstrated through a number of mechanisms via:

- a quantitative method, such as via technical assessments (e.g. modelling studies) or where the costs of the various options can be compared with the respective impact/risk reduction

- semi-quantitative method where impacts/risks within a certain level require a pre-defined number of barriers of a certain effectiveness in place to prevent this hazard being released, or via
- qualitative analysis, whereby ALARP is established using standards, legislative requirements and judgement based on experience.

Shell applies the following hierarchy of control process to demonstrate ALARP as shown in Figure 9-3.

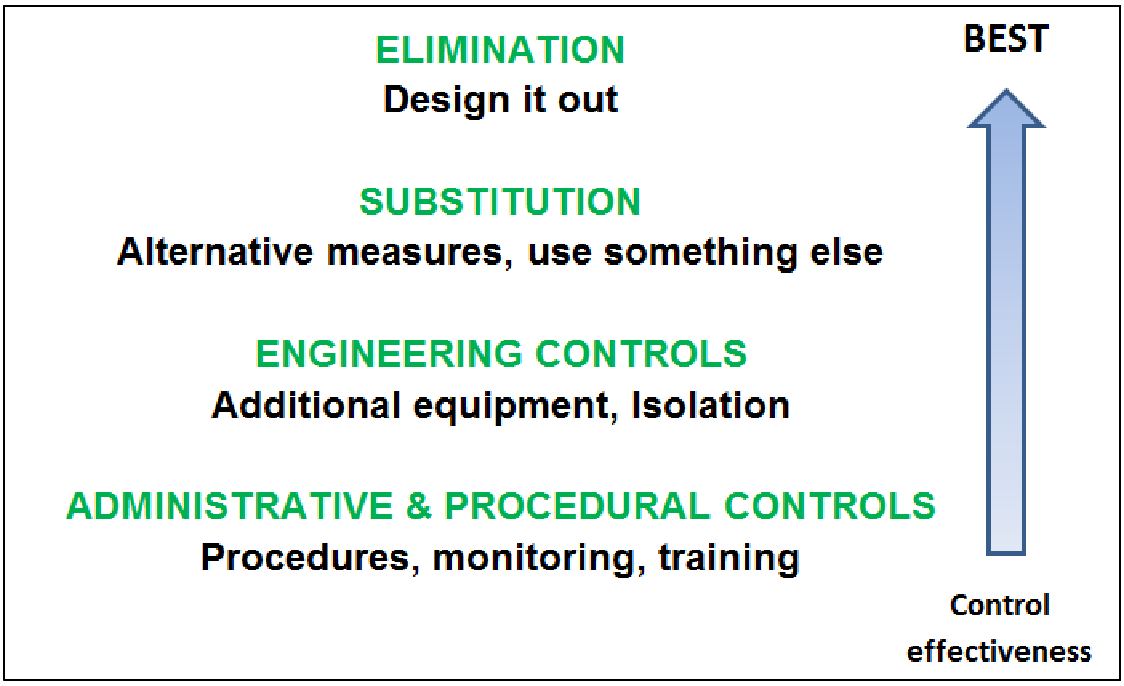


Figure 9-3: Hierarchy of Controls

9.3 Physical Presence

9.3.1 Aspect Context

The physical presence of the Prelude FLNG facility, associated subsea infrastructure and support vessels could potentially affect activities and access to areas associated with fishing, tourism, defence, commercial shipping and the oil and gas industry in the region. Refer to Section 6.0 for a description of the FLNG facility and supporting activities/infrastructure.

A PSZ of 500 m has been established and gazetted around the FLNG mooring chain touchdown locations and well centre (DC-1P), as per the OPGGS Act (NOPSEMA 2015), from which unauthorised marine users are prohibited from entering. The PSZ is a key safety measure to reduce potential interactions with the FLNG facility and associated subsea infrastructure. Temporary exclusion zones will be maintained around any required vessel-based campaigns outside of the PSZ as required.

9.3.2 Description and Evaluation of Impacts

Socio-Economic Environment

The expected impact of the Prelude activities on the fishing industry (commercial, recreational and traditional), is expected in the worst-case scenario to be slight due to the significant water depth and low fishing effort in the region and the limited extent of the PSZ in relation to the area available for fishing.

There are no known tourism activities in the area due to the considerable water depths and distance offshore. Therefore, no impacts to tourism are expected.

There are no known defence exercise areas or planned activities within the Operational Area. Therefore, no impacts to defence are expected.

The closest permanent petroleum infrastructure to WA-44-L are the Ichthys facilities about 20 km south of the Operational Area. Exploration activities undertaken by other operators in the region within other permit areas are also possible and likely however, Prelude petroleum activities are not expected to affect these.

Commercial shipping activity in the vicinity of the Operational Area is high and the Prelude petroleum activities are not expected to significantly affect these other activities associated with the Ichthys facility. Overall, the worst-case residual impact ranking is assessed as Slight (Magnitude -1, Sensitivity L).

9.3.3 Impact Assessment Summary

Table 9-7: Physical Presence Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Socio-Economic Environment	-1	L	Slight

9.3.4 ALARP Assessment and Environmental Performance Standards

Table 9-8: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	Physical Presence cannot be eliminated for Prelude activities.	N/A	N/A	N/A
Substitution	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Engineering	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Administrative and Procedural Controls	For specific vessel based campaigns, the Australian Hydrographic Service (AHS) is given advance notification before arrival on location to enable a 'Notice to Mariners' to be issued prior to petroleum activities outside of the PSZ but within the Operational Area.	Yes	Allows notifications to be made to other marine users in the area to minimise disruption to their activities. A 'Notice to Mariners' may be issued by the relevant authority before the activity. However, routine activities undertaken by support vessels to existing offshore infrastructure or facilities do not warrant promulgation of a 'Notice to Mariners'. Similarly, activities occurring within NOPSEMA's gazetted PSZs do not require promulgation of a 'Notice to Mariners'.	1.1	AHS is given notification in advance to enable a 'Notice to Mariners' to be issued prior to vessel based petroleum activities outside of the PSZ but within the Operational Area.	Records available of advance notification to the AHS which enables issuing of Notice to Mariners' or the relevant Notice to Mariners.
Administrative and Procedural Controls	Stakeholder engagement	Yes	Consultation with relevant stakeholders has been undertaken during the preparation of the EP and is ongoing. Shell will ensure all Relevant Persons are provided with sufficient information and have the opportunity to raise any objections or claims regarding potential disruption from Prelude operations.	1.2	Disruption to other marine users will be managed during ongoing stakeholder consultation.	Stakeholder engagement records
Administrative and Procedural Controls	PSZ	Yes	A PSZ of 500 m has been established and gazetted around the FLNG mooring chain touchdown locations and well centre (DC-1P), in accordance	1.3	Compliance with PSZ as per Section 616 of the OPGGS Act.	Gazette notice of PSZ

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			with the OPGGS Act (NOPSEMA 2015). Unauthorised marine users are prohibited from entering the PSZ and therefore it is a key safety measure to reduce potential interactions with the FLNG facility and associated subsea infrastructure.			Incident report form used to record breaches of PSZ requirements.
Administrative and Procedural Controls	Reduce size of the PSZ	No	A smaller PSZ would result in a smaller area from which other marine users are displaced. However, the size of the PSZ is determined by legislation (OPGGS Act) and therefore it is not able to be reduced. In relation to available space in WA-44-L, the PSZ represents a small portion of total navigable space.	N/A	N/A	N/A

9.3.5 Acceptability of Impacts

Table 9-9: Acceptability of Impacts – Physical Presence

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Socio-economic and Cultural Environment	Fishing Industry	No interference with fishing to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Yes	Shell considers the enforcement of permanent exclusion of activities other than Shell-authorised petroleum activities in the PSZ as legally binding and safer for both the other marine users and Shell. Furthermore, additional temporary exclusions of such users from the Operational Area and potentially its immediately adjacent waters (e.g. due to the physical presence of specific campaigns and the FLNG facility and support, supply and product offloading vessels) is considered to be acceptable and necessary from a safety, security and oil spill prevention (collision) perspective. Permanent displacement with the gazetted PSZ will be managed through consultation with Relevant Persons and designation on Australian Hydrographic Office nautical charts.
	Tourism and Recreation	No negative impacts to nature-based tourism resources resulting in demonstrated loss of income.	Yes	
	Defence	No interference with defence activities as directed by the Department of Defence.	Yes	
	Shipping	No interference with navigation to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Yes	
	Oil and Gas Industry	No interference with other titleholders to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out the petroleum activities.	Yes	

The assessment of impacts from physical presence determined the residual impact rating of slight (Table 9-4). As outlined above, the acceptability of the impacts from physical presence associated with the petroleum activities has been considered in the following context.

Principles of ESD

The impacts from physical presence are consistent with the principles of ESD based on the following points:

- The physical presence aspect does not degrade the biological diversity or ecological integrity of the Commonwealth marine area in the Browse Basin.
- Significant impacts to MNES will not occur.

- The health, diversity and productivity of the marine environment will be maintained for future generations.
- The project does not significantly impinge upon the rights of other parties to access environmental resources (e.g. commercial and traditional fishers).
- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental impacts and risks.

Relevant Requirements

Management of the impacts from physical presence are consistent with relevant legislative requirements, including:

- Section 616 of the OPGGS Act
- Compliance with international maritime conventions, including:
  - STCW Convention
  - SOLAS Convention
  - COLREGS.
- Compliance with Australian legislation and requirements, including:
  - Navigation Act 2012:
    - Marine Order 21 (Safety of Navigation and Emergency Procedures)
    - Marine Order 30 (Prevention of Collisions)
    - Marine Order 71 (Masters and Deck Officers).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of impacts from the physical presence of the Prelude FLNG facility, associated subsea infrastructure and marine vessels indicates no potential for significant impacts to threatened and migratory species.

Commonwealth Marine Environment

The evaluation of impacts from the physical presence of the Prelude FLNG facility, associated subsea infrastructure and marine vessels indicates significant impacts to the Commonwealth Marine Environment are not credible.

External Context

There have been no objections or claims raised by Relevant Persons to date around the physical presence aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking the assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and Environmental, Social and Health Impact Assessment (ESHIA) requirements. The EPO and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from physical presence determined the residual impact rankings were slight or lower (Table 9-4 Impact Consequence Ranking Matrix). As outlined above, the acceptability of the impacts have been considered in the context of:

- The established acceptability criteria for the physical presence aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the physical presence aspect.

Based on the points discussed above, Shell considers the impacts from physical presence associated with the Prelude petroleum activities to be ALARP and acceptable.

9.3.6 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
No adverse interactions between Prelude activities and other marine users. Displacement of other marine users is limited to the PSZ and any temporary displacement due to vessel-based campaigns.	No supported claims reported which demonstrate direct loss of income or other impacts to marine users as a result of undertaking the petroleum activities.

9.4 Lighting

9.4.1 Aspect Context

The Prelude FLNG facility and supporting activities require 24-hour external illumination to meet maritime and operational safety standards. Artificial light emissions are generated from two primary sources:

- Navigational and operational lighting required for safe function of the FLNG facility and supporting vessels
- Flaring activities from the FLNG facility either from the constantly lit pilot light or during intermittent flaring events as described in Appendix A: Detailed Facility Description.

9.4.2 Description and Evaluation of Impacts

Lighting can create light spill, which has the potential to impact on marine fauna populations for animals that show avoidance or attraction to lights by potentially changing navigational cues that ultimately affect energy expenditure or alter predation and/or feeding rates. Impacts may include the following:

- Disorientation, misorientation, attraction or repulsion
- Disruption to natural behavioural patterns and cycles
- Secondary impacts such as increased predation
- Reduced fitness.

Biological Environment

Reptiles

Of the turtle species identified as protected under the EPBC act, only green turtles (Scott-Browse Stock) are known to nest on Browse Island (~ 40km to the southeast of the Prelude FLNG Project area), with important internesting habitat located within ~20km of Browse Island (Commonwealth of Australia 2017).

Light pollution on nesting beaches can alter critical nocturnal behaviours in adult and hatchling turtles (Commonwealth of Australia 2019). Research suggests that artificial lighting can disrupt or affect the choice of nesting location by female turtles, particularly light visible on the landward side of nesting beaches (Salmon 1992). Turtle hatchlings leaving nesting beaches are particularly sensitive to artificial lighting as they use celestial cues to orientate (Limpus 2008, Salmon et al. 1992; cited in Lorne et al. 1997).

Marine turtle hatchlings may use celestial lights as navigational markers during oceanic migrations and are attracted towards bright lights. Hatchlings can become disorientated and trapped within light spill around platforms and vessels, resulting in increased energy expenditure, increased predation and decreased survival rates (Witherington & Martin 1996; cited in Lorne et al. 1997; Commonwealth of Australia 2019). However, as hatchlings swim offshore from their natal beach, they become less influenced by light cue and rely predominantly by wave motion, currents and the earth's magnetic field (Lohmann and Lohmann 1992).

The table below indicates the extent of visibility of the lighting from the Prelude FLNG facility with respect to turtles (ERM 2009b).

Table 9-10: Line of Sight Limits for Turtles

Light Source	Marine Turtles (limit of light visibility)
Flare (when operating)	51km
Topsides (Process Facilities)	27km
Sky glow from combined luminaries	Effects expected to be minimal given the low levels of particulate matter in the air offshore

Vessels have lower deck height than the FLNG facility therefore, the line-of-sight assessment undertaken for the FLNG facility suffices for the impact assessment. Even if the FLNG facility is visible, it would only be visible on the seaward horizon and unlikely to alter hatchlings journey from the dunes towards the ocean.

Extensive light attraction studies have been conducted on turtle hatchlings, including at Barrow Island (Pendoley 2005), approximately 1,000 km southwest of the Operational Area. These studies demonstrated that hatchlings crawl away from tall, dark horizons (sand dunes and vegetation) towards lower and lighter horizons (the sea and stars), and that artificial lighting can alter this response.

Turtles in the nearshore or on the beaches of Browse Island may be able to see the lighting of the Prelude FLNG facility especially during flaring events but this is not expected to have an adverse impact to nesting turtles or hatchlings given the ~40 km separation distance. The flare is potentially visible from the northern beaches of Browse Island low on the seaward horizon with an expected intensity less than that presented by a quarter moon (Imbricata 2018). As the flare is low on the horizon, the Island's landmass blocks light from the flare to the southern beaches so that no beaches on Browse Island are subjected to light from the flare on their landward horizon and the landward horizons remain unaltered to nesting and hatchling turtles. Furthermore, at the date of writing this EP there have been no recorded instances of turtle hatchling sightings or aggregations around the FLNG.

Once in the water, hatchling navigation is influenced predominantly by wave motion, currents and the earth's magnetic field. There is no expected impact of lighting from Prelude activities on hatchlings once in the water.

Studies also suggest that light generated by flares may not affect hatchlings as much as other light sources. Witherington and Bjorndal (1991) examined the roles of light wavelength and intensity in the sea-finding mechanisms of loggerhead and green turtle hatchlings and found the most disruptive wavelengths to be in the range of 300 to 500 nanometres (nm) (blue – green wavelengths). Spectral analysis of flares at Thevenard Island (Pendoley 2000) suggests that flare light typically does not contain a high proportion of light wavelengths within this range.

There are no important habitat for listed turtle species that are known to be affected by artificial light within 20km of the Operational Area. Important habitats are those areas necessary for an ecologically significant proportion of a listed species to undertake important activities such as foraging, breeding, roosting or dispersal. The applied 20 km threshold is in alignment and provides a precautionary limit based on observed effects of sky glow on marine turtle hatchlings demonstrated to occur at 15-18 km (Commonwealth of Australia 2019). Therefore, any light generated from within the Operational Area will not result in any environmental damage or effects given the separation distance to the nearest sensitive habitats as follows:

- 23 km to the Green Turtle critical internesting habitat
- 40 km to Browse Island – Turtle nesting and hatchlings.

Given the limited amount of flaring that is expected to occur during normal operations, the large separation distance of the Prelude FLNG facility from Browse Island and the closest turtle critical habitat and the unaltered landward horizon at Browse Island, there is no expected residual impact consequence from Prelude activities' light spill on turtle hatchlings and adult turtles (Magnitude 0, Sensitivity – M).

There is no literature available on the effects of light on sea snakes. However, anecdotal evidence based on absence of observed sea snakes in waters in the Operational Area suggest that sea snakes are not attracted to artificial light sources.

Birds

Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around lit offshore infrastructure (Marquenie et al. 2008) and that lights can attract birds from large catchment areas (Wiese et al. 2001). Either birds may be attracted by the light source itself or indirectly as structures in deep water environments tend to attract marine life at all trophic levels, creating food sources and shelter for birds (Surnam 2002). The light from operating production facilities may also provide enhanced capability for birds to forage at night. Negative potential impacts to birds attracted by artificial lighting are limited but include collisions with infrastructure and alteration of normal behaviours (Commonwealth of Australia 2019).

When considering line of sight with respect to light assessment for birds, the factors that need to be considered include:

- the location and height of the light source (FLNG facility and flare)
- the distance between the light source and the receptor
- the potential elevation of the receptor (birds).

Migratory birds are known to fly at altitudes of between 150 and 600m. To be conservative, the light assessment has used an elevation of 600m as the potential maximum elevation of the migratory birds. Based on a potential flying height of 600m, the light from the FLNG facility will be visible to birds out to a distance of approximately 151km when the flare is operational or 127km when the flare is not being used (ERM 2009b). Table 9-11 indicates the extent of visibility of the lighting from the FLNG with respect to birds.

Table 9-11: Line of Sight Limits for Migratory Birds and Seabirds

Light Source	Birds (Limit of Light Visibility)
Flare (when operating)	151km
Topsides (Process Facilities)	127km
Sky glow from combined luminaries	Effects expected to be minimal given the low levels of particulate matter in the air offshore

If migratory birds are reliant on visual cues in addition to their magnetic compass, such as ambient light, moonlight and starlight to navigate, then artificial light could alter their natural migratory patterns, particularly in the absence of terrestrial landmarks. Light emissions from offshore platforms in the North Sea have been shown to attract migrating birds and birds that migrate during the night are especially affected (Verheijen 1985). During other studies conducted in the North Sea (Marquenie et al. 2008), it was noted that birds travelling within a 5km radius of illuminated offshore platforms may deviate from their intended route and either circle or land on the nearby platform. Beyond this distance, it is assumed that light source strengths were not sufficient to attract birds away from their preferred migration route.

Injuries and mortalities to birds occur through direct collisions with infrastructure and the rate of collision is (as inferred from literature) relates to weather conditions, the cross-sectional area of the obstacle, amount of light and number of birds travelling through an area. Where bird collision incidents have been reported, low visibility weather conditions (cloudy, overcast and foggy nights) have usually been implicated as the major contributing factor, in contrast there are seldom collision incidents on clear nights (Avery 1976; Elkins 1988; Weise et al. 2001). It should be noted that conditions in the Operational Area are not conducive to significant fog formation, however most rainfall is seasonal associated with summer monsoon and cyclones in November to

April which does overlap with the peak migratory period for birds as indicated in Section 7.2.8.3 Seasonal Sensitivities of Threatened Species.

According to Bamford et al. (2008), 33 species of migratory birds that use the East Asian-Australian Flyway (EAAF) are regularly present within Australia. The EPBC listed streaked shearwater was not identified as using the EAAF in Bamford's study. Migratory shorebird species are mostly present in Australia during the non-breeding period, from as early as August to as late as April/May each year (DoEE 2017b) As defined previously, the documented zone of impact for migratory birds that resulted in a recorded change in natural behaviour (Marquenie et al. 2008) is two orders of magnitude smaller than the limit of visibility, at a radius of 5 km from an artificial light source.

There are no important habitats for listed bird species that are known to be affected by artificial light within 20 km of the Operational Area. Important habitats are those areas necessary for an ecologically significant proportion of a listed species to undertake important activities such as foraging, breeding, roosting or dispersal. The applied 20 km threshold provides a precautionary limit based on observed effects of sky glow on fledgling seabirds grounded in response to artificial light 15 km away (Commonwealth of Australia 2019). Therefore, any light generated from within the Operational Area will not result in any environmental damage or effects given the separation distance to the nearest sensitive habitats as follows:

- 59km to the nearest bird breeding BIA.

It is considered possible that small numbers of mature birds may be attracted to the lighting of the FLNG facility. Within the first two years of the FLNG being on location in the Operational Area, there had been recorded observations of one live bird resting on the FLNG and 8 deceased birds of unknown cause, none of which were listed as Threatened. Even if all the recorded birds could be attributed to a single species with lighting as the key cause, this number would represent a very low proportion of the total number of birds that would have flown through the area within the same timeframe and would be well below what would be considered an ecologically significant proportion. Therefore, it is concluded that under the worst-case conditions, there are no expected residual impact consequence (Magnitude – 0, Sensitivity – M).

Pelagic Communities

Fish and zooplankton may be directly or indirectly attracted to lights. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al. 2001), with traps drawing catches from up to 90 m (Milicich et al. 1992). Lindquist et al. (2005) concluded from a study of larval fish populations around an oil and gas platform in the Gulf of Mexico that an enhanced abundance of clupeids (herring and sardines) and engraulids (anchovies), both of which are highly photopositive, was caused by platform light fields.

The concentration of organisms attracted to light results in an increase in food source for predatory species and marine predators are known to aggregate at the edges of artificial light halos. Shaw et al. (2002), in a similar light trap study, noted that juvenile tunas (Scombridae) and jacks (Carangidae), which are highly predatory, may have been preying upon concentrations of zooplankton attracted to the light field of the platforms. This could potentially lead to increased predation rates compared to unlit areas. The intensity of lights may potentially result in a concentration of some marine fauna, although for a period of approximately two years there have been no recordings of significant aggregations of marine fauna from when the FLNG first arrived on location.

The potential for increased predator activity is unlikely to result in a significant impact on the plankton or fish populations. Given the relatively small impact area surrounding the petroleum activities in respect to zooplankton and fish habitat, the potential impacts are expected to be highly localised and unlikely to have discernible consequences at the population level. The distances from Prelude to the closest island (Browse Island) and shoal (Echuca Shoal) are approximately 40 km and 61 km from the Operational Area respectively. Therefore, it is unlikely that artificial lighting will impede or disturb natural lighting cycles that may affect coral spawning.

The range of attraction for fish and invertebrates to lighting from the FLNG facility and support vessels is expected to be localised with no discernible residual impact consequence (Magnitude – 0, Sensitivity - L) and is not expected to attract individuals away from any named shoals/banks, offshore reefs/islands or KEFs. Considering a low receptor sensitivity to such impacts, there are no credible residual impacts at a population level.

9.4.3 Impact Assessment Summary

Table 9-12 lists the highest impact consequence rating in the relevant environmental receptor groups.

Table 9-12: Light Emissions Evaluation of Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	N/A	N/A	N/A
Biological Environment	0	M	No Impact
Socio-Economic Environment	N/A	N/A	N/A

9.4.4 ALARP Assessment and Environmental Performance Standards

Table 9-13: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	No lighting	N/A	No additional or alternative control measures have been identified for this impact for the Prelude activities, given the requirement for a well-lit work area.	N/A	N/A	N/A
Elimination	No flaring	No	Occasional flaring is necessary for safe operations. Collection of all flared gas (including pilot and purge) would entail significant cost with the corresponding environmental benefit grossly disproportionate to the additional cost. Flare minimisation is one of the key controls for minimising GHG emissions (see Section 9.11).	N/A	N/A	N/A
Substitution	Use different wavelength lights	No	During the Design Phase of the FLNG facility a lighting assessment was undertaken and the cost comparison indicated as much as 163% extra cost for the changing the lighting to different wavelength lights. Given the low densities of migratory birds and seabirds that may pass through the project area, and that the lighting risk assessment indicates that the impacts to birds and turtles will be nil, it was concluded that installing different spectrum lighting was not demonstrably ALARP for Prelude.	N/A	N/A	N/A
Engineering	Lighting of the FLNG designed to minimise light spill via: Shielding; Use low spill/ directional lighting; Use of low-reflective paints; Directing luminaires inwards on	No	The use of low-spill/directional and shielded lighting is not warranted due to the distance of the FLNG from the nearest turtle nesting beach (approximately 40km from Browse island) and bird rookery (approximately 162km from Ashmore Reef National	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	the FLNG facility and away from the ocean.		Nature Reserve) and the absence of other light-sensitive fauna around the FLNG location.			
Administrative and Procedural controls			No additional or alternative control measures have been identified for this impact for the Prelude activities, given the requirement for a well-lit work area.	N/A	N/A	N/A

9.4.5 Acceptability of Impacts

Table 9-14: Acceptability of Impacts - Lighting

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations. Management of aspects of the project must be aligned to conservation advice, recovery plans and threat abatement plans, including for bird and marine turtle species.	Yes	Light from the FLNG and support vessels may attract threatened and migratory birds, which may roost on the structures. Given there are no important habitats within 20 km of the facilities (20 km being a conservative threshold distance for impacts), light emissions are not expected to result in significant impacts at a population level. Light emissions are not anticipated to have a significant impact on marine turtle species given the separation distance of the facilities from any sensitive habitat and are therefore not inconsistent with the requirements of the relevant recovery plan.
	Pelagic communities (Non-Threatened or Migratory)	No significant adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	Yes	The range of attraction for fish and invertebrates to lighting from the FLNG facility is expected to be localised and no discernible impacts are expected. The facility is also not expected to attract individuals away from any named shoals/banks, offshore reefs/islands or KEFs. Considering a Low receptor sensitivity to such impacts, there is no credible potential for residual impacts at a population level.
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of impacts from light emissions determined no residual worst-case impact (Table 9-12). As outlined above, the acceptability of the impacts from light emissions associated with Prelude operations has been considered in the following context.

Principles of ESD

The impacts from light emissions are consistent with the principles of ESD based on the following points:

- The light emissions aspect does not degrade the biological diversity or ecological integrity of the Commonwealth Marine Area and significant impacts to MNES are not anticipated to occur.
- The precautionary principle has been applied, and studies/reviews undertaken (ERM 2009b; Imbricata 2018) where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental impacts.

Relevant Requirements

Management of impacts from light emissions are consistent with relevant legislative requirements, including:

- Draft National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds (Commonwealth of Australia 2019).
- Management of impacts are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (Table 9-15).
- Implementation of recognised industry standard practice, such as minimisation of flaring.

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of lighting impacts indicates significant impacts to threatened and migratory species will not credibly result from the light emissions aspect of Prelude FLNG operations.

Alignment of Prelude operations with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-15.

Commonwealth Marine Environment

The impacts from the light emissions aspect of Prelude operations on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 8-1.

Table 9-15: Summary of Alignment of the Impacts from Light Emissions Aspect of the Prelude field with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory species - Birds	Significant impact criteria for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The evaluation of environmental impacts indicates that impacts from artificial light emissions on threatened or migratory species are likely to be minor and would not constitute a significant impact to populations. As such, residual impacts from artificial light associated with Prelude operations does not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.

	Wildlife Conservation Plan for Migratory Shorebirds (DoE 2015a)	Managing the light aspect of Prelude operations has been aligned to 'Objective 4' of the Plan by ensuring that anthropogenic disturbance was considered in development assessment processes. Migratory birds have been considered as an environmental receptor in the evaluation of lighting impacts.
	Draft National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2019).	Seabirds and migratory birds have been identified in the draft National Light Pollution Guidelines to be affected by artificial light sources. The management of light emissions for Prelude operations has considered the light management actions described in the guidelines and the impact assessment/thresholds have been based on the precautionary limits referenced in the guidelines (Section 9.4.2).
Threatened and Migratory species - Marine Reptiles	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The evaluation of environmental impacts indicates that impacts from artificial light emissions on threatened or migratory marine reptiles are slight and would not constitute a significant impact. As such, residual impacts from artificial light associated with Prelude operations do not exceed any of the significant impact criteria for Threatened and Migratory marine reptile species provided in Table 8-1**.**
	Recovery Plan for Marine Turtles (Commonwealth of Australia 2017)	Light pollution has been identified as a threat in the Recovery Plan for Marine Turtles (Commonwealth of Australia 2017). Nesting females and hatchling turtles are at greatest risk of light impacts; however, the nearest potential nesting habitat is Browse Island (approximately 40 km from the FLNG). Potential light-related impacts to turtles on nesting beaches is slight. Actions in the Recovery Plan for Marine Turtles (Commonwealth of Australia 2017) relating to the threat of artificial light include: • Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats • Develop and implement best practice light management guidelines for existing and future developments adjacent to marine turtle nesting beaches • Identify the cumulative impacts on turtles from multiple sources of onshore and offshore light pollution Given the Operational Area is beyond any BIAs or habitat critical for the survival of marine turtles (e.g. nesting, inter-nesting or foraging areas) and the light modelling and other studies indicate that impacts to marine turtles will be nil, the actions listed above are not applicable to Prelude operations.
	Draft National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2019).	Marine turtles have been identified in the draft National Light Pollution Guidelines to be affected by artificial light sources. The management of light emissions for Prelude operations has considered the light management actions described in the guidelines and the impact assessment/thresholds have been based on the precautionary limits referenced in the guidelines (Section 9.4.2).
Commonwealth marine area	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	The evaluation of environmental impacts indicates that the light emissions aspect of Prelude operations will not exceed the Commonwealth marine environment significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date around the lighting aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking the assessment of impacts and risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from light emissions determined the residual impact ratings were Nil (Table 9-12) given that any visible light (including sky glow) will not displace or disrupt any MNES listed species from important habitat, nor will it prevent these species from being able to undertake critical behaviours such as foraging, reproduction and dispersal. Shell considers residual impacts of nil to be acceptable if they meet legislative and Shell requirements. To this effect, the acceptability of these impacts have been considered in the context of:

- The established acceptability criteria for the light emissions aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Based on the discussion of these considerations presented above, Shell considers impacts from light emissions associated with Prelude operations to be acceptable.

9.4.6 Environment Performance Outcomes

Environment Performance Outcome	Measurement Criteria
No injury or mortality of listed Threatened or Migratory MNES species as a result of artificial light emissions. Management of artificial light emissions associated with the project must be aligned to conservation advice, recovery plans and threat abatement plans, including for bird and marine turtle species.	Fauna observations and incident reports demonstrate no mortality of listed Threatened species as a result of artificial light emissions.

9.5 Noise

9.5.1 Aspect Context

Airborne and marine noise emissions from Prelude operations are generated from the following operational sources and activities:

- Subsea infrastructure including wells, pipelines and risers
- Supply and other marine vessel (e.g. ASV during maintenance) operations

- Power Generation and Production Process at the FLNG vessel, including Flaring
- Product Offtake Operations including Tanker Arrival, Loading and Departure
- Helicopter Operations
- Subsea Inspection, Maintenance and Repair (IMR) works.

Subsea Infrastructure

The broadband noise produced by an operational wellhead is very low, 113 dB re 1 µPa, which is only marginally above rough sea condition ambient noise (McCauley, 2002). For this noise level to be exceeded, there would need to be multiple wellheads within a very close proximity of each other (approximately less than 50 m apart) before their signals combine to increase the total noise field (with two adjacent sources only increasing the total noise field by 3 dB). Hence for Prelude field wellheads, the broadband noise level in the vicinity of the wellheads would be expected to be of the order of 113 dB re 1 µPa and this would fall to background levels within less than 200 m from the wellhead (McCauley, 2002). Similar to wellhead noise, which includes flow noise in pipelines, the noise field produced along a pipeline/flowline may be expected to be very close in levels to that described for wellheads, with the radiated noise field falling to ambient levels within approximately a hundred meters. Hence noise impacts from subsea infrastructure including wellheads and flowlines are not considered credible and will not be discussed further.

Subsea IMR activities are typically undertaken from vessels that use a Dynamic Positioning (DP) system. This allows manoeuvrability, station keeping and avoids anchoring when undertaking works near subsea infrastructure. As the vessel will maintain its position with the continual use of DP thrusters, the thrusters will dominate as the source of underwater noise. Noise generated from these activities will be intermittent and of short duration and like the noise produced by other marine vessels in the field (e.g. supply boats).

Subsea inspections generally involve the IMR vessel travelling along the route of the subsea system with an ROV to identify or undertake maintenance or repair activities that may be required to ensure the assets are being maintained. Inspection techniques with the potential to generate underwater noise include side-scan sonar. Sonars are used in relatively shallow water depths (70 to 240 m) to detect objects on the sea floor including existing infrastructure and potential seabed hazards, however their use will be occasional only, e.g. once every 1-3 years, and only for several weeks at a time. The sonar operates at high frequencies (typically around 100–500 kHz) with the frequency being dependent on the substrate type, resolution of data required, and water depth.

Supply and Other Marine Vessel Operations

During normal operations, support vessels may be required to complete routine round-trip voyages between the Operational Area and Darwin or another Australian Port. The underwater noise that is produced by vessels arises from two continuous sources – propeller cavitation and the propulsion machinery (engines) inside the vessel.

Support vessels typically produce sound levels around 160-180dB re 1µPa at 1m generally dominated by low frequencies during transit and drop with reduced speed. As the ship's speed increases, broad band noise such as propeller cavitation and hull vibration noise become dominant over machinery related tones (NRC 2003). When vessels are holding station, frequencies increase considerably with the use of thrusters to maintain position. A vessel using DP produces noise of low frequency, less than 1kHz, with broadband values up to 177dB re 1µPa at 1m (Simmonds et al. 2004)

Power Generation, Production and Product Offtakes

When the FLNG thrusters are not operating, the facility's underwater noise signature is dominated by the noise produced by the utilities (e.g. power generation) and production facilities. These include the steam turbine generators, boilers, air compressors, and pumps located within the hull and topsides process equipment including compressors and motors. Other production related noise contributors include occasional hydrocarbon flaring and continuous acid gas venting.

The resulting noise amplitudes from Prelude normal operations are predicted to peak at 50Hz, and the overall source level in the frequency range 10Hz to 2kHz is predicted to be 189.1dB re1µPa at 1m. Figure 9-4 shows predicted maximum received noise levels from FLNG facility plant as described.

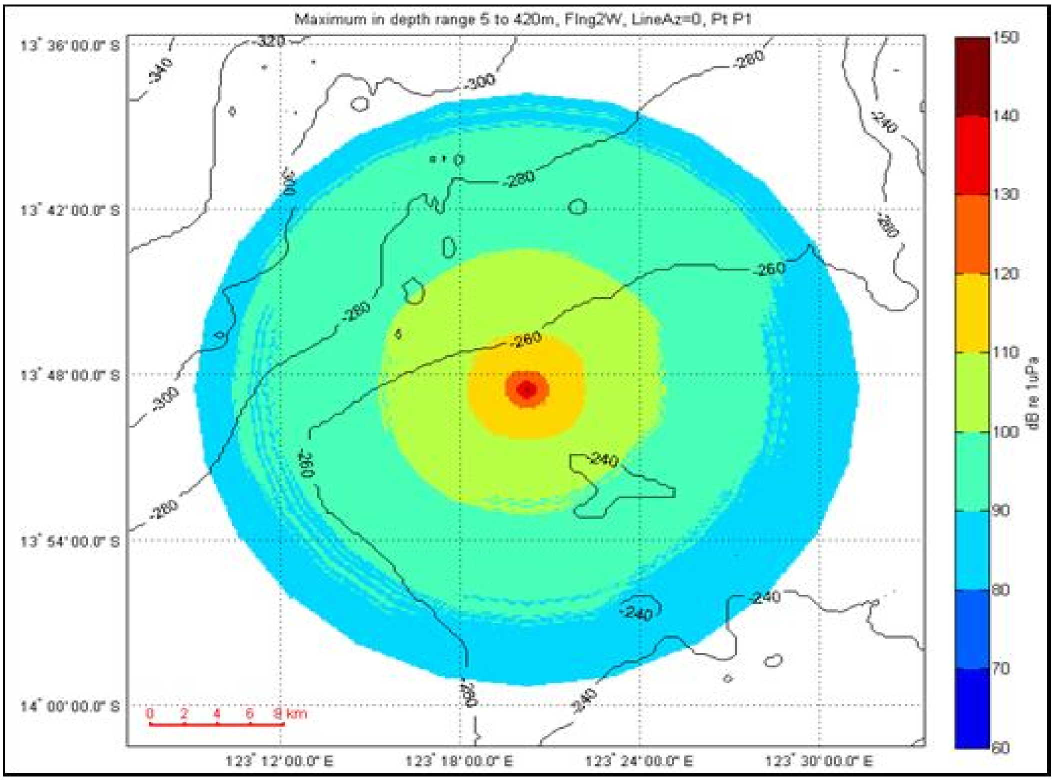


Figure 9-4: Predicted Maximum Received Levels at Any Depth Due to Non-Offtake FLNG Facility Noise as a Function of Range and Azimuth

The highest underwater noise levels will be experienced when the vessel's thrusters are used to maintain position. The requirement to use thrusters is determined by weather conditions and may occur during the berthing and de-berthing of the product offtake vessels and on occasions throughout the off-loading period. Thrusters may also be required during helicopter operations.

The alongside offloading configurations for the LNG and LPG carriers may involve the simultaneous operation of thrusters on the FLNG facility, thrusters on the two in-field support vessels (acting as tugs), and the main engines of the berthing tanker. Thrusters on the FLNG facility and tugs generate high levels of thrust in poor flow conditions, resulting in significant propeller cavitation and consequent high underwater noise levels.

Predicted noise levels peak in the frequency range 200Hz to 400Hz. The corresponding broadband source levels over 10Hz to 2kHz are predicted to be 189.1dB re 1µPa at 1m for the FLNG facility, and 189.7dB re 1 µPa at 1m for the combined effect of two tugs. If all sources are co-located, their combined source level is estimated at 192.4dB re 1µPa at 1m. Figure 9-5 shows the maximum predicted received level of noise at any depth as a function of range and azimuth for the different sources during offtake operations, as well as their combined effect.

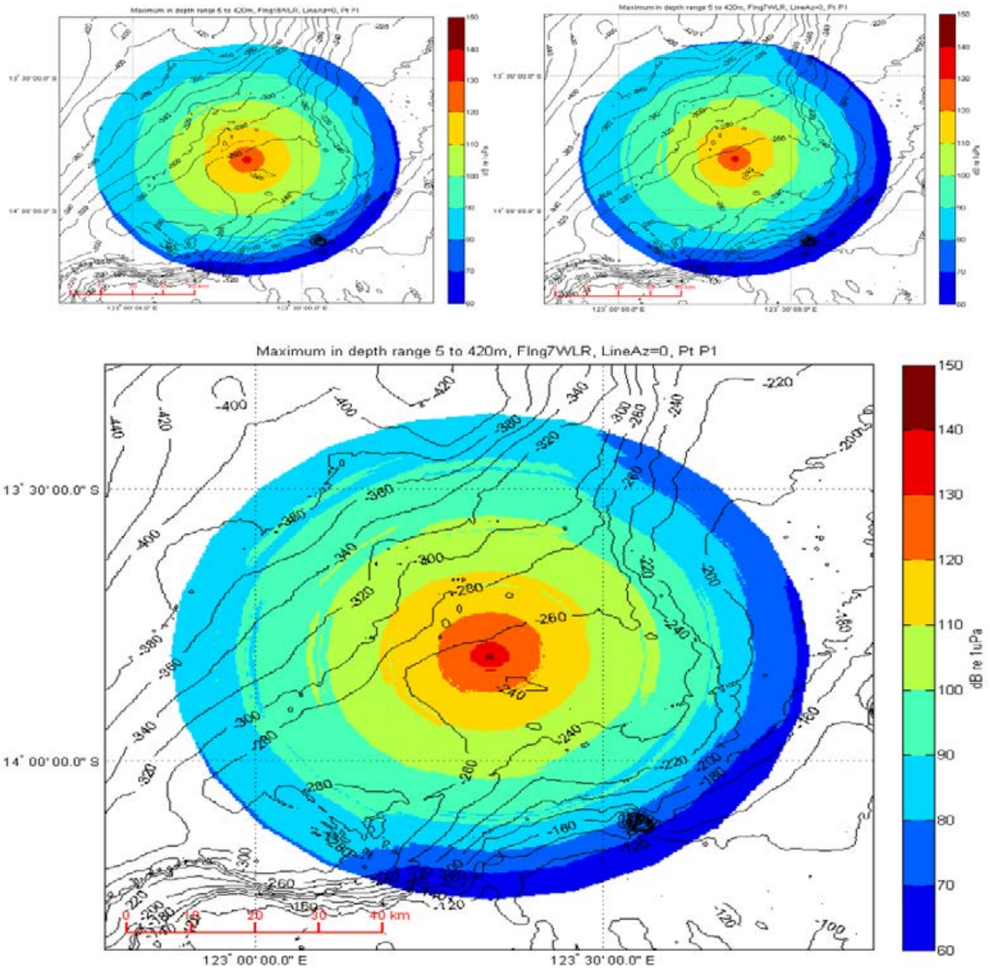


Figure 9-5: Predicted Maximum Received Levels at Any Depth due to Cavitation Noise. Top Left FLNG Facility Only; Top Right: 2 x Tugs only; Bottom: Combined Effect of Tugs and FLNG Facility. Note Change in Scale Compared to Previous Figure

Table 9-16 illustrates the maximum distances from Prelude at which noise levels from normal operations and offtake operations are likely to be exceeded.

Table 9-16: Maximum Distance from FLNG at Which the Specified Received Levels are Likely to be Exceeded

Received Noise Level in 10Hz to 2kHz band (dB re 1µPa)	Cavitation noise during offtake operations	Plant noise during operations
160	60m	17m
150	200m	50m
140	850m	190m
130	3.7km	600m
120	9km	1.3km
110	17km	4.5km
100	30km	10km
90	44km	20km

Helicopter Operations

Helicopter flights are required from the operating base at Broome or from Djarindjin (Lombadina) Airport to site for the purposes of crew change out. The main acoustic source associated with helicopters is the impulsive noise from the main rotor. Dominant tones in noise spectra from helicopters are generally below 500Hz (Richardson et al. 1995). The level of underwater sound from helicopters is affected by helicopter altitude, aspect and strength of noise emitted, and the receiver depth, water depth and other variables (Richardson et al. 1995).

The angle at which the line from the aircraft and receiver intersects the water surface is important. In calm conditions, at angles greater than 13° from the vertical, much of the sound is reflected and does not penetrate the water (Richardson et al, 1995). Therefore, strong underwater sounds are detectable for a period roughly corresponding to the time the helicopter is within a 26° cone above the receiver. Richardson (Richardson et al, 1995) reports figures for a Bell 214 helicopter (stated to be one of the noisiest) being audible in air for 4 minutes before it passed over underwater hydrophones, but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. The maximum received level was 109 dB re 1µPa2. s. Due to their short duration and near surface impacts only, helicopter noise emissions are not considered to be a credible source of noise impact/ risk and will not be discussed further.

Summary

Table 9-17 provides a summary of sound frequencies and sound levels expected from noise sources produced by FLNG activities and support operations.

Table 9-17: Expected Sound Frequencies and Broadband Source Levels of FLNG and Support Operations

Source	Dominant Frequency Range (Hz)	Expected source levels (dB re 1µPa at 1m)
Support vessels	100 -2,000	164-182

Source	**Dominant Frequency Range (Hz)**	**Expected source levels (dB re 1µPa at 1m)**
Vessel using dynamic positioning (DP)	50 - 1,000	177
Side Scan Sonar	100,000 – 500,000	no data
34m twin diesel work boat	630	159
Tug (pulling empty barge)	37 - 5,000	145 - 166
Tug (pulling loaded barge)	1,000 - 5,000	161 - 170
Prelude FLNG (normal operations)	< 2,000 (peak 50)	189.1 (10 - 2,000 Hz)
Prelude FLNG and offtake tankers simultaneously using thrusters	< 2,000 (peak 200-400)	192.4 (10 - 2,000 Hz)
Helicopters	< 500	Received levels at 3m water depth of 101-109dB for a Bell 212 helicopter at an altitude of 610-152m respectively.

Source: Woodside Energy Limited 2011 and Shell 2009

Underwater Noise Impact Levels

Marine species with the greatest sensitivity to underwater noise are marine mammals (whales and dolphins), turtles and fish (including larvae). Other species that could be affected by underwater noise include sea snakes, sharks and rays and invertebrates.

Impacts to marine fauna can be grouped in the following decreasing order of effect:

- mortality or potential mortal injury – physical injury that may result in the death of an animal
- impairment:
  - permanent threshold shift (PTS) – a permanent reduction in the ability of an animal to perceive sound. Recovery is not expected to occur.
  - temporary threshold shift (TTS) – a temporary reduction in the ability of an animal to perceive sound. Recovery to pre-exposure levels is expected to occur.
  - masking – no change in the ability for an animal to perceive sound, but biologically meaningful sounds may be “drowned out” by anthropogenic noise.
- behavioural impacts – typically short-term behavioural responses such as avoidance, surfacing etc. Behaviour will return to normal following cessation of the anthropogenic noise.

Impact thresholds for the fauna groups were derived from scientific literature and published guidelines, including:

- Sound exposure guidelines for fishes and sea turtles: a technical report prepared by American National Standards Institute (ANSI)-Accredited Standards Committee S3/SC1 and registered with ANSI (Popper et al. 2014).

- Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NOAA 2018).

Marine Mammals (Cetaceans)

The vulnerability of marine mammals to underwater noise is linked to their ability to perceive sound. Cetaceans can be grouped based on similarities in their hearing. Underwater noise exposure thresholds can then be weighted for each cetacean group to emphasise noise frequencies that a group may be particularly vulnerable to. This approach is described in Southall et al. (2007) and has been applied to a range of underwater noise guidelines and impact assessments on cetaceans. The impact thresholds for continuous (non-impulsive)[8] underwater noise are summarised in Table 9-18. These are derived primarily from technical guidelines published by NOAA (2018).

Table 9-18: Marine Mammal Sound Exposure Criteria (Continuous Noise)

Type of Animal	Generalised Hearing Range[1] [Hz]	PTS – Permanent Injury (received levels)[2]	TTS – Impairment	Behaviour
Low-frequency cetaceans (baleen whales including humpback, blue, sei, fin, brydes, etc)	7 – 35,000	199 dB $L_{E/p,\ 24h}$	179 dB $L_{E/p}$	120 dB L_p
Mid-frequency cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 – 160,000	198 dB $L_{E/p,\ 24h}$	178 dB $L_{E/p}$	120 dB L_p
High-frequency cetaceans (true porpoises, river dolphins, cephalorhynchid, etc.)	275 – 160,000	173 dB $L_{E/p,\ 24h}$	153 dB $L_{E/p}$	120 dB L_p

Notes:

1. Represents the generalised hearing range for the entire group as a composite (i.e. all species within the group), where individual species hearing ranges are typically not as broad.
2. LE/p, 24h is the weighted cumulative sound exposure level ($L_{E/p}$) and has a reference value of 1µPa2s. The recommended accumulated period is 24 hrs. The weighted cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle).
3. Lp – Continuous (non-impulsive) noises are quantified as Sound Pressure Level (SPL, or Lp) using units of dB re 1 µPa.

Sea Turtles, Fish and Other Fauna

Table 9-19 provides a summary of sound frequencies understood to be utilised by marine fauna and response thresholds, where known. All data, except where noted, is

[8] Underwater noise can generally be considered as two types:

- impulsive noise – typically discrete, short duration noises punctuated by periods of low/no noise, characterised by high peak sound pressure levels with relatively rapid rise and decay times, and
- non-impulsive – noises that do not have rapid rise and decay times, typically of longer duration.

referenced from the most recent and comprehensive scientific literature survey on marine noise from oil and gas activities and impacts on marine fauna, compiled by the Centre for Marine Science and Technology (CMST), Curtin University, Perth (Kent, C. et al., 2016).

Table 9-19: Sound Frequencies Utilised by Marine Fauna and Known Response Levels

Species	Frequency Range	Response levels
Fish	Hearing range: 100 Hz – 1,000 Hz (with peak hearing from 100 Hz – 400 Hz) < 1,000 Hz (whale sharks)	Recoverable injury: 170 dB Lp for 48 hour exposure (Popper et al. (2014). TSS: 158 dB Lp for 12 hour exposure Popper et al. (2014) Avoidance: > 155-165 dB re 1μPa^2.s Physical damage: 210-211 dB re 1μPa^2.s
Turtles	Vocalisation (in air) 300 Hz – 4000 Hz Best hearing sensitivity: 100 Hz – 700 Hz	Avoidance: > 155 dB re 1μPa^2.s at 1m Erratic swimming: > 164 dB re 1μPa^2.s at 1m

Sharks and rays were grouped with fish (Table 9-19) for this assessment of impacts. No suitable published guidelines were identified for sea snakes. Sea snakes were grouped with fish (Table 9-19) for the purposes of this assessment.

While there are reputable published studies indicating the potential for underwater noise to impact upon invertebrates, no suitable published guidelines were identified for the specific receiving environment. Invertebrates have been considered in the assessment of risks and impacts from underwater noise, although no threshold values have been applied.

Modelling Results vs Threshold Levels

Prelude FLNG activities have the potential for localised and temporary noise impacts on marine fauna, including fish, marine turtles and cetaceans. Based on the thresholds outlined above and the hearing bands for different fauna, underwater noise levels would:

- fall below the relevant cumulative permanent hearing damage criteria for all marine fauna except high frequency cetaceans, at all locations.
- fall below the permanent hearing damage criteria for high frequency cetaceans (24-hour cumulative exposure period) within tens of metres of the facility.
- fall below the relevant temporary hearing threshold shift criteria for fish (12-hour exposure period) beyond 60 metres from the facility.
- fall below the relevant temporary hearing threshold shift criteria for cetaceans beyond 150 metres from the facility during offloading operations.
- fall below the relevant behavioural disturbance criteria for cetaceans at ranges beyond 9 km during offtake operations (cavitation noise) and 1.3 km during normal production operations (plant noise).

9.5.2 Description and Evaluation of Impacts

Physical Environment

There are no impacts on the physical environment protected under the EPBC Act such as air or water quality. Noise impacts are limited to the biological environment as discussed below.

Biological Environment

Ecosystems, Communities and Habitats

Benthic Communities

Underwater noise generated by operational platforms does not appear to have any detrimental effect on benthic communities. Inspection of fixed platforms worldwide shows these structures serve as artificial reefs and develop relatively diverse benthic communities (Lindquist et al. 2005). Benthic habitat surveys in the Operational Area indicate the presence of diverse but not abundant or sensitive benthic communities. Given the frequency spectrum and intensity of noise generated during production operations, no impacts to benthic communities because of underwater noise are expected to occur.

Islands, shoals, banks and near the Operational Area may potentially be exposed to increased underwater noise levels as a result of vessels using DP. These host relatively diverse fauna communities, such as demersal fish and marine turtles (see Threatened Species and Ecological Communities below for further discussion). However, given the distance of these islands shoals and banks from the noise sources in the Operational Area and the consequent reduction in noise intensity, the received noise levels will be significantly lower than the source levels. The nearest island to the Prelude FLNG vessel location is Browse Island, which lies approximately 39 km to the south. The nearest shoal, Echuca Shoal, is 61 km south. At these distances noise emissions from the Prelude operations would have fallen to within background noise levels (see Table 9-16), hence there are no credible potential impacts to island communities (Refer to Threatened Species and Ecological Communities below for further discussion of noise impacts on marine turtles).

Pelagic Communities

Pelagic communities in the Operational Area include planktonic communities and pelagic fish and invertebrates. The effects of noise on free swimming pelagic fish are assessed below with Threatened Species and Ecological Communities and are not addressed further in this section.

Planktonic communities comprise a diverse range of taxa, which will differ in their potential to be impacted by underwater noise. Many species of pelagic and demersal fish have a planktonic larval stage.

Modelling studies by the CSIRO indicate that planktonic communities are highly dynamic and have the potential to recover rapidly following disturbance (Richardson et al. 2017). Experiments have shown mixed results of larval stages to underwater noise. For example, experiments on several species of fish larvae and lobster larvae did not detect significant effects as a result of high intensity impulsive noise (Bolle et al. 2012; Day et al. 2016; Payne et al. 2009).

Impacts to planktonic larvae have not been reliably demonstrated under conditions analogous to those that will be encountered during Prelude operations, being orders of magnitude less than that of experimental designs referenced above. The more intensive noise sources are of limited duration (e.g. vessels using DP), which limits the exposure of planktonic organisms. As such, the residual impact consequence to planktonic communities are considered to be Slight (Magnitude -1, Sensitivity – L).

The Operational Area is not expected to host highly abundant or diverse assemblages of fish, sharks or rays. The noise modelling indicates that no exceedance of the permanent injury threshold for any category of fish would occur in the Operational area and underwater noise levels would fall below the relevant temporary hearing threshold shift criteria for fish (12 hr exposure period) within 60 m from the facility. The approximate received level threshold for behavioural disturbance in fish is variable but indicated to be greater than 90dB re 1μPa above hearing thresholds (Popper et al. 2003, Scholik and Yan 2002a, 2002b, Xodus 2009, Hastings et al. 1996; cited in Woodside Energy Limited 2011). Therefore, the highest impact on masking vocalisation and changes to behaviour will occur within tens and hundreds of metres from the facility for pelagic fish and sharks and rays.

Given the highly mobile nature of fish, sharks and rays and their continual sightings in the Operational Area around the hull, it is concluded that continuous noise sources from the FLNG in its production only and simultaneous production and offloading modes of operation will have at most a slight residual impact consequence (Magnitude -1, Sensitivity – L) on these resident and transient populations.

Key Ecological Features

The nearest KEF to the Operational Area are the Continental Slope Demersal Fish Communities, covering a vast area of approximately 33,182 km^2, located approximately 14 km in its closest point to Prelude. These are a high diversity of demersal fish assemblages on the Australian continental slope featuring more than 500 fish species, 76 of which being endemic, which makes it the most diverse slope bioregion in the whole of Australia.

The noise levels at the closest point of this KEF will be between 120 and 110 dB re: 1uPa in the 10 Hz to 2 KHz band. At these distances there is no potential for permanent, temporary or behavioural impact to fish with moderate potential for masking fish choruses only. Potential impacts to the demersal fish communities are therefore considered not to credible. Other KEFs are too distant from the Operational Area to be credibly impacted by underwater noise.

Threatened and Migratory Species

Marine Mammals

Most cetacean species use sound to communicate (e.g. humpback whale calls) or perceive their environment (e.g. echolocation of prey). This reliance on underwater noise, and their high conservation value, makes cetaceans of concern when assessing potential impacts from underwater noise. Low frequency cetaceans are expected to be most vulnerable to underwater noise from Prelude Operations (cavitation and plant noise) due to the frequency spectra of these noise sources overlapping the functional hearing range of these species (approximately 7 Hz to 30 kHz). Several low frequency cetaceans (blue, humpback, sei, fin and Bryde's whales) were identified as potentially occurring within the Operational Area (Section 7.2.3). Noise monitoring in the Timor Sea for the Barossa development indicated pygmy blue and Bryde's whales are the most likely to occur (McPherson et al. 2016). Detection of low-frequency cetaceans calls were not constant, but occurred sporadically, often in groups or sets of calls.

Mid frequency cetaceans are also vulnerable to underwater noise, although their hearing range means they are more vulnerable to noise frequencies overlapping their functional hearing range (approximately 150 Hz to 160 kHz). Mid frequency cetaceans include most toothed whales, dolphins and porpoises and a number of species of mid frequency cetaceans were identified as potentially occurring within the Operational Area and adjacent ZPI (Section 7.2.3). Noise monitoring in the Timor Sea indicates mid-frequency cetaceans are present year-round (McPherson et al. 2016).

Given that modelling indicates underwater noise levels fall below the relevant cumulative permanent hearing damage criteria for low and mid frequency cetaceans at all locations within the Operational Area and fall below the relevant TTS criteria for cetaceans beyond 150 m from the facility during offloading operations it is considered that the potential for significant impacts to cetaceans within the Operational area is not credible. Given also that noise levels from Prelude operations fall below the relevant behavioural disturbance criteria for cetaceans at ranges beyond 9 km during offtake operations (cavitation noise) and 1.3 km during normal production operations (plant noise), the overall impact to marine mammals is considered to be Slight (Magnitude -1, Sensitivity -M).

Other sources of noise, associated with short term operations, such as operational flaring or helicopter operations, will be short in duration and largely reflected off the seawater air barrier to be causing any greater impact on cetaceans than a temporary behavioural response. A similar level of impact is expected from use of side scan sonars during subsea infrastructure IMR activities, which due to being high-frequency sounds are known to be outside the hearing thresholds of cetaceans (see data summary in Table 9-17). Impacts from side scan sonars are therefore expected to cause no greater than slight impacts to marine mammals.

Marine vessel underwater noise emissions are of frequencies detectable by marine mammals however the sound levels at the source itself will be of magnitude that could cause at worst a TSS for an animal happening to be in a very close proximity (within tens of meters of the vessel). The most likely impact consequence at these levels is a behavioural response such as avoidance. For a PTS impact to occur, the mammal should be swimming within metres of the vessel for more than 24 hours, which is a non-credible scenario. It is therefore concluded that noise emissions from marine vessels could potentially cause only a slight residual impact on marine mammals (Magnitude -1, Sensitivity - M).

Marine Reptiles

Marine reptiles such as turtles and sea snakes are not known to be particularly sensitive to underwater noise. Research on marine turtles suggests that functional hearing is concentrated at frequencies between 100 and 600 Hz (which is a subset of the low frequency cetacean range). Several turtle species were identified as likely to occur within the Operational Area (Section 7.2.3), although no critical habitat or BIAs overlap the Operational Area. The closest critical marine turtle habitats include green turtle nesting habitat some 17 km from Prelude FLNG and foraging habitat some 43 km from Prelude. Noise levels at the 17 km distance from Prelude are approximately 110 dB re 1uPa during offloading operations only (24 to 48 hrs per week on average) and 90dB re 1uPa for the rest of the time (background plant operations noise) and impacts to marine turtles at this distance are expected to be slight (refer to Table 9-19). All other marine turtle habitats are more than 100 km away from the Operational Area, hence there are no potential for impacts to those. Impacts from marine vessel noise emissions are also expected to be Slight (Magnitude -1, Sensitivity - M) due to the large separation distance between the Operational Area and the closest marine turtle habitats and the continuous nature and sound levels of marine vessel noise at source.

Impacts on sea snakes from all sources discussed above are similarly expected to be slight with reference to response levels for fish in Table 9-19.

Whale Sharks

Whale sharks may traverse the Operational Area and broadly the ZPI with a BIA for foraging whale sharks located 33 km from the Operational Area. However, it is expected that whale shark presence within the Operational Area would not be in significant numbers and would be transitory and of short duration. This is consistent with tagging studies of whale shark movements which show continual movement of whale sharks in deeper, open offshore waters (Meekan & Radford 2010). Whale sharks are also not considered to be particularly vulnerable to noise related impacts (refer to response levels for fish in Table 9-19).

Overall, the worst-case residual impact consequence to biological communities is assessed as Slight (Magnitude -1, Sensitivity - M).

Socio-Economic Environment

No reasonably foreseeable adverse impacts from Prelude noise emissions, including consideration of supply vessel and helicopter operations and impacts on commercial fishing stocks (discussed in Biological Environment), have been identified on the socio-economic environment.

9.5.3 Impact Assessment Summary

Table 9-20 lists the highest residual impact consequence ranking of the relevant environmental receptor groups.

Table 9-20: Noise Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	N/A	N/A	N/A
Biological Environment	-1	M	Slight
Socio-Economic Environment	N/A	N/A	N/A

9.5.4 ALARP Assessment and Environmental Performance Standards

Table 9-21: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Substitution	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Engineering	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Administrative and Procedural Controls	Marine support vessel interactions with threatened and migratory species to follow the of EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017).	Yes	The EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017) are recognised as the industry standard for minimising disturbance due to physical presence and noise to whales and dolphins and will be applied to other species as relevant, .i.e. turtles and whale sharks.	3.1	Vessels will comply with EPBC Regulations 2000 Part 8, Division 8.1 Interacting with cetaceans and the Australian National Guidelines for Whale and Dolphin Watching.	Incident report form used to record breaches of requirements outlined in the EBPC Regulations 2000 and Australian National Guidelines for Whale and Dolphin Watching.
Administrative and Procedural Controls	Infield environmental noise monitoring	No	Marine noise monitoring alone will not prevent impact to marine fauna, but will provide the noise signature of Prelude operations in time.	N/A	N/A	N/A

9.5.5 Acceptability of Impacts

Table 9-22: Acceptability of Impacts - Noise

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Benthic Communities	No significant direct impacts to bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities which adversely effects biological diversity or ecological integrity. No direct impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.	Yes	Benthic habitat surveys in the Operational Area did not indicate the presence of particularly diverse or sensitive benthic communities. Benthic habitats associated with high value sensitive benthic communities e.g. named reefs, banks and shoals are too distant to be affected by noise (i.e. Browse Island is approximately 39 km from the Operational Area and Echuca Shoal is approximately 61 km from the Operational Area). Given the frequency spectrum and intensity of noise generated during production operations and the large separation distances to the nearest high value sensitive benthic communities, no impacts to benthic communities as a result of underwater noise are expected to occur.
	Pelagic Communities including planktonic communities and pelagic fauna	No significant adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	Yes	No exceedance of the permanent injury threshold for any category of fish is predicted to occur in the Operational area and beyond and ambient underwater noise levels would fall below the relevant temporary hearing threshold shift criteria for fish (12 hr exposure period) beyond 60 metres from the facility. Masking vocalisation and changes to

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
				behaviour could occur only within tens and hundreds of metres from the facility. Impacts to widely distributed planktonic communities in the Operational Area have been assessed as 1-Slight.
	KEFs	No impacts to environmental values of KEFs	Yes	The nearest KEF is the Continental Slope Demersal Fish Communities, located approximately 14 km in their closest point to Prelude. The noise levels at this point indicate no potential for permanent, temporary or behavioural impact to fish with moderate potential for masking fish choruses only. Other KEFs are too distant from the Operational Area to be credibly impacted by underwater noise.
	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations as a result of noise emissions. Management of aspects of the project must be aligned to conservation advice, recovery plans and threat abatement plans.	Yes	Noise levels emitted from the FLNG and support vessels during normal production and offtake operations have been assessed as potentially able to cause a slight impact on threatened or migratory marine fauna. Side scan sonar sources are of frequencies outside of hearing range of cetaceans. Turtle nesting and inter-nesting habitats are at least 20 km from the FLNG vessel and known whale migration routes and congregation areas are hundreds of kilometres distant from Prelude. Noise emissions would therefore have no significant impact on

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
				threatened and migratory species.
Socio-economic and Cultural Environment	N/A	N/A		N/A

The assessment of impacts from noise determined the worst-case residual ranking of Slight or lower (Table 9-22). As outlined above, the acceptability of the impacts from noise associated with the Prelude operations have been considered in the context of:

Principles of ESD

Impacts from noise emissions are consistent with the principles of ESD based on the following points:

- The noise emissions aspect does not degrade the biological diversity or ecological integrity of the Commonwealth Marine Area and significant impacts to MNES are not anticipated to occur.
- The precautionary principle has been applied, and since the last revision of this EP the most recent and comprehensive scientific literature compilation (Kent et al, 2016) and the most recent international guidelines on noise impacts (Popper et al. 2014) have been reviewed and referenced to ensure latest research and knowledge are taken into account in the evaluation of environmental impacts.

Relevant Requirements

Management of impacts from noise emissions is consistent with relevant legislative requirements, including:

- Assessment of noise impacts is guided by the latest scientific research in defining impact thresholds (Popper et al. 2014) and includes a purpose conducted noise emissions modelling for the main modes of FLNG operation.
- Management of noise impacts is consistent with policies, strategies, guidelines and conservation advice (refer to Table 9-23).
- Marine support vessel interactions with threatened and migratory species to follow the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017), i.e.
    - Marine support vessels will not deliberately approach closer than 50 m to a dolphin, turtle or whale shark; 100 m for an adult whale; 300m for a whale calf; and 150m for a dolphin calf.
    - If the whale, dolphin, turtle or whale shark shows signs of being distressed, marine support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of noise impacts indicates significant impacts to threatened and migratory species will not credibly result from noise emissions from production, offloading, materials and personnel transfer and subsea infrastructure operations and maintenance aspects of the Prelude petroleum activities.

Alignment of Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-23.

Commonwealth Marine Environment

Impacts from the noise aspect of the Prelude field on the Commonwealth Marine Environment will not exceed any of the significant impact criteria provided in Table 9-22.

Table 9-23: Summary of Alignment of the Impacts from the Noise Aspect of the Prelude petroleum activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species - Marine Mammals	Conservation advice on sei whale (Balaenoptera borealis) (DoE 2015c)	Vessel interactions with threatened and migratory species to follow the of EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017). A noise assessment consistent with the recommendations of the Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NOAA 2018) was undertaken.
	Conservation advice on fin whale (Balaenoptera physalus) (DoE 2015d)	
	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015–2025 (Commonwealth of Australia 2015a)	
	Conservation advice on humpback whale (Megaptera novaeangliae) (DoE 2015b)	
Threatened and Migratory Species - Marine Reptiles	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1).	The evaluation of environmental impacts indicates that impacts from noise emissions on threatened or migratory marine reptiles are slight and would not constitute a significant impact. As such, the Prelude field does not exceed any of the significant impact criteria for Threatened and Migratory marine reptile species provided in Table 8-1.
	Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017)	Acute and chronic noise pollution has been identified as a threat in the Recovery Plan for Marine Turtles (DoEE 2017), however there are no specific actions in the Plan in relation to noise pollution, except a recognised need to conduct additional research on impacts of noise on turtles. A noise assessment consistent with the recommendations of the Sound exposure guidelines for fishes and sea turtle (Popper et al. 2014) was undertaken.
Other Species – Sharks and Rays	Conservation advice on whale shark (*Rhincodon typus*) (DoE 2015e)	A noise assessment consistent with the recommendations of the Sound exposure guidelines for fishes and sea turtle (Popper et al. 2014) was undertaken. This considered the potential impacts of underwater noise on whale sharks.

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Commonwealth Marine Environment	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	The evaluation of environmental impacts indicates that the noise emissions aspect of Prelude operations will not exceed the Commonwealth marine environment significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date on the noise aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of impacts and risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from noise determined the residual impact rankings were Slight (Table 9-21). As outlined above, the acceptability of impacts from noise have been considered in the context of:

- The established acceptability criteria for the noise aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of noise of Slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to noise.

Based on the points discussed above, Shell considers the impacts from noise associated with the Prelude project to be acceptable.

9.5.6 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
No injury or mortality to listed Threatened or Migratory MNES species as a result of noise emissions.	Fauna observations and incident reports demonstrate no injury or mortality of listed Threatened or Migratory species as a result of noise emissions within the Operational Area.

9.6 Disturbance to Seabed

9.6.1 Aspect Context

During certain IMR related activities, localised seabed disturbance may occur. Such disturbance may result from activities including, but not limited to:

- Replacement of subsea equipment/infrastructure
- Placement of ROV tool baskets and DP transponders
- IMR activities such as free-span rectification, scour protection, groutbag/mattress installation, pipeline secondary stabilisation and/or water jetting/sand displacement to allow access to infrastructure.

The physical presence of permanent infrastructure already installed is addressed in Section 9.4 is not considered further in this section.

9.6.2 Description and Evaluation of Impacts

Physical Environment

Subsea facilities have a physical impact on the seafloor and the associated benthic communities. The significance of the impact depends on the sensitivity of the seafloor habitat being affected. The disturbance footprint associated with subsea infrastructure will be highly localised.

The disturbance from IMR related activities such as rectification and/or stabilisation is expected to be highly localised to discrete areas. The footprint on the seabed of grout bags on the seabed is typically confined to a small area directly below the flowline. The footprint of a grout bag is a consequence of the size of the bag. Bag size selection typically depends on the size of the span that requires rectification; larger spans typically require larger bags; most have a footprint < 100 m^2. The footprint of a mattress depends on the size of the mattress being used; typical mattresses cover approximately 100 m^2. Mattress size selection is dependent on the scale of the span or stabilisation required. While the need for grout bags or mattresses (if any) is currently unknown, operational experience indicates they will not be required in large numbers given typically the short flowline length/ span requiring support.

Water Quality

The potential for activities to increase turbidity is based on the possibility of sediment resuspension as a result of water jetting, ROV thruster wash, flushing grout lines or via placement of equipment, infrastructure, rock, mattresses or grout bags for example.

ROV thrusters can resuspend unconsolidated material, including sediments, and restrict visibility and operation of the ROV in the immediately vicinity which is counter-productive for the pilot. For this reason, ROV operators aim to minimise thruster wash by reducing use of thrusters adjacent to unconsolidated material and operating at a height above the sea floor that reduces resuspension.

Any impacts to water quality (turbidity) from seabed disturbance are expected to be restricted to highly localised and short-term sediment plumes. Sediment plumes may result in a slight and temporary decrease in water quality due to increase in suspended sediments. These temporary impacts to water quality are expected to have no credible environmental damage or effects.

Sediment Quality

Impacts to sediment quality from seabed disturbance are considered to have no environmental damage or effects. Significant changes to physical properties, such as particle size distribution and geological origin, are not expected to occur due to the small-scale, localised and infrequent nature of the associated activities.

Biological Environment

The seabed within the Operational Area has low density of epibenthic communities due to the low variance of sea floor topography and absence of hard substrates limiting habitat for epibenthic organisms (Baker et al. 2008; Heyward & Smith 1997). This has been determined for the Prelude location from benthic surveys, side scan sonar, 3D seismic survey and geotechnical data collected across the permit area (Shell 2009).

The soft seabed comprises of very soft siliceous carbonate silts, which has been shown to support a high diversity but low abundance community of infaunal assemblages. The likely impacts to the benthic communities from seabed disturbance include smothering and temporary disturbance but soft sedimentary communities have been shown to respond rapidly to disturbance and impacts are thus expected to be slight and short-lived (Shell 2009).

The habitats associated with these communities are broadly distributed in the wider region and are not considered to be unique or highly sensitive. The installation of additional infrastructure associated with the petroleum activities (including stabilisation or span rectification using grout bags/mattresses) may result in the disruption of a relatively small area of soft sediment habitats, which will then become hard substrate habitats due to the presence of subsea infrastructure.

Given the widespread extent of similar habitat, the low sensitivity of the benthic habitat within the Operational Area, and the high likelihood that temporarily affected areas will recover in a short timeframe, the environmental effects are considered to be of minimal ecological significance. Thus, the overall residual impact consequence level is ranked as Slight (Magnitude -1, Sensitivity – L).

9.6.3 Impact Assessment Summary

Table 9-24: Benthic Disturbance Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	0	L	No Impact
Biological Environment	-1	L	Slight
Socio-Economic Environment	N/A	N/A	N/A

9.6.4 ALARP Assessment and Environmental Performance Standards

Table 9-25: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Eliminate IMR activities	No	Subsea IMR activities (that result in seabed disturbance) are essential for maintaining the integrity of the subsea hydrocarbon system and cannot be avoided. The alternative of doing nothing would potentially compromise the integrity of the system, with increased technical risks and production failures, resulting in significant financial costs and potentially leading to increased risks of loss of containment, resulting in environmental costs.	N/A	N/A	N/A
Substitution	N/A	N/A		N/A	N/A	N/A
Engineering	During IMR activities, infrastructure is laid on the seabed according to plan	Yes	The costs are not disproportionate to the negligible environmental benefit potentially gained through avoiding the small and infrequent seabed disturbances associated with IMR activities.	4.1	During IMR activities, infrastructure is laid on the seabed within the Operational Area	As-laid surveys are performed following installation activities to confirm the facilities have been laid within the Operational Area
Administrative and Procedural Controls	Anchoring in the Operational Area for support vessels is prohibited except in emergency situations or under issuance of a specific permit by Shell	Yes	No alternative control measures have been identified.	4.2	No support vessel anchoring in the Operational Area except in emergency situations or under issuance of a specific permit by Shell	Records verify no breaches of anchoring procedures in the Operational Area.

9.6.5 Acceptability of Impact

Table 9-26: Acceptability of Impact – Disturbance to Seabed

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Benthic Communities – Bare Sediment	No significant direct impacts to bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities	Yes	No significant impacts are expected, given the Operational Area represents a small portion of a large regional bare sediment benthic environment. Habitats associated with these communities are broadly distributed in the wider region and are not considered to be unique or highly sensitive. Any seabed disturbance within the Operational Area will be small in scale, infrequent and represent a small fraction of the overall Operational Area and therefore any impacts are not expected to affect ecosystem function or connectivity of communities.
	Commonwealth Marine Environment	No significant impacts to the Commonwealth Marine Environment	Yes	
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of impacts from seabed disturbance determined the residual ranking of Slight or lower. As outlined above, the acceptability of the impacts associated with the petroleum activity have been considered in the following context.

Principles of ESD

The impacts from seabed disturbance are consistent with the principles of ESD based on the following points:

- Seabed disturbance on such a small scale will not degrade the biological diversity or ecological integrity of the Commonwealth Marine Environment and therefore significant impacts to MNES will not occur.
- The health, diversity and productivity of the marine environment will be maintained for future generations.
- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified (Refer to Section 7.2.1). This knowledge has been applied during the evaluation of environmental impacts.

Relevant Requirements

Management of the impacts from seabed disturbance are consistent with relevant legislative requirements, including:

- Management of impacts are consistent with guidelines for the protection of MNES (Table 8-1).

Matters of National Environmental Significance

Commonwealth Marine Environment

The impacts from the seabed disturbance aspect of the Prelude field on the Commonwealth Marine Environment will not exceed any of the significant impact criteria provided in Table 9-27.

Table 9-27: Summary of Alignment of the Impacts from the Seabed Disturbance Aspect of the Prelude Petroleum Activities with Relevant Requirements for MNES

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Commonwealth Marine Environment	Significant Impact Guidelines for the Commonwealth Marine Environment (Table 8-1)	The impact assessment indicates that the seabed disturbance aspect will not exceed the Commonwealth Marine Environment significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date around the seabed disturbance aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from seabed disturbance determined the residual impact rankings were Slight or lower Table 9-24). As outlined above, the acceptability of the impacts have been considered in the context of:

- The established acceptability criteria for the seabed disturbance aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of Slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the seabed disturbance aspect.

Based on the points discussed above, Shell considers the impacts from seabed disturbance associated with the Prelude petroleum activities to be ALARP and acceptable.

9.6.6 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
No direct disturbance to benthic habitats outside of the Operational Area as a result of inspection, maintenance and repair activities associated with Prelude operations.	Records demonstrate there has been no significant direct disturbance to bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities, that is activities associated with inspection, maintenance and repair.

9.7 Vessel Movements

9.7.1 Aspect Context

Marine vessels moving in the Operational Area may present a hazard to threatened and migratory fauna, such as whales, turtles and whale sharks (though the abundance of such fauna in and around the Operational Area has been observed to be low). Vessel movements can result in collisions between the vessel and marine fauna, potentially resulting in injury or death. Factors affecting the likelihood and severity of impacts from collisions include vessel type, vessel speed, water depth and the behaviours of animals present (Commonwealth of Australia 2017).

9.7.2 Description and Evaluation of Risks

The risks of vessel collisions with marine fauna, particularly threatened and migratory species (i.e. MNES), described below are consistent with the acceptable levels of impacts defined in Section 8.0. Shell's environmental management of the vessel movements aspect of the petroleum activities is aligned with conservation advice, recovery plans and threat abatement plans published by the DAWE; refer to discussion of MNES in the discussion of acceptability below.

Potential risks associated with vessel movements within the operational area are discussed below. As outlined in Section 9.2.3, the assessment considers only the residual risks following the application of controls.

Biological Environment

Threatened and Migratory Species

The Operational Area is not adjacent to or near any known important habitats for threatened or migratory species or the humpback whale migration routes. There are no BIAs or critical habitats within the Operational Area with the closest such areas located 23 km away for turtles, 33 km away for whale sharks and 78 km for marine mammals.

Therefore, the abundance of threatened or migratory species in the Operational Area is expected to be low and their presence transient.

Turtles: The Operational Area does not represent important habitat for marine turtles given the absence of potential nesting. Much of the project area is in water depths exceeding 90 m, which is deeper than typical foraging dives by marine turtles (e.g. Hays et al. 2001; Polovina et al. 2003). As such, the presence of marine turtles within the Operational Area is likely to be restricted to individual turtles transiting the area. As with cetaceans, the risk of collisions between turtles and vessels increases with vessel speed (Hazel et al. 2007). The typical response from turtles on the surface to the presence of vessels is to dive (a potential "startle" response), which decreases the risk of collisions (Hazel et al. 2007). Given the low speeds of vessels in the operational area, along with the expected low numbers of turtles in the area, the likelihood of collisions between vessels and turtles is assessed as remote.

Whale sharks: These are at risk from vessel strikes when feeding at the surface. Whale sharks have been observed traversing the Operational Area however, it is expected that whale shark presence would not comprise of significant numbers given there is no main aggregation area within the vicinity, and their presence would be transitory. This is consistent with tagging studies of whale shark movements which show continual movement of whale sharks in deeper, open offshore waters (Meekan & Radford 2010). There are no constraints preventing whale sharks from moving away from vessels (e.g. shallow water or shorelines).

Whales and Dolphins: Whales are particularly vulnerable to collisions with vessels due to their large size and the relatively high proportion of time spent at or near the sea surface. The likelihood and consequence of vessel collisions with whales are influenced by vessel speed; the greater the speed at impact, the greater the risk of mortality (Jensen and Silber 2004; Laist et al. 2001). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots. According to the data of Vanderlaan and Taggart (2007), it is estimated that the risk is less than 10% at a speed of 4 knots. Although dolphins are at much lower risk from collision due their small size, manoeuvrability and echolocation abilities compared to whales, they are still included in this assessment given they surface to breathe and are known to feed near the surface at times.

Marine vessels within the Operational Area, carrying out petroleum activities, are likely to be travelling at speed less than 8 knots; much of the time vessels are holding station or moving very slowly under Dynamic Positioning (DP) due to operational safety requirements. Therefore, the likelihood of a vessel collision with threatened or migratory species is remote (B).

Marine mammals, turtles and sharks are expected to alter course away from the FLNG as well as stationary or slow-moving product offtake, IMR, supply and support vessels in the Operational Area. The cruising speed of supply and support vessels is relatively low and a watch is maintained at all times and any interactions will be managed in line with the requirements of the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017).

This activity is identical to vessel movements for other offshore activities along the Western Australian coastline where the incidence of vessel strike is remote. Any

collisions are only likely to affect fauna at an individual scale rather than at a population or species scale. Therefore, an injury or death of an individual from a threatened or migratory species from a collision is considered to be of minor impact consequence (Magnitude -2, Sensitivity – M) and remote (B) likelihood with a residual risk assessed as Dark Blue.

9.7.3 Risk Assessment Summary

Table 9-28: Vessel Collision with Marine Life Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Biological Environment	Minor	B - Remote	Dark Blue

9.7.4 ALARP Assessment and Environmental Performance Standards

Table 9-29: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Elimination	N/A	No appropriate control measures have been identified to eliminate this risk from Prelude activities.	N/A	N/A	N/A
Substitution	Substitution	No	The number of vessels used is already considered minimal. Any fewer vessels will not meet operational needs.	N/A	N/A	N/A
Engineering	Engineering	No	No appropriate control measures have been identified to reduce noise through engineering means.	N/A	N/A	N/A
Administrative and Procedural Controls	Vessel interactions with threatened and migratory species to follow the of EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017).	Yes	The EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017) are recognised as the industry standard for minimising disturbance due to physical presence and noise to whales and dolphins and will be applied to other species as relevant, .i.e. turtles and whale sharks.	3.1	Vessels will comply with EPBC Regulations 2000 Part 8, Division 8.1 Interacting with cetaceans and the Australian National Guidelines for Whale and Dolphin Watching.	Incident report form used to record breaches of requirements outlined in the EBPC Regulations 2000 and Australian National Guidelines for Whale and Dolphin Watching.
Administrative and Procedural Controls	Environmental awareness training for personnel	Yes	All employees and contractors working on or in connection with Prelude with defined responsibilities to fulfil as part of the EP are required to attend EP training that is formally tracked. The EP training covers	5.1	Relevant vessel-based personnel are aware of requirements to avoid harm to marine fauna from vessel movements.	EP training records

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			marine fauna interaction (Section 10.3.2).			
Administrative and Procedural Controls	Dedicated Marine Fauna Observers (MFOs) on vessels	No	The cost to have dedicated trained MFOs on vessels represents a disproportionate cost given the low likelihood of the event occurring due to the absence of critical habitats within the Operational Area.	N/A	N/A	N/A

9.7.5 Acceptability of Risks

Table 9-30: Acceptability of Risks – Vessel Movements

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations (Refer to Table 8-1)	Yes	Vessel movement risks are of an acceptable level, given the Operational Area is not located in any BIAs or habitat critical to the survival of a species. Given the low speeds of vessels, along with the expected low abundance of threatened and migratory species within the Operational Area, significant impacts to Threatened and Migratory Species are not anticipated.
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of risks from vessel movements determined the residual ranking of Dark Blue (Table 9-6), deemed as Inherently Acceptable. As outlined above, the acceptability of risks from vessel movements associated with the petroleum activities has been considered in the following context.

Principles of ESD

Risks from vessel movement are consistent with the principles of ESD based on the following points:

- The vessel movements aspect does not degrade the biological diversity or ecological integrity of the Commonwealth marine area in the Browse Basin. Significant impacts to MNES will not occur.
- The health, diversity and productivity of the marine environment will be maintained for future generations.
- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental risks.

Relevant Requirements

Management of risks from vessel movements are consistent with relevant legislative requirements, including:

- Marine support vessel interactions with threatened and migratory species to follow the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017), i.e.
    - Marine support vessels will not deliberately approach closer than 50 m to a dolphin, turtle or whale shark; 100 m for an adult whale; 300m for a whale calf; and 150m for a dolphin calf.
  - If the whale, dolphin, turtle or whale shark shows signs of being distressed, marine support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.
- Management of risks are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (refer to Table 9-31 below).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of risks indicates significant impacts to threatened and migratory species will not credibly result from the vessel movements aspects of the petroleum activities.

An unplanned collision between project vessels and threatened or migratory fauna is unlikely to occur and may result in injury to or death of individual animals. This unplanned event is not considered to have the potential for significant impacts to threatened or migratory species at the population level.

Alignment with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-31.

Commonwealth Marine Environment

The impacts and risks from the vessel movements aspect of Prelude operations on the Commonwealth marine environment will not credibly exceed any of the significant impact criteria provided in Table 8-1.

Table 9-31: Summary of Alignment of the Risks from the Vessel Movements Aspect of the Prelude Petroleum Activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species – Marine Mammals	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The risk assessment indicates that the likelihood of vessel collisions with threatened or migratory marine mammals is remote, and the consequence of any such collision would be restricted to an individual animal. As such, the petroleum activities do not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.
	National Strategy for Reducing Vessel Strikes on Cetaceans and other Marine Megafauna (Commonwealth of Australia 2017a)	Vessel movements will be aligned to 'Objective 3: Mitigation' of the Strategy by: • Maintaining separation of vessels and whales; • Maintaining slow vessel speeds; and • Avoidance manoeuvres. This will be met by marine support vessels adhering to Part 8 (Interacting with cetaceans and whale watching) of the EPBC Regulations.

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
		Note the other objectives of the Strategy relate to actions for Government agencies.
	Conservation advice on sei whale (Balaenoptera borealis) (DoE 2015c)	The risk of vessel strikes will be managed by marine support vessels adhering to the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017.
	Conservation advice on fin whale (Balaenoptera physalus) (DoE 2015d)	
	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (Commonwealth of Australia 2015)	
	Conservation advice on humpback whale (Megaptera novaeangliae) (DoE 2015b)	
Threatened and Migratory species - marine reptiles	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The risk assessment indicates that the likelihood of vessel collisions with threatened or migratory marine reptiles is remote, and the consequence of any such collision would be restricted to an individual animal. As such, the petroleum activities do not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.
	Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia 2017b)	Marine support vessel collisions with turtles are inherently unlikely due to the offshore location (and resultant low densities of turtles), slow speeds of vessels and diving startle response of turtles. Furthermore, the risk of a vessel collision with a turtle will be further reduced via the implementation of the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017.
	Conservation advice on leatherback turtle (Dermochelys coriacea) (DEWHA 2009a)	
Threatened and Migratory species - sharks and rays	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The risk assessment indicates that the likelihood of vessel collisions with threatened or migratory sharks and rays is remote, and the consequence of any such collision would be restricted to an individual animal. As such, the petroleum activities do not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.
	Conservation advice on whale shark (*Rhincodon typus*) (DoE 2015e)	The Operational Area is not recognised as a BIA or habitat critical to the survival of whale sharks. The conservation advice recommends minimising offshore developments close to marine features that may aggregate whale sharks and cites Ningaloo Reef and Christmas Island as examples. Studies of whale sharks tagged while aggregating at Ningaloo Reef have shown individuals transiting through the Timor Sea (Meekan & Radford 2010) but showed no evidence of aggregation around particular marine features in the open offshore waters within or in the vicinity of the Operational Area.

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Wetlands of International Importance	N/A	N/A
Commonwealth Marine Environment	Significant Impact Guidelines for the Commonwealth marine environment (Table 7-3)	The impact assessment indicates that vessel movements will not exceed the Commonwealth Marine Environment significant impact criteria provided in Table 8-1 as the aspect does not pose a credible risk.

External Context

There have been no objections or claims raised by Relevant Persons to date around the vessel movement aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of the risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

As outlined above, the acceptability of the associated risks have been considered in the context of:

- The established acceptability criteria for the vessel movements aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

The residual risks have been assessed as Dark Blue (minor). Shell considers residual risks of minor or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the vessel movements.

Based on the points discussed above, Shell considers the risks from vessel movements associated with the Prelude petroleum activities to be ALARP and acceptable.

9.7.6 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
No injury or mortality of listed Threatened or Migratory MNES species associated with vessel collisions within the Operational Area.	Fauna observations and incident reports demonstrate no injury or mortality of listed Threatened or Migratory MNES marine species as a result of vessel movements within the Operational Area.

9.8 Introduction of Invasive Marine Species from Vessels

9.8.1 Aspect Context

Invasive Marine Species (IMS) are non-indigenous marine fauna or flora that have been introduced into an area beyond their natural geographical range, and may have the ability to survive, reproduce and establish a population such that they threaten native species through increased competition for resources and/or increased predation.

The vessels and equipment sourced from outside Australian waters have the potential to introduce or transfer IMS to the Operational Area, which may potentially spread to new areas or increase the impact of IMS already established in the wider region through oceanic currents and transport via activities such as support vessel movements. There are two primary mechanisms which may cause the inadvertent introduction and spread of IMS; hull fouling (biofouling) and ballast water discharges.

Establishment of IMS in the Operational Area requires a sequence of events to occur:

- the potential IMS must be present on (e.g. biofouling) or in (e.g. ballast water) the vector; and
- the potential IMS must be released into the environment (e.g. ballast water discharge, release of propagules from biofouling); and
- the potential IMS must survive, reproduce (either sexual or vegetative reproduction) and subsequently persist in the environment.

The introduction of IMS is recognised globally as a threat to marine biodiversity, and the International Maritime Organisation (IMO) has developed guidelines for the management of biofouling and ballast water. Commonwealth, State and Territory authorities also regulate the risk of IMS from biofouling and ballast water. Vessels operating in Australia are required to meet these requirements, and vessels meeting these requirements pose an inherently lower risk of harbouring IMS or releasing IMS into the environment.

If potential IMS become established in the Operational Area (i.e. on the Prelude FLNG, from tankers or other vessels), support vessels that operate in the field may subsequently provide vectors for translocation of potential IMS to new areas (NOPSEMA, 2020) or increase the impact of IMS already established in the wider region (Department of Fisheries, 2017). The likelihood of this sequence of events is considered extremely remote given the controls that are routinely applied to vessels (e.g. anti-fouling coating, inspections, hull cleaning etc.), the remote offshore location and nature of typical vessel activities (e.g. short periods alongside the Prelude FLNG during operations).

The Prelude FLNG facility will take up and discharge ballast water regularly as it produces cargoes and exports the products to off take tankers, but this ballast water does not pose a credible threat as the FLNG facility is permanently moored and does not travel to or from other ports. Support vessels will generally come from Australian ports and typically stay alongside the Prelude FLNG for short durations (generally in the order of hours) to offload and load materials.

Most native fouling species likely to be encountered within or transiting through the Operational Area will be widely distributed as similar habitats are broadly represented in the Timor Sea and Browse Basin. An IMS may compete with these native species if it were to become established in the Operational Area or wider region. This may decrease the species diversity of benthic communities.

IMS are typically extremely difficult to eradicate once established and reproducing in an area. In the highly unlikely event, an IMS becomes established and reproductively viable, it would be almost impossible to eradicate.

Ballast water exchange needs for the support vessels are expected to be limited. All vessels operating in the Operational Area are obliged to conduct ballast tank operations in line with IMO guidelines and, where applicable, comply with the Biosecurity Act 2015.

All known and potential introduced marine pests listed by Australian agencies are nuisance foulers, predators, invasive seaweeds or noxious dinoflagellates that inhabit harbours, embayment's, estuaries, shorelines and/ or shallow coastal waters less than 200m deep (Hayes et al. 2004, Barry et al. 2006). The water depth in the Operational Area is in excess of 240 m.

The offshore environment of the Operational Area is relatively deep, oligotrophic (nutrient-poor) and hard substrate habitats do not naturally occur. Many potential IMS are sessile invertebrates that require hard substrate for attachment. In the unlikely event potential IMS are released into the Operational Area, the IMS are highly unlikely to encounter suitable substrate for settlement and establishment. Most potential IMS are adapted to coastal waters, such as ports and harbours. If a potential IMS were to become established in the field, it is unlikely to survive in the relatively deep-water offshore environment. The deep water, low nutrient and open ocean environment in Operational Area provides minimal larval retention times or suitable habitat for coastally adapted IMS.

9.8.2 Current Knowledge about IMS on Prelude FLNG and Associated Vessels

Various studies were conducted both prior to and after the Prelude FLNG arrived in the Operational Area in July 2017, which provides more certainty on the presence/absence or persistence of potential IMS. A detailed summary of the outcomes and timing of various monitoring measures is outlined in Figure 9-6 below.

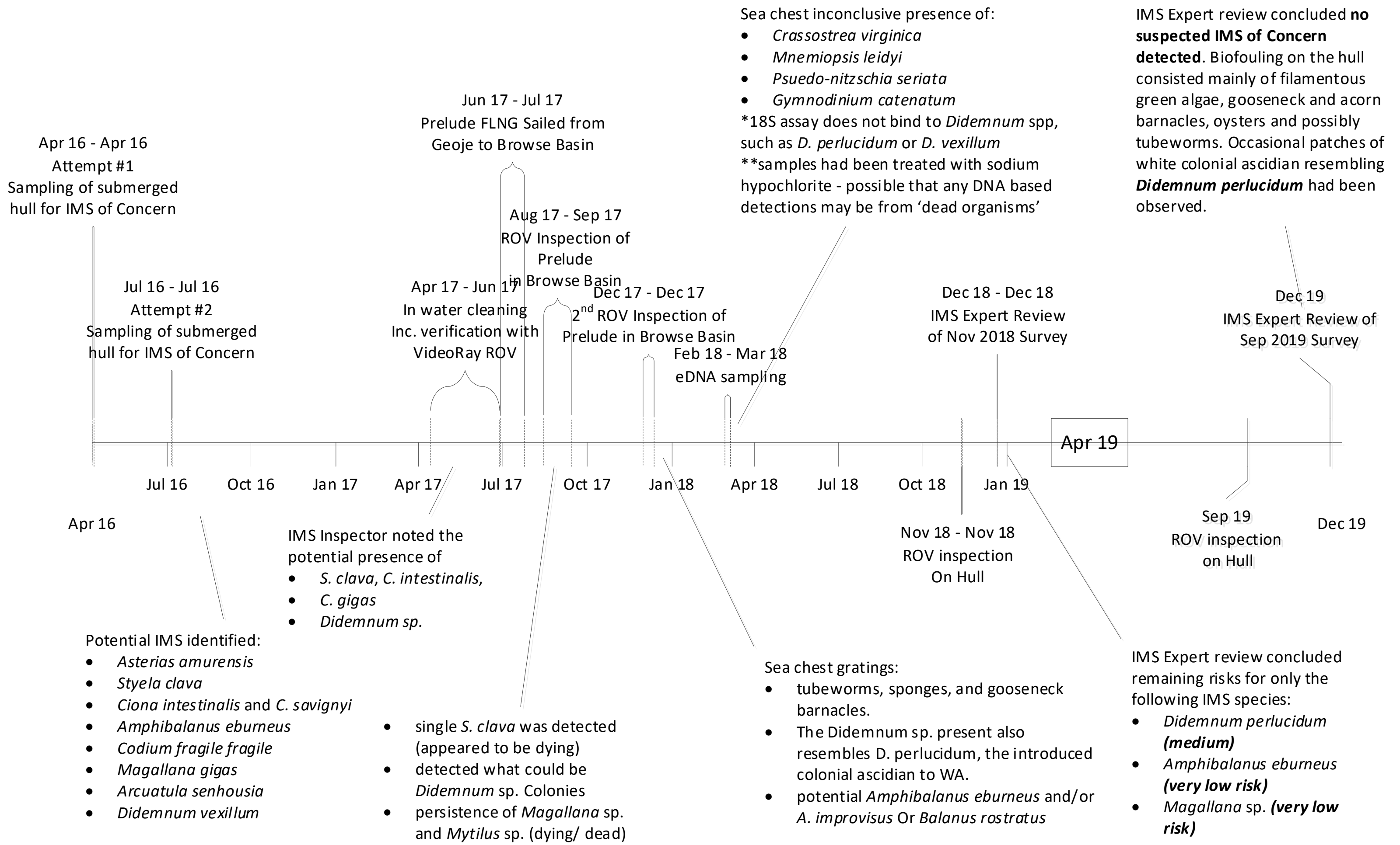


Figure 9-6: Timeline of Prelude FLNG IMS monitoring program since April 2016 until December 2019.

<u>Pre-arrival</u> of Prelude FLNG in the Operational Area, 'ALARP Cleaning' (April - June 2017) was conducted in the Geoje shipyard to reduce IMS numbers and potential inoculum pressure (and was considered the best practicable risk management outcome available). Specific to biofouling management, Shell contracted biofouling specialists to provide advice on the clean-up required as well as inspection services. Biofouling experts have produced the following reports for Prelude pre-mobilisation:

- **International Anti-Fouling System Certificate** from Lloyds Register.
- **IMS Risk Assessment (BFS1445)** – Assessed the risk of Prelude FLNG introducing IMS of concern to Australian waters. The risk assessment is based on "Infection Modes and Effects Analysis" (IMEA) for two IMS management scenarios: 1) Do nothing, and 2) ALARP. The study indicated that ALARP cleaning could vastly reduce IMS numbers and potential inoculum pressure and was considered the best practicable risk management outcome available.
- **Biofouling Management Plan (BFS1456)** – Outlined the proposed biofouling removal from the FLNG.
- **Biofouling/IMS Mitigation and Final Inspection (BFS1476)** – Final inspection report after biofouling removal in Geoje, and the assessment of the residual IMS Risk. The cleaning effort of the hull achieved a significant reduction in the number of IMS of concern and their cumulative reproductive potential. Despite residual risk, significant level of effort was applied in the in-water cleaning campaign. (Biofouling Solutions, 2017a)

<u>Post-arrival</u> of Prelude FLNG in the Operational Area (July 2017) until December 2019, there have been four ROV surveys and one set of eDNA sampling conducted, with data reviews from the biofouling experts. The updated residual risk assessment was developed in consultation with IMS agencies (i.e. DPIRD, NT Fisheries, Department of Agriculture, Water and the Environment (DAWE) after the first post-arrival ROV survey to agree on an aligned approach to managing IMS risk and the ongoing adaptive IMS risk management process. The Prelude FLNG Biosecurity Management Plan (2000-010-G000-GE00-G00000-HX-5798-00003) has been updated upon new information and understanding of the IMS residual risk.

- **Prelude ROV Inspection Report (BFS1499)** - the IMS Inspector noted the presence of *S. clava, C. intestinalis*, suspected *C. gigas* and *D. vexillum* persisting amongst inaccessible and/or uncleaned areas. IMS of concern which had been detected during previous inspections or any additional IMS of concern which maybe present within Korean waters, remained undetected. The *Didemnum* sp. present resembled *D. perlucidum*, the introduced colonial ascidian to Western Australia. This is not surprising considering the species were confirmed on two other installations in the area (i.e. the ROV survey and physical sample results post arrival of the neighbouring Ichthys facilities). (Biofouling Solutions, 2017b)
- **eDNA water sampling report from Trace and Environmental DNA (TrEnD) Laboratory at Curtin University -** No IMS of Concern detections in the categories 'highly probable', 'probable' or 'possible'. However, the presence of *Crassostrea virginica, Mnemiopsis leidyi, Psuedo-nitzschia seriata* and *Gymnodinium catenatum* were considered inconclusive. (Curtin University, 2018)

To provide additional context to the studies listed above, Biofouling Solutions undertook a residual risk assessment (Biofouling Solutions 2018). The report presented a residual risk assessment including new information from two ROV inspections (2017 and 2018) and eDNA water sampling undertaken by Shell at the recommendation of WA DPIRD. Water samples were collected from the moonpool and internal seawater systems via sea strainers on the FLNG. While DNA was successfully extracted from all samples collected, the yields of DNA were reported as being low (relative to seawater). Unfortunately, this could be a consequence of the water samples being collected from internal seawater systems where sodium hypochlorite is continuously dosed into each sea chest. DNA degradation could also have occurred during the transit of samples to the laboratory.

Nevertheless, the eukaryotic nuclear 18S gene (V1-V3) was amplified according to the TrEnD Lab's standard operating procedures and the DNA sequences recovered were queried against a custom database of marine invasive species reference sequences and compared to the National Centre for Biotechnology Information (NCBI) database for taxonomic identification to family level.

The results of the eDNA study detected a diverse range of taxa. Potential IMS detections were screened as either of the following categories; Highly Probable, Probable, Possible or Inconclusive. From the eDNA samples collected, no IMS of concern were detected in the Highly Probable, Probable or Possible categories.

The presence of four species were screened as Inconclusive. These included *Pseudo-nitzschia seriata* and *Gymnodinium catenatum* that are species of toxic dinoflagellates which only cause concern when they form toxic blooms. These blooms are often linked to increased stress such as excessive pollution or nutrient runoff. The distribution of *G. catenatum* in Australian waters is uncertain and species in the genus *Pseudo-nitschia* are frequently present throughout Australian waters. The presence of these species is unable to be fully determined using only 18S sequences, as they cannot be distinguished from other closely related taxa.

The Biofouling Solutions (2018) report concluded that the results of the eDNA study were not reliable. This was because the water samples were collected from internal seawater systems which contained sodium hypochlorite which is known to influence eDNA analysis. Other factors included that not all native and IMS species of concern have been sequenced and are available on the NCBI database and that eDNA cannot distinguish between live and dead cells. Finally, it was concluded that the detection of a species does not necessarily mean that they originated from the FLNG and could originate from other sources (such as ballast water discharges from other international vessels).

Another important point is that while the eDNA results detected the Phylum Chordata, unfortunately the 18S assay does not bind to *Didemnum* spp., such as *D. perlucidum* or *D. vexillum*, hence this technique cannot be used for reliable detections. Furthermore, Curtin University were advised by Dr. Justin McDonald of WA DPIRD, that *D. perlucidum* is now so widespread throughout Western Australia that it does not need to be reported to the WA DPIRD, hence Curtin University did not pursue further testing of this genus.

The outcome of the residual risk assessment undertaken by Biofouling Solutions (2018) reported that as of July 2018 there were five IMS of concern that have either been confirmed and/or have the potential to be present on the FLNG (*Amphibalanus eburneus, Codium fragile, Didemnum perlucidum* (unconfirmed), *Magallana gigas* and *Pseudo-nitzschia seriata).* The report further considered the potential for natural spread and artificial spread via domestic conveyances, where such transportation incorporates a series of stages along an invasion pathway. In the case of the FLNG such a pathway constitutes a two-stage stepping-stone process whereby visiting domestic conveyances become contaminated during an interaction with the FLNG, followed by the subsequent transfer of viable individuals from the domestic conveyance to high value areas and/or inshore coastal waters of Australia. The likelihood of these stepping-stone events occurring depends on a multitude of variables including the size of the population of IMS of concern on the FLNG, the reproductive biology and maturity of the IMS of concern, their larval phenology, the ability of the species to transfer asexually or even via entanglement, the environmental conditions experienced during the interactions, the duration and frequency of the interactions, and the availability of appropriate habitat for larvae or fragments to colonise or be entrained. The interaction of these (and other) variables is extremely complex and results in a highly stochastic probability of transfer which makes it extremely difficult to make any meaningful likelihood assessment beyond a broad consideration of plausibility.

In the event that domestic conveyances were to become contaminated with IMS of concern via settlement on the external hull or entrainment within internal seawater systems (including ballast water) from the FLNG, the likelihood of these species being successfully translocated to high value areas and/or inshore coastal waters of Australia depends on a whole suite of new selective filters such as the vessel's frequency, duration and distance, environmental conditions, proximity and suitability of habitats, (especially artificial substrates), etc. Biofouling Solutions (2018) concluded that the likelihood of IMS of concern being successfully introduced from the FLNG to either high value areas or inshore coastal waters via domestic conveyances is considered to be very low for all five IMS of concern. Although one species (*Didemnum perlucidum* which maybe present on the FLNG but remains unconfirmed, has the greatest likelihood of being both naturally spread or artificially transmitted from the FLNG to high value areas such as Browse Island (approximately 40 km form the Operational Area). If this species were to be introduced to a high value area, it has a theoretical potential to cause moderate impacts/ consequences. Similarly, *Pseudo-nitzschia seriata* also has the potential to cause moderate impacts if introduced into the inshore coastal waters of Australia.

Based on the uncertainty following the eDNA study (2018), further additional ROV inspections were undertaken in 2018 and 2019 as listed below.

- **Prelude ROV Inspection interpretation** – An ROV survey was conducted on the Prelude hull 12-13 November 2018. IMS expert reviewed the results and updated the specific residual risk of IMS species. Outcomes of the review indicated that there was no evidence to suggest the presence of the IMS of concern, *Didemnum vexillum.* The survey also confirmed the consistent mortality of *Magallana* spp. since the arrival of the FLNG in the Operational Area this is because the genus is beyond its temperature and reproductive tolerance and will slowly die out given there is unlikely to be fresh recruitment. The IMS expert review identified a morphologically similar growth resembling *Didemnum* to be present on the general hull and on sea chest gratings. However, whether this growth is in fact *D. perlucidum* can only be confirmed via sample collection and genetic testing. *Pseudo-nitzschia seriata, Gymnodinium catenatum and Codium fragile fragile* were all not observed during the latest and previous post arrival ROV surveys. *Amphibalanus eburneus* (acorn barnacle) may persist in turret area. Although in order for species to persist, individuals need to be in high abundance and within close proximity in order to cross-fertilise. Even if they do reproduce, the competency period of larvae is too long to enable an F2 generation to re-establish on the hull, hence all individuals are likely to die of old age over time.

  Based on the Dec 2018 IMS expert review of the survey data available, individual IMS of concern's residual risk of being transmitted to high value areas or inshore waters of Australia were deemed to be Moderate or lower which corresponds to a risk ranking of Dark Blue in Table 9-32. This assessment was subsequently reviewed by NT DPIRD and WA Department of Fisheries in February 2019 and the outcome of the residual risk assessment was aligned.

- **Prelude ROV Inspection Report (BFS1629)** - An ROV survey was conducted on the Prelude hull 19 September 2019. Overall, the assemblages of biofouling observed by the IMS expert on the FLNG were moderately diverse and abundant, varying from 40-100% coverage and were typical of biofouling communities associated with offshore structures located in the Northwest Shelf region of Western Australia. Observations of paint conditions show that the anti-foul coating is generally in good condition though significant delamination/damage was observed in one location. The report concluded "*no IMS of concern when reviewing the footage but did observe that white colonial ascidians with a colony structure and basic morphology resembling colonial ascidians of in the genus Didemnum were widely distributed on the vessel. This group includes Didemnum perlucidum which is considered an IMS but is now confirmed to be widely distributed throughout Western Australian coastal waters*." Although the species is no longer considered a noxious fish in Western Australian waters with the exception of the Montebello Islands. (Biofouling Solutions, 2019).

The ROV inspections and the eDNA studies to date confirm that the likelihood of the FLNG as a source of introducing IMS of concern is very low based on either natural or artificial transfer to new areas, with no IMS of concern on the Prelude hull since arrival in field in 2017.

9.8.3 Description and Evaluation of Impacts and Risks

A range of environmental sensitivities within the following groups may be at risk from the introduction of potential IMS, including:

- Biological Environment
- Socio-economic environment.

Potential risks associated with IMS establishment as a result of the petroleum activities are discussed below.

Biological Environment

The introduction and subsequent establishment of IMS could result in changes to the structure of benthic communities leading to a change in ecological function due to predation of native marine organisms and/or competition for resources. Once IMS establish, spread and become abundant in coastal waters some species could have Major ecological, economic, human health and social/cultural consequences (Hewitt et al. 2011; Pimental et al. 2000).

Shallow water, coastal marine environments are susceptible to the establishment of invasive populations, with most IMS associated with artificial substrates in disturbed shallow water environments such as ports and harbours (e.g. Glasby et al. 2007; Dafforn et al. 2009a, 2009b).

Benthic communities within the operational area are characterised by low density epibenthic communities of deposit and filter feeders on bare sediments. The seabed within the entire Operational Area does not receive sufficient sunlight to support benthic primary producer habitat, such as macroalgae and zooxanthellate corals. Very few potential IMS identified can credibly survive in the water depths of the Operational Area. For example, the non-oceanic species identified in the Australian Marine Pest Monitoring Manual (Department of Agriculture, Fisheries and Forestry 2010) indicated very few IMS (aside from planktonic oceanic species such as dinoflagellates) could credibly survive in the Operational Area; only three (European clam, soft-shell clam and Northern Pacific sea star) were identified as potentially surviving in > 90 m water depth; none were identified as credibly surviving at > 200 m water depth. These three species are typically found in shallower, coastal waters. The Operational Area is all > 230 m water depth. In the highly unlikely event these species were introduced into the Operational Area, they are unlikely to survive or become established on natural substrate due to the water depth alone.

With the stated controls in place, the likelihood of introduction of IMS associated with specific vessel-based campaigns is considered extremely remote as the potential vectors (e.g. support vessels) will typically be near the FLNG for relatively short periods (up to a week). Further, general support vessels will typically be sourced from Australian waters and will undertake the required assessments described in the Prelude FLNG Biosecurity Management Plan.

The waters associated with benthic communities (shoals, banks reefs and island surrounds), some KEFs (e.g. ancient coastline), WA mainland coastline and some of the Commonwealth Marine Environment in the wider region are typically shallower than those of the Operational Area. As outlined above, most potential IMS require shallower habitats than those found in the Operational Area. Hence, these shallower habitat waters in the region may be more vulnerable to introduction of IMS, however it is completely dependent on the extremely rare event of subsequent transport by support vessels.

With consideration of the habitat preferences of IMS (shallow water environments), the closest shallow water habitat to the Prelude FLNG is Browse Island, located some 40 km south-southeast of the Operational Area, and it is neither disturbed nor contains artificial structures that IMS are reported to prefer. Although not part of the petroleum activity, support vessels may spend some time during cyclone season or inclement weather to seek shelter near Browse Island (or other banks, shoal or islands in the area) for safety reasons. With the stated controls in place to minimise potential IMS risk, direct introduction of IMS to a shoal, bank or island during these short-duration and infrequent sheltering events is considered extremely remote.

Socio-economic Environment

The socio-economic receptors from IMS introduction / establishment risk are industries outside of the Operational Area such as fishing, tourism/recreation, marine protected areas or other oil and gas operators (e.g. Inpex Ichthys). The likelihood for IMS introduction, establishment and survival at or within these receptors is extremely remote with the stated controls in place.

9.8.4 Risk Assessment Summary

Table 9-32: IMS Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Biological Environment	Major effect	A - Extremely remote	Dark Blue
Socio-Economic Environment	Major effect	A - Extremely remote	Dark Blue

9.8.5 ALARP Assessment and Environmental Performance Standards

Table 9-33: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	No vessels	No	Vessels are essential for supply, standby safety support, and operations.	N/A	N/A	N/A
Substitution	Only use local support vessels	No	Although the use of local vessels is preferred, there are cases when this is impracticable due to availability of specialised vessels for the activities.	N/A	N/A	N/A
Engineering	Anti-foul coating/anti-foul system	Yes	Anti-foul coating/system on the FLNG/ vessels will help prevent biofouling accumulation on the hull. It is noted that anti-foul systems must be maintained in good condition in order to be an effective control for the management of marine pests. Therefore, the implementation of the Prelude FLNG Biosecurity Management Plan will confirm that vessels maintain Low Risk with respect to IMS, in conjunction with the presence of valid anti-foul coating/system documentation.	6.1	Vessels (of appropriate class) will have an anti-foul coating applied in accordance with the prescriptions of the International Convention on the Control of Harmful Antifouling Systems on Ships (2001) and the Protection of the Sea (Harmful Antifouling systems) Act 2006[9].	Valid International anti-fouling systems certificate or a Declaration on anti-fouling systems. Records of implementation of the Prelude FLNG Biosecurity Management Plan.
Administrative and Procedural controls	Ballast Water Management Plan and Certificate	Yes	Vessels that are intending to discharge internationally sourced ballast water within Australian waters must submit a	6.2	Vessels coming from overseas will have required DAWE	Records of the Maritime Arrivals Reporting System (MARS) or

[9] Advice from the Registered Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			Ballast Water Report through Maritime Arrivals Reporting System (MARS) at least 12 hours prior to arrival to gain DAWE clearance. The acceptable area for a ballast water exchange between an offshore oil and gas installation and an Australian port is in areas that are no closer than 500 m from the offshore installation and no closer than 12 NM from the nearest land and in water at least 50 m deep. Ballast tank sediment must be disposed of in an area outside 200 nautical miles from the nearest land, and in at least a depth of 200 metres, or at an approved land-based reception facility. The Biosecurity Act 2015 requires that vessels have a Ballast Water Management Certificate and Ballast Water Management Plan (BWMP), and undertake reporting and management of ballast in accordance with the Act. The BWMP must: • be vessel specific (vessel name and International Maritime Organization (IMO) number) • be approved by a survey authority, recognised organisation, or the vessel's flag administration • nominate the rank(s) of the responsible officer and crew		clearance including the Ballast Water Certificate and Ballast Water Management Plan if the vessel is required to discharge ballast in Australian waters. All vessels (incl. domestic) shall have a Ballast Water Management Plan in place consistent with the IMO Ballast Water Convention's Guideline.	equivalent demonstrate the vessel has sufficient DAWE clearance to operate within the Operational Area and Australian Territorial Waters. Vessel Ballast Water Management Plan Vessel Ballast Water Certificate

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			• contain the ballast water management method and pumping rates. BWMPs should be consistent with the IMO Ballast Water Convention's Guidelines for Ballast Water Management and Development of Ballast Water Management Plans (G4 Guidelines). A valid Ballast Water Certificate must be issued by either a survey authority, classification society, or the administration of the vessel, and be in accordance with Regulation E-1 of the Ballast Water Convention.			
	Ballast water management within the Operational Area	Yes	Only low risk ballast water will be discharged within the Operational Area. Although the Prelude FLNG facility location is classified as a suitable location for ballast exchange per the Australian Ballast Water Management Requirements i.e. will occur > 12 Nm from land and in water depths > 50m deep, no ballast water (originating from outside Australian waters) exchange will occur within the Operational Area of the FLNG. The product carriers and other international vessels will exchange their ballast before arriving at the Operational Area, therefore, they will discharge only low risk ballast water at the facility.	6.3	Only low risk ballast water will be discharged within the Operational Area.	Sample ballast exchange logs for internationally sourced vessels and offtake tankers demonstrate only low risk ballast water has been discharged within the Operational Area.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural controls	Vessel Specific Biofouling Management Plans	Yes	IMO biofouling guidelines - Guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species is considered 'best practice' for mitigation of transfer of invasive aquatic species to ALARP. Vessel specific (as per IMO guidance) Biofouling Management Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP.	6.4	Vessels will have a Biofouling Management Plan as per IMO guidance.	Vessel-specific Biofouling Record Book (BRB) recording implementation of BMP.
Administrative and Procedural controls	Prelude FLNG Biosecurity Management Plan	Yes	The Prelude FLNG Biosecurity Management Plan applies to the FLNG and associated support/installation vessels. The plan details preventative control measures to cover aspects of biofouling management, ballast water management and non-marine biosecurity risk. These controls include; • biofouling management record book • biofouling risk assessments for vessels operating within the Prelude PSZ • valid anti-foul coating certifications • ballast exchange logs • treatment of internal seawater systems • vessel sharing biofouling risk assessment for domestic movements (refer Figure 10-13). The following FLNG-to-vessel	6.5	Adhere to class requirements for marine vessel hull integrity inspection frequency (In-water every 2.5 years, Dry-dock every 5 years). Carry out the required Marine Vessel Biofouling Risk Assessments aligned with National Biofouling Guidelines for the Petroleum Production and Exploration Industry – for vessels originating from overseas or vessels being shared between operators.	Records of hull inspections Prelude Biosecurity LOW risk status from DAWE Vessel Low Risk Biosecurity Status Biofouling Risk Assessments for vessels operate within Prelude PSZ

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			interactions are exempted from this exposure: • Transfer of products (ex. LNG, LPG, condensate, diesel) via the offloading arms or hoses. • Offloading of equipment from another vessel onto the FLNG, but the equipment will be deployed directly to the seabed. • Transfer of pilots to support vessels during pilotage of product offtake tankers. Consistent with the published Biosecurity Reference Case by Maritime Industry Australia (Oct 2020), biofouling risk assessments shall include considerations of: • periods of layup/inactivity since last dry dock • details of antifouling system applied • presence or absence of MGPS • information about previous vessel locations. Risk results: • Low risk: vessel can be hired for normal operations • Uncertain/high risk: not to be used for normal operations Under unplanned or emergency circumstances where there is potential for escalated safety or environmental risk, uncertain/high risk vessels may be used as part of the response. In which case IMS risk assessments shall be			

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			conducted retrospectively and risk managed accordingly.			
Administrative and Procedural controls	Conduct opportunistic 3rd Party IMS Review during supply vessel class Underwater Inspection In Lieu of Drydocking (UWILD).	Yes	UWILD as required by Class ensures the functionality of antifouling coating and systems of vessels. A 3rd party IMS review of the footage and photos taken during the UWILD will provide even more certainty on the vessel's biofouling status.	6.6	Conduct a 3rd Party IMS review associated with support vessel UWILD and dry docking.	3rd Party IMS review report associated with support vessel UWILD and Dry Docking.
Administrative and Procedural controls	Limit time for support vessels to be alongside the FLNG and in ports, if vessels deemed low risk.	No	The latest Biosecurity Reference Case (Oct 2020) states that vessels with low risk biofouling status (such as the supply vessels and ISVs) do not require a time limit for operating alongside a facility with low risk biofouling status (such as the FLNG); unless the biofouling status is uncertain or high. Therefore, limiting the time spent by supply vessels and ISVs alongside the FLNG is not considered an effective control.	N/A	N/A	N/A
Administrative and Procedural controls	Conduct routine IMS surveys on the Prelude Hull and associated sampling of potential IMS species.	No	Leading up to Prelude's arrival in Australia in June 2017 there was significant biosecurity monitoring and management activities implemented to minimise the risk of introducing any IMS into Australian territory via Prelude. Although significant monitoring and management took place prior to sail-away, there was still a residual level of risk that remained at the time of sail-away.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			In order to follow-up, ROV hull surveys were carried out in the months following Prelude's arrival in September 2017 and again in January 2018 to inspect whether the species which could not be removed from the hull were surviving in WA-44-L. The results of these surveys found all of those IMS present before sail-away were gone with some remaining uncertainty regarding the presence of *Didemnum vexillum* (often confused with *Didemnum perlucidum* which has already been introduced in WA waters). Further monitoring in the form of eDNA water monitoring was undertaken in March 2018 and the results were inconclusive although feedback from WA DPIRD was that it was not on the list of IMS of concern due to it being widespread throughout WA. Further IMS specific ROV surveys were conducted on the Prelude FLNG hull in 2018 and 2019. The surveys were reviewed by independent IMS expert and concluded no IMS of concern have been identified. The results and assessments of the subsequent ROV surveys were reviewed by NT DPIRD and WA Department of Fisheries which confirmed their alignment on the residual risk. The financial and potential H&S costs of conducting dedicated IMS Hull surveys or physical sampling of potential IMS is considered grossly disproportionate to			

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			the benefit where the gain in terms of overall risk reduction is negligible in the context of the monitoring results since 2017 and the additional controls placed around periodic IMS reviews for supply vessels which are the main vectors for potentially spreading IMS. It is noted that IMS reviews of Prelude Hull surveys has to be dedicated campaigns at an additional cost due to the technical requirements of the necessary footage.			
Administrative and Procedural controls	Conduct IMS Reviews on the Prelude Hull and associated sampling of potential IMS species, when triggered by a support vessel IMS review or conducted at least once within the 5 year period of the EP.	Yes	Although it is disproportionate to conduct regular IMS reviews of the Prelude Hull and eDNA sampling, it is feasible to conduct this review if triggered by the support vessels' IMS reviews identifying IMS of concern or conducted once within period of 5 years.	6.7	Conduct a 3rd Party IMS review of Prelude Hull Survey triggered by a support vessel IMS review (i.e. identified IMS of concern), or at least once within the 5 year period of the EP.	3rd Party IMS Review report from a Prelude Hull Survey
Administrative and Procedural controls	eDNA water sampling within Ports visited by vessels going to and from the Operational Area	No	eDNA analysis of water samples from the port will be inconclusive as to whether the risk has originated from the petroleum activities due to the number of users of the port. As agreed by the State marine biosecurity agencies, this is the responsibility of the State agencies.	N/A	N/A	N/A
Administrative and Procedural controls	Further investigation of biology, method of reproduction, propagule pressure/competency periods and behaviour, ability for	No	The biology of each species needs to be considered to determine the likelihood of the species reproducing, spreading and contaminating both nearby and distant sensitive receptors and/or anthropogenic	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	adults to depart the FLNG, oceanic currents, interaction with vessels and domestic ports		structures. This might involve investigating each species' methods of reproduction (e.g. sexual and asexual), potential larval/propagule pressure based on assessed abundance and density witnessed on the Prelude FLNG, larval/propagule competency periods and behaviour, ability for adults and/or fragments to depart the vessel, strength, direction and prevailing oceanic currents, interaction with domestic conveyances, and their interaction with domestic ports of Australia. Such an assessment is complex, time-consuming and will suffer from significant knowledge gaps/uncertainty.			
Administrative and Procedural controls	In-water cleaning of the FLNG's hull	No	Limited availability of suitable cleaning methodology – Only two cleaning methodologies have been approved by the paint/coating provider for the Prelude FLNG: caviblaster and robotic/ROV cleaner provided by Samsung Heavy Industry. Other technologies have been considered and tested in Geoje (South Korea), but were determined not to be suitable as they will damage the coating, therefore, voiding the intended functionality of the coating and the warranty. The robotic/ROV cleaner can only access flat areas, but will not be able to clean the niches. The caviblaster will require divers. Not all areas can be cleaned by the ROV cleaner, and divers	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			will be required which present a significant safety exposure (diving in an offshore environment, and under a weathervaning facility). The indicative total cost would likely be more than $10 million per cleaning activity. This cost is disproportionate to the benefit gained as any in-water cleaning approach does not give certainty to the removal of all potential IMS. Cleaning will also result in disruption to operations in order for the sea-chest gratings to be cleaned as water intakes have to be shutdown which will cause disruption to normal seawater supply into the facility. Therefore, in-water cleaning may result in considerable operational disruption which will result in significant costs. As there will always be residual risk of IMS even after in-water cleaning (regardless of any cleaning technology used or even if the removed biofouling are contained) and this has been deemed as acceptable under the Shell risk assessment methodology, there is therefore limited benefit of in-water cleaning at such a disproportionate cost and safety risks. Therefore, in-water cleaning is not considered ALARP.			
Administrative and Procedural controls	Develop specific IMS response plans and carry out training and drills to prepare	No	The resources and time that would be needed for a mitigative control such as this is significant and considered grossly	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	for the need to respond to an IMS incident		disproportionate to the benefit gained since the time it would take to prepare a response plan in the event of an incident is not considered to be significant in the context of breeding and reproductive cycles of most potential IMS species. Furthermore, IMS response plans are planned to be developed by government as outlined in the National Strategic Plan for Marine Pest Biosecurity 2018-2023.			

9.8.6 Acceptability of Impacts and Risks

Table 9-34: Acceptable Levels of Risks - IMS

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Biological Environment	Benthic communities	Limited environmental impact which directly impacts bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities which adversely effects biological diversity or ecological integrity. Limited environmental impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.	Yes	The introduction of an IMS as a result of the Prelude operations is unlikely to survive given the water depth in the Operational Area. However, surrounding shallower habitats in the wider region such as Browse Island (the closest receptor to Prelude, approx. 40 km away) are likely to be more susceptible to an IMS becoming established due to their relatively shallow depth. Based on ongoing controls such as using a risk-based approach to manage the pathways and vectors that are responsible for the establishment of an IMS, the likelihood of an IMS becoming established is extremely remote. Shell will take industry-standard measures to reduce the likelihood of an IMS being introduced at the Operational Area or to new areas as a result of petroleum activity. If an IMS were to be become established, it would be very difficult to eliminate, however there is an extremely remote likelihood of significant impacts to the identified potential receptors.
	KEFs	No impacts to environmental values of KEFs	Yes	
	Commonwealth Marine Area	No significant impacts to the Commonwealth Marine Environment (Refer to Table 8-1).	Yes	
	WA Mainland Coastline	No impacts to mainland coastline.	Yes	
Socio-economic and Cultural Environment	Marine Protected Areas	No impacts to ecological values of Marine Protected Areas	Yes	Based on ongoing controls such as using a risk-based approach to manage the pathways and vectors that are responsible for the establishment of an IMS, the
	Fishing Industry	No negative impacts to	Yes	

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
		exploited fisheries resource or aquaculture stocks which result in a demonstrated direct loss of income or other benefits.		likelihood of an IMS becoming established is extremely remote. Shell will take industry-standard measures to reduce the likelihood of an IMS being introduced at the Operational Area or to new areas as a result of petroleum activity.
	Tourism and Recreation	No negative impacts to nature-based tourism resources resulting in demonstrated loss of income.	Yes	

The assessment of risks from IMS determined a residual risk ranking of Dark Blue (Table 9-32).As outlined above, the acceptability of the risks from the introduction of IMS associated with the petroleum activities has been considered in the context of:

Principles of ESD

The inherent risks from the introduction of IMS resulting from the petroleum activities are inconsistent with some of the principles of ESD based on the following:

- The introduction of an IMS poses a risk to the diversity and ecological integrity of the biological and socio-economic environments in the vicinity of the Operational Area and the wider region.

However, Shell will apply a range of controls to ensure that the risk of IMS introduction is reduced to a level that is acceptable and ALARP. Following successful application of these controls, Shell considers the residual risk to be consistent with the principles of ESD.

Relevant Requirements

Management of the risks from an introduction of IMS resulting from the Prelude project are consistent with relevant legislative requirements, including:

- compliance with international maritime conventions, including
  - The International Convention for the Control and Management of Ships' Ballast Water and Sediments
  - The International Convention on the Control of Harmful Anti-Fouling Substances
  - IMO 2011 Guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species.
- compliance with Australian legislation and requirements, including:
  - Protection of the Sea (Harmful Anti-fouling Systems) Act 2006:
    - Marine Order 98 – Marine Pollution prevention – anti-fouling systems.
  - Biosecurity Act 2015:
    - National Biofouling Management Guidelines
    - Australian Ballast Water Management Requirements.

- NT Fisheries Act
- WA Fish Resources Management Act 1994, subsequent Fish Resources Management Regulations 1995 and the Aquatic Resources Management Act 2016
- the WA DPIRD Biofouling Biosecurity Policy*.

*The WA DPIRD Biofouling Biosecurity Policy (WA Department of Fisheries Jan 2017) specifies the objective to minimise the adverse impacts of aquatic pests and diseases in WA through “1. Preventing the establishment of aquatic pests and diseases in new locations” and “2. Minimising the impact of established aquatic pests and diseases”. As such, the acceptable level of risk for IMS (stated in the EPO) is consistent with this policy.

Matters of National Environmental Significance

Threatened and Migratory Species

The policies, strategies, guidelines, conservation advice and recovery plans for MNES that may occur within the potential area affected by an IMS do not identify IMS as a threat.

Commonwealth Marine Environment

The impacts and risks from the introduction of IMS will not result in significant impacts to the Commonwealth Marine Environment.

Table 9-35: Summary of Alignment of the Risks from the IMS Aspect of the Prelude Petroleum Activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Threats Relevant to the Project	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	N/A	N/A	N/A
Commonwealth Marine Area	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	Introduction of IMS	The residual risk assessment indicates that the petroleum activities will not exceed the Commonwealth marine environment significant impact criteria provided in Table 8-1.
Wetlands of International Importance	N/A	N/A	N/A

External Context

Shell’s ongoing consultation program will consider statements and claims made by stakeholders when undertaking the assessment of impacts and risks.

Ongoing monitoring and engagement with Relevant Persons for IMS will be carried out in accordance with the process below established in agreement with the Relevant Persons as further described in Section 10.4.3 and Figure 10-12 with respect to the adaptive management of IMS.

The following claims were made by DPIRD regarding controls to consider:

- Suggest support vessels which aligns with proposed "NOPSEMA Offshore Support Vessel Reference Case" process. – Shell has reviewed the published Biosecurity Reference Case (Maritime Industry of Australia Ltd, 2020) and has ensured alignment. The associated NOPSEMA regulatory advice states that reference case delivers a suitable evaluation of impacts and risks and appropriate control measures for: the management of ballast water risks; and the biofouling risks associated with vessels coming from within the same region (locally-sourced) operating in less sensitive areas (e.g. deep water) and alongside low risk facilities (e.g. facilities with no known established NIMS).
- IMO biofouling guidelines considered 'best practice' for mitigation of transfer of invasive aquatic species to ALARP – Shell has adopted this.
- Suggest supporting vessels encouraged to have vessel specific (as per IMO guidance) Biofouling Management Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP. – Shell has adopted this.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of risks from IMS determined the residual risk rankings were Dark Blue (Table 9-32). As outlined above, the acceptability of the impacts and risks from IMS associated with Prelude Field has been considered in the context of:

- The established acceptability criteria for the IMS aspect of the Prelude field
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Given the considerable water depth (>230 m), potential IMS species which may be present on Prelude FLNG would not able to settle and establish on the available natural substrate within the Operational Area and the nearest shallow water sensitive receptor, Browse Island, is located approximately 40km away. Considering all of the controls which are in place, the residual risk of potential species of IMS persisting on Prelude FLNG, spreading, attaching to support vessel hulls and establishing in new areas such as high value areas and/or inshore coastal waters of Australia such as at ports following a long distance vessel transit is Moderate given the potential consequences following the very remote likelihood of establishment.

Shell considers residual risks of moderate to be acceptable with controls if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the IMS aspect of the petroleum activities.

Based on the points discussed above, Shell considers the risks from IMS associated with the petroleum activities to be acceptable.

9.8.7 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No IMS of concern[10] established in the natural environment as a result of Prelude operations. No introduction of IMS to the marine environment from ballast water exchange operations undertaken or biofouling by project vessels.	No confirmed and externally reported instances of IMS establishment in the natural environment as a result of the petroleum activities.

9.9 Discharge of Liquid Effluent

A range of aspects of the Prelude petroleum activities will result in the discharge of liquid waste streams to the marine environment. These aspects include:

- Drainage and bilge effluent
- Food waste, greywater and sewage
- Cooling Water (CW)
- Desalination brine, boiler blowdown and Mixed Bed Polisher (MBP) Effluent
- Produced Water (PW)
- Use and release of chemicals in ad-hoc discharges.

Descriptions of the characteristics of each of the routine liquid discharge streams are summarised in Table 9-36 and further detailed specifically in Section 9.9.1 below. Note that unplanned spills, e.g. of chemicals or hydrocarbons, are considered separately in Section 9.14.

Table 9-36: Types, location, source depth, discharge depth, flow rates and orientations of the planned and routine liquid discharges from Prelude FLNG

Discharge Port Name	Discharge Type	Port or Starboard	Source Depth Below Sea Level (BSL) (m)	Typical Discharge Depth BSL (m)	Orientation	Maximum Estimated Flowrate (m^3/hr)
P47	Sewage	Port	N/A	11.5	Vertical	0.17-0.43 (Continuous)
						20 (Batch)
P50	Grey Water	Port	N/A	11.5	Vertical	2.4-2.7
P50	Foodwaste	Port	N/A	11.5	Vertical	0.01-0.03
P6	Produced Water	Starboard	N/A	5	Horizontal outboard	50-165

[10] IMS of concern are species that are listed on the Western Australian Prevention List for Introduced Marine Pests or Commonwealth National Introduced Marine Pest Information System, and could survive in the natural environment beyond the Prelude FLNG and installed infrastructure.

Discharge Port Name	Discharge Type	Port or Starboard	Source Depth Below Sea Level (BSL) (m)	Typical Discharge Depth BSL (m)	Orientation	Maximum Estimated Flowrate (m^3/hr)
P51	SW1 CW Discharge	Port	Near Surface	12.1	Vertical	142
P60	SW1 CW Discharge	Starboard	Near Surface	13	Vertical	142
P61	SW1 CW Discharge	Starboard	Near Surface	12.6	Vertical	142
P53	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P54	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P63	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P64	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P48	SW3 CW Discharge	Starboard	Near Surface	17.2	Vertical	4028
P49	SW3 CW Discharge	Port	Near Surface	17.2	Vertical	4028
P35	SW4 CW Discharge	Port	Near Surface	6.2	Horizontal Outboard	1750
P36	SW4 CW Discharge	Port	Near Surface	6.2	Horizontal Outboard	1750
P37	SW4 CW Discharge	Port	Near Surface	6.4	Horizontal Outboard	1750
P59	Desalination Brine	Starboard	N/A	12	Vertical	1100
P30	Boiler Blowdown	Starboard	N/A	18.5	Vertical	14-30
P38	MBP Effluent	Port	N/A	12	Vertical	200
P62	Drainage effluent	Port	N/A	11.5	Vertical	15.8
P39	Bilge	Starboard	N/A	19	Vertical	18

9.9.1 Aspect Context

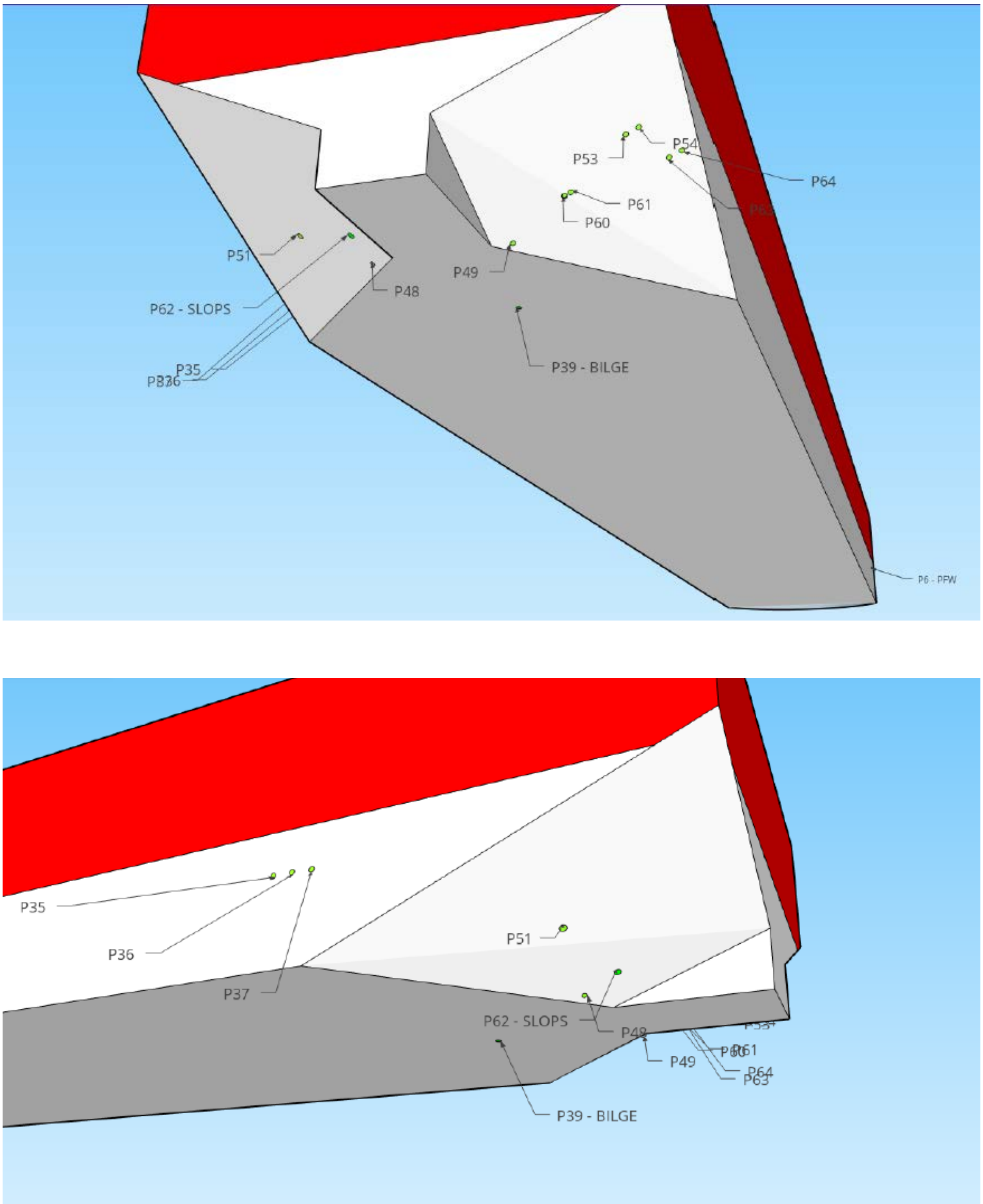


Figure 9-7: Locations of all routine planned liquid discharges on the Prelude FLNG. Numbers correspond with those in Table 9-36.

9.9.1.1 Drainage (Slops) and Bilge Wastes

Marine Support Vessels

Deck drainage and bilge from Marine support vessels consists mainly of wash down water, seawater spray and rainwater and may contain small quantities of oil, grease, metals, detergents (surfactants) and other residual chemicals present on the deck, which has the potential to create surface sheens and short term, localised reduction in water quality if it enters the marine environment.

FLNG

The FLNG Open Hazardous Drainage System collects and disposes both deck drainage (e.g. rain water), potentially oil contaminated streams (e.g. deluge water, accidental spills, and cleaning water during maintenance activities) as well as continuous process drainage streams (e.g. automatic filter backwash, analyser conditioning systems). When there is deck drainage, the majority of inputs into the Open Hazardous Drainage system originates from continuous process drainage sources (~200 m^3 per week). All open hazardous drainage sources are directed to the Open Drain Tanks and then Slops Tanks where it is treated by gravity separation prior to discharge. The Slops Tanks can also act as a further separation mechanism for managing Produced Water.

Unlike other LNG facilities, the Prelude FLNG facility has a machinery space and thrusters. Similar to regular trading vessels, run-off from this area is collected in the Bilge System and treated prior to being discharged using a unit designed to meet MARPOL limits.

Runoff from deck areas containing LNG, Mixed Refrigerant (MR) or LPG is not contained to ensure that cryogenic spills are not left in-situ to develop into flammable gas clouds on the facility. This is a design safety measure. In the unlikely event of a spill, the liquefied hydrocarbons would change into a gaseous phase rapidly with minimal effect on the marine environment. Therefore, in areas where potential cryogenic spills can occur, Entirely Oil Free streams of storm-water, sea spray and water generated from routine operations such as deck and equipment cleaning and fire drills are not collected and contained. To protect the environment from potential spills during maintenance of hydrocarbon containing equipment in cryogenic areas, spill equipment is stored onboard the facility to enable the establishment of temporary containment facilities.

The closed drain system will not have any liquids discharged to the ocean, therefore, there are no risks or impacts associated with the closed drains systems.

The FLNG's drainage system is further described in Appendix A: Detailed Facility Description.

9.9.1.2 Food Waste, Sewage and Greywater

Vessels

Vessel activities within the Operational Area will require planned discharges that will likely include sewage, greywater and food waste. Typical discharge volumes per vessel type are provided in Table 9-37. These volumes are indicative only and are provided for the purposes of the corresponding impact assessment and may vary.

FLNG Facility

The sewage system on the FLNG facility collects black water, some greywater and sweat drains from the following prior to discharge:

- Accommodation
- Hospital
- Toilets in the aft machinery space.

The pumps and screens within the vacuum toilet and sewage collection system effectively comminutes sewage particles. There is a sewage holding tank which was designed to hold sewage if not appropriate to discharge overboard.

The grey-water system processes the effluent stream from sinks, washbasins, showers, laundry and sweat drains. Drains from the galley sinks are routed to the grey-water system. Grey water quantity is greater than black water and can be managed separately if required. Grey water can be discharged directly overboard or overboard via the grey water tank.

The food waste system includes a macerator, which discharges to the ocean.

The expected production and release rates of sewage, greywater and food waste for the FLNG and typical vessels are shown in Table 9-37. These estimates are based on the anticipated upper bound, assuming peak manning and all listed vessels in the Operational Area at the same time which is highly unlikely.

Table 9-37: Upper bound estimates of sewage, grey water and food waste volumes and associated calculated nutrient input estimations into the marine environment

Vessel/Facility	Typical Max POB	Estimated Sewage volume (m^3/day)[1]	Estimated Greywater Volume (m^3/day)[2]	Estimated Food Volume (kg/day)[3]	Estimated Total Nitrogen (TN) Load (kg/day)[4]	Estimated Total Phosphorus (TP) Load (kg/day)[5]
FLNG	340	10.2	57.8	3 40	Sewage: 1.02 Greywater: 1.52 Food waste: 8.16 Total: 10.70	Sewage: 0.09 Greywater: 0.58 Food waste: 1.36 Total: 2.03
Supply Vessel	68	2.0	11.6	68	Sewage: 0.20 Greywater: 0.30 Food waste: 1.63 Total: 2.14	Sewage: 0.02 Greywater: 0.12 Food waste: 0.27 Total: 0.41
Infield Support Vessel	10	0.3	1.7	10	Sewage: 0.03 Greywater: 0.04 Food waste: 0.24 Total: 0.31	Sewage: 0.003 Greywater: 0.02 Food waste: 0.04 Total: 0.06
Installation Vessel	120	3.6	20.4	120	Sewage: 0.36 Greywater: 0.54 Food waste: 2.88 Total: 3.78	Sewage: 0.03 Greywater: 0.21 Food waste: 0.48 Total: 0.72
Accommodation Vessel (e.g. Major Maintenance Campaign)	650	19.5	110.5	650	Sewage: 1.95 Greywater: 2.91 Food waste: 15.6 Total: 20.46	Sewage: 0.17 Greywater: 1.12 Food waste: 2.6 Total: 3.88

Vessel/Facility	Typical Max POB	Estimated Sewage volume (m^3/day)[1]	Estimated Greywater Volume (m^3/day)[2]	Estimated Food Volume (kg/day)[3]	Estimated Total Nitrogen (TN) Load (kg/day)[4]	Estimated Total Phosphorus (TP) Load (kg/day)[5]
Total Upper Bound (Rounded)					**37**	**7**

1. Calculated based on 0.03m^3 per person/per day
2. Calculated based on 0.17m^3 per person/per day (USEPA 2011)
3. Calculated based on 1kg per person/per day
4. Conservatively assumes no consumption via vessel treatment systems. Calculated based on sewage discharge of 100 mg/L TN for sewage (Washington State Department of Health 2005), 26.3 mg/L for greywater (USEPA 2011) and 2.4% TN for food waste (Polglaze 2003).
5. Conservatively assumes no consumption via vessel treatment systems. Calculated based on sewage discharge of 8.6 mg/L TP for sewage (State of Idaho Department of Environmental Quality 2012), 10.1 mg/L for greywater (USEPA 2011) and 0.4% TP for food waste (Polglaze 2003).

9.9.1.3 Cooling Water

Vessels

Based on relatively low predicted volumes of cooling water discharged from vessels coupled with expected rapid dilution and dispersion, these discharges are not considered to present credible impacts to receptors and are not described further.

FLNG

Seawater is used as a heat exchange medium for the cooling of machinery engines and in the production process. Seawater is drawn from the ocean and flows counter current through closed circuit heat exchangers, transferring heat from the machinery or production process to the seawater via an intermediate circulating freshwater system. Seawater is then discharged to the ocean at an average of approximately 5°C to 9°C above the ambient seawater temperature (depending on season and the depth it is drawn from).

The Prelude FLNG facility has 12 cooling water discharge outlets which are situated below the water line towards the stern of the facility. They differ by flow rate and orientation as shown in Table 9-36 and Figure 9-7. The total throughput of cooling water during normal operations is approximately 80,000 m^3/h.

Chlorine in the form of sodium hypochlorite, produced through the Electrochlorination Unit (ECU), is added to the cooling water to reduce the potential for marine growth within the pipework of the cooling water system. The entire system is designed for fixed amount of seawater flowing into the ECU unit. Hypochlorite injection is controlled by varying the current sent to the ECU cells and the rate at which hypochlorite is dosed into the various systems. An investigation into a power trip on Prelude in February 2020, which resulted in a shutdown of production on the facility, found a key cause of the trip to be fouling in the sea water heat exchangers resulting in the trip of the back-up power system. Details on the investigation into the ECU performance and the discharge limits based on the current development is further discussed in the section below. After considering the identified ECU operating constraints, a decision has been made to operate in a target range of 0.12 – 0.43mg/l and a maximum of 0.6mg/l to allow for shock dosing.

Cooling is required for the FLNG facility from a safety and technical integrity critical perspective as part of the hydrocarbon production process. Therefore, maintaining a system that is free of internal marine fouling is absolutely integral to the safe and efficient operation of the facility.

9.9.1.4 Desalination Brine and Mixed Bed Polisher Effluent

The production of freshwater from seawater in the seawater distillers on the FLNG facility results in a discharge of seawater with a slightly elevated salinity (approximately 10% higher than seawater). The volume of the discharge is dependent on the operational demand for fresh (or potable) water. Standard demand for freshwater for the FLNG facility will be approximately 70 m^3/hr, however this may be up to 120 m^3/hr during major maintenance activities or other campaigns, which require a greater number of people to be located at the facility for short periods of time. Chlorine scavenging, scale inhibiting and/or small volumes of other treatment chemicals may be present in the waste stream at low concentrations.

Mixed Bed Polisher (MBP) effluent discharge is a batch discharge, characterised in Table 9-36 and location shown within Figure 9-7. The discharge typically managed to pH 6-12 and is generated from the requirement to regenerate the mixed bed polishers to ensure their reliable operation.

The boiler blowdown discharges are associated with water within the boiler system that is discharged with flashed steam as is the case for many commercial vessels that utilise marine boiler systems. The boiler blowdown discharge is a continuous discharge of approximately 2 m^3 per hour per boiler. On irregular occasions, when deposits in the boiler drums have to be removed, approximately 30 m^3 per hour may be discharged for short durations. The discharge is characterised in Table 9-36 and location shown within Figure 9-7. The discharge typically is managed to a pH between pH 9-12 and also contains residual chemical additives which are used to prevent corrosion and scale build-up within the boilers to maintain safe, energy efficient and functional integrity.

9.9.1.5 Produced Water (PW)

PW is water which has permeated into the gas reservoir over time and includes condensed water. When the liquid and gaseous hydrocarbons are extracted from the reservoir the PW is separated from the hydrocarbon products in the inlet facilities. PW, including condensed water, is an undesirable by-product of the gas and condensate extraction process and is discharged into the marine environment directly from the FLNG following treatment. The PW discharge is located near the bow, approximately 40 m from the turret, and on the starboard side of the FLNG facility at approximately 5 m below the water line.

The PW treatment system of the FLNG facility is designed for a maximum 165 m^3/hr discharge capacity. However, for the duration of this EP and prior to the breakthrough of the produced formation water (saline aquifer in the liquid phase), it is anticipated that discharge of condensed PW (freshwater condensed out of the gas phase through the process) will occur in batches and at a considerably lower rate of approximately 50 m^3/hr.

Hydrocarbons from the PW are treated by the Macro Porous Polymer Extraction (MPPE) Package. This system is further described in Section 6.0 and Appendix A: Detailed Facility Description. Treated water from MPPE package is then routed overboard to sea. The package is designed to discharge PW at less than 42 mg/L Total Petroleum Hydrocarbon (TPH) content instantaneous and less than 30 mg/L TPH over a 24hr average. The definition of TPH is documented in Prelude FLNG Oil in Water

Measurement Philosophy (HSE_GEN_16227). A buffer tank is available to recycle and retreat PW prior to discharge if it is off-specification.

During initial ramp-up to the maximum flowrate for each well, including the initial production test runs at up to 200 MMSCFD production, there may also be short time periods (approximately 72-96 hours per well) where the PW discharge may contain concentrations of up to 100 mg/L TPH required to complete the well clean-up process which involves flowing the wells at 100% capacity. During these completions of the initial 'clean up' activities, it is expected each well will produce higher rates of drilling mud.

As described further in Appendix A: Detailed Facility Description, MEG is used in the subsea system for hydrate prevention and preservation under certain scenarios. This may result in PW discharges containing up to approximately 20% MEG for short durations following these events.

9.9.1.6 Use and Discharge of Chemicals

Chemical usage is required for various routine and non-routine process and non-process applications and as such, chemicals may be present in waste water streams which are discharged to the ocean.

Chemicals are utilised on the Prelude FLNG facility, marine support vessels and associated subsea facilities for a variety of purposes and can be divided into four broad categories, as described below.

<u>Operational Process Chemicals</u>

An operational process chemical is the active chemical added to a process or static system, which provides functionality when injected in produced fluid, utility system streams or for treatment. These chemicals types may be present in continuous or batch discharge streams into the ocean:

- Hydrate inhibitor
- Oxygen scavenger
- Scale inhibitor
- Biocide
- Antifoam
- Demulsifier
- Reverse Demulsifier
- Hypochlorite
- Boiler Water Treatment
- Water Clarifier
- Acids e.g. Hydrochloric, citric, sulphamic
- Paraffin Inhibitor/Pour Point Depressant
- Hydraulic control fluid (subsea) - Subsea control fluids are used to open or close wellhead/subsea valves resulting in small volumes of subsea control fluids being discharged each time a valve is activated.

Environmental impact assessment of the routine planned waste streams and their respective chemical constituents is detailed further in Sections 9.9.2 and 9.9.3 and are not addressed further in this subsection.

Facility Maintenance/Non-Process Chemicals

Facility maintenance chemicals include chemicals which are required for general maintenance activities on the FLNG facility, marine support vessels and respective equipment. These may include paints, degreasers, greases, fire-fighting foam, lubricants and domestic cleaning products. They may also include chemicals required for speciality tasks, such as laboratory testing and analysis. These non-process chemicals generally present negligible risk to the environment as they are either not usually discharged as a result of their use (e.g. paint) or are used intermittently and/or are typically only ever discharged in small volumes and/or low concentrations (e.g. domestic cleaning products, washdown cleaners, closed cooling water change out or fire-fighting foam during testing).

Subsea Operation, IMR and Intervention Activity Chemical Discharges

The majority of the maintenance and intervention activities are non-intrusive visual inspections undertaken via ROV as the facilities are designed for a minimum of 25 years field life with minimal intervention. However, in the event that the certain subsea equipment needs maintenance, repair, replacement or well intervention due to failure or damage for example, the estimated associated discharge types and volumes are provided in Table 9-38.

Table 9-38: Estimated Chemical Discharge Types and Typical Volumes during Subsea Operation, IMR and Intervention Activities

Discharge Type	Estimated Discharge Per Event
Control module replacement	Approximately 4L of HT2 TransAqua Hydraulic Fluid (or similar)
Choke valve replacement	Approximately <1m^3 of MEG with residual produced hydrocarbon per valve replacement
Flow module replacement	Approximately <1m^3 of MEG with residual produced hydrocarbon per flow module
Flowline connector replacement	Approximately <1m^3 of MEG with residual produced hydrocarbon per connector
Flexible riser connector replacement	Approximately 20m^3 of MEG with residual produced hydrocarbon per connector
Riser replacement	Approximately 40m^3 of MEG with residual produced hydrocarbon per riser
Light well intervention (Refer to Section 6.4.5-6.4.6)	Approximately 3.2 m^3 MEG, residual produced hydrocarbon, freshwater and associated dosing chemicals discharged from the production trees and well intervention tooling.

Discharge Type	Estimated Discharge Per Event
Dye used for leak detection and environmental monitoring purposes	Approximately 5-50L per leak test or monitoring event
Cycling of subsea valves[1]	Approximately 0.01-11L per actuation per valve of HT2 TransAqua Hydraulic Fluid (or similar)
Hotstab activities	Approximately 0.5-10L of associated chemical in use per hotstab
Sulphamic acid (or similar alternative) used for marine growth removal or pipe treatment	For SCM replacement – Approximately 5m^3 For general inspection/ROV manipulation – Approximately <0.1m^3 per inspection point/activity
Grouting, grout bag installation and grout line flushing	Approximately 0.2m^3 per discharge

1 – Note cycling of valves and associated discharges is also a routine ongoing activity

A number of other planned liquid discharges may occur during the project life, including hydraulic fluids from ROVs or other underwater equipment, downline flushing (e.g. grout and/or hotstab lines during IMR campaigns), lubrication fluids from planned maintenance of the subsea system, fluids from IMR activities such as coatings repair, closed cooling water replacements, hydrotest fluids and others from time to time. These discharges are expected to be for short durations, infrequent and/or relatively minor in nature and scale and any potential impacts of such discharges are expected to occur within the area influenced by the larger planned discharges described in this section and are unlikely to result in impacts to the environment that are not already assessed within this EP.

It is impractical to forecast exact types and volumes of all required liquid discharges for potential future activities throughout the facility lifetime and therefore Table 9-38 is indicative only for the purposes of this impact assessment.

9.9.2 Description and Evaluation of Impacts

Planned liquid discharges to marine waters creates a potential for the localised decline in water and sediment quality and for biota in those environments to be exposed to physical characteristics and contaminants at concentrations that may cause acute or chronic effects.

The identified effect pathway associated with the planned liquid discharges can be summarised by the following:

- Changes to physical and/or chemical water quality resulting in:
    - Impacts to sensitive biological receptors.

Any effects on water quality are expected to be within the surface layers only and have no effect on or damage to seabed/benthic receptors (refer to Section 9.9.2.2 Biological Environment for further details).

The magnitude and sensitivity of any impacts on the identified sensitive receptors varies according to multiple factors, including discharge composition, plume dilution/dispersion, bioavailability, duration of exposure and marine species physiology and behaviour. A detailed description and evaluation of these impacts is provided in the subsections below. A summary presenting credible interactions associated with the various liquid discharges is provided in Table 9-39 assessed per environmental receptor category. Where credible interactions have been identified these have been discussed in further detail in the subsequent impact assessment sections and are broken down further into receptor sub-category where relevant. The subsequent impact assessment also provides justification on why certain receptors, e.g. sediments and benthic habitats, have been assessed as having no credible interaction and/or where no environmental damage or effects have been identified for the duration of this EP.

Table 9-39: A matrix summarising credibility of interactions with the identified environmental receptors from the various planned liquid discharge streams

	Drainage (Slops) and Bilge	Sewage, Greywater and Food Waste,	Cooling Water	Brine, Boiler Blowdown and MBP Effluent	Produced Water	Ad-Hoc Discharges
Water Quality	✓	✓	✓	✓	✓	✓
Sediment Quality	×	×	×	×	×	×
Benthic Communities	×	×	×	×	×	×
Pelagic Communities	✓	✓	✓	✓	✓	✓
KEFs	×	×	×	×	×	×
Threatened Ecological Communities	×	×	×	×	×	×
Ramsar Wetlands	×	×	×	×	×	×
Commonwealth Marine Area	✓	✓	✓	✓	✓	✓
WA Mainland Coastline	×	×	×	×	×	×
Threatened and Migratory Species	✓	✓	✓	✓	✓	✓
Heritage	×	×	×	×	×	×
Marine Protected Areas	×	×	×	×	×	×
Fishing Industry	×	×	×	×	×	×
Tourism and Recreation	×	×	×	×	×	×
Defence	×	×	×	×	×	×
Shipping	×	×	×	×	×	×
Indonesian Coastline	×	×	×	×	×	×
Oil and Gas Industry	×	×	×	×	×	×

×	**Interaction Assessed as Non-Credible and/or No Environmental Damage or Effects**
✓	**Interaction Considered Credible - Discussed Through Relevant Impact Assessment Sections Below**

9.9.2.1 Physical Environment

Drainage (Slops) and Bilge Effluent

Open Drainage (slops) and bilge waste discharges are intermittent discharges which can result in water quality changes immediately surrounding the discharge point, with the spatial extent of changes to water quality remaining very localised. It is recognised that there may be various minor quantities of metal and chemical constituents that may not be captured as a part of the oil treatment systems associated with the open drains and bilge systems outlined in Appendix A: Detailed Facility Description and onboard support vessels. This may result in the discharge of minor quantities of diluted toxicants into the ocean which may cause localised and temporary reductions in water quality. Overall, the residual impact of the discharge of open drainage and bilge effluent to water and sediment quality is considered of slight impact consequence (Magnitude – 1, Sensitivity – L).

Food Waste, Sewage and Greywater

Discharge of sewage, greywater and food waste into the marine environment may impact on water quality, including eutrophication, increased turbidity, increased pathogens (bacteria, viral agents and/or parasites), and increased biological oxygen demand (BOD), with the associated impacts on marine biota as discussed further in Section 9.9.2.2 Biological Environment below. These discharges can contain a variety of substances typically at very low concentrations, including oil/grease, some organic compounds, detergents, metals, suspended solids, chemicals, personal hygiene products and pathogens.

Discharges of food waste, sewage and grey water can cause some temporary localised nutrient enrichment of the surface waters around the discharge point and have the potential to attract marine fauna that feed on the particulate material. Such low volume outputs of nutrients relative to the receiving environment presents no environmental damage or effects to water quality associated with eutrophication, increased BOD and/or decreased dissolved oxygen concentrations. The BOD of the sewage, greywater and food waste effluent is unlikely to lead to oxygen depletion of the receiving waters as highly oxygenated receiving waters will rapidly assist with oxygenation of the discharge in such a dynamic offshore environment.

At a discharge release depth of >11 m, the positively buoyant sewage and greywater effluent plumes are typically heavily diluted by the time they reach the surface of the water column. Therefore, no detectable impacts to marine sediment quality are forecast for sewage or grey water due to the significant water depth, buoyant nature of the plumes and highly dispersive and dilutive environment. For food discharges, based on biodegradability and water depth in the open-ocean currents, the discharges are expected to be rapidly diluted and dispersed by the open-ocean ambient currents, with no detectable impacts to marine sediment quality predicted.

In 2008, Woodside conducted monitoring of 10 m^3 of sewage discharged at distances of 50 m, 100 m and 200 m downstream of a platform and at five different water depths over a period of 24 hrs (Woodside 2008). This monitoring confirmed that discharges of macerated sewage were rapidly diluted or nutrients rapidly metabolised. No elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station. This Woodside monitoring scenario is conservative when compared to the Prelude case because Prelude's movement around the turret and the sewage discharge point being near the back of the hull (more turbulent) will lead to more mixing of the sewage discharged.

The Woodside (2008) study demonstrated that a 10 m^3 sewage discharge over 24 hrs from a stationary source in shallow water, reduced to approximately 1% of its original concentration within 50 m of the discharge location. In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were rapidly diluted or nutrients rapidly metabolised and no elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station. As sewage discharge from the FLNG facility is ~10 m^3/day as well, this study provides confidence to the residual impact ranking given the deep water and highly dispersive offshore environment where the Operational Area is located.

Given the volume and properties of the discharged effluent which are highly biodegradable, low toxicity and low persistence, the rapid dilution in the open ocean environment, localised impact area, and distance from the nearest value (Continental Slope Demersal Fish Communities ~ 14 km and Browse Island ~40 km away), the residual impact consequence to water quality is assessed as slight (Magnitude -1, Sensitivity – L).

Cooling Water

The effect of chlorine and chlorine breakdown products in cooling water discharges have been the subject of many studies, generally through toxicity testing. Chlorine is a strong oxidant and following discharge and dilution, the residual (free) chlorine quickly reacts with inorganic constituents such as sodium, iron (II), nitrite and sulphide to produce chlorides (such as NaCl). The potential impacts of chlorine on the biological environment are discussed further in Section 9.9.2.2 Biological Environment.

<u>Chlorine Modelling Outcomes</u>

Initially, 0.2 mg/L free chlorine was set as a target concentration for the CW discharge from FLNG based on the standard practice in the industry and the APASA 2012 dispersion modelling report prior to the commissioning of the facility. A new study was commissioned in 2019 by Shell to model the field of effect for CW discharges to align with observed operational conditions around Prelude FLNG. The RPS (2019b) modelling approach accounted for the swing weathervaning of the facility relative to both the compass and water flow past the facility. The study additionally recognised that movement of the facility, relative to the receiving water would affect dispersion rates and the dilution efficiencies as the facility most of the time closely aligns with the current flow. This approach was more realistic than modelling discharge from a fixed point; however, a stated assumption in the model was that interaction of the hull of the FLNG with the current did not modify the dispersion of the discharges. The study modelled a worst case discharge concentration of continuous 0.6 mg/L of free chlorine from the point of discharge and a no-effect threshold concentration of 0.003 mg/L under the 95th percentile current speed. The 95th percentile current speed in combination with relatively conservative dispersion allowances was considered suitably conservative as the most extreme currents recorded for the area (based on 1 year of measurements at the site) were observed to be short-lived. This gives the dispersion plume little time to decay, and is closely related to stormy conditions resulting in higher dispersion allowances. Under the 99th percentile current (0.82 m/s), the field of effect extended a further 30% (250 m extension) which is more extreme and considered a rare occurrence for current speeds in the area.

For the purposes of the impact assessment, discharge concentrations of 0.6 mg/L free chlorine and temperatures up to the maximum design level were assessed based on the modelling as the worst-case scenario. The investigation of the cooling water discharges considered processes occurring at near-field and far-field scales and focused on the fate of free chlorine within the streams which included application of a conservative decay rate due to its highly volatile nature (RPS 2019b).

The 12 discharge points of the cooling water system vary by flow rate, location, orientation and port size (Table 9-36) and were assessed in a cumulative fashion in the detailed mixing and dispersion study undertaken. The cooling water discharges are located sufficiently close so that interaction is likely between a number of the cooling water plumes much of the time (Figure 9-8 and Figure 9-9).

Figure 9-8: View of cooling water discharge ports P53, P54 (inboard pair), P63 and P64 (outboard pair) that discharge rearwards on the starboard side

The dispersion study (RPS 2019b) indicated a dilution level of 200-fold was required for the CW discharge plume to reach the field of no effect concentration of 0.003 mg/L. The collective field of effect (impact area) attributable from all cooling water discharges occurring simultaneously, was predicted to achieve a 200-fold dilution level at approximately 180 m from the FLNG hull for the worst-case under the 95th percentile current speed, assuming relatively calm sea conditions. Furthermore, the results indicated that the field of effect for any lower current speeds and more energetic sea conditions should be even shorter due to faster dispersion rates and smaller displacement of the plume. Proportionally shorter fields of effect should result from discharge of free chlorine at any concentrations lower than 0.6 mg/L thus, a free chlorine discharge concentration of 0.6 mg/L or less is deemed safe for operation.

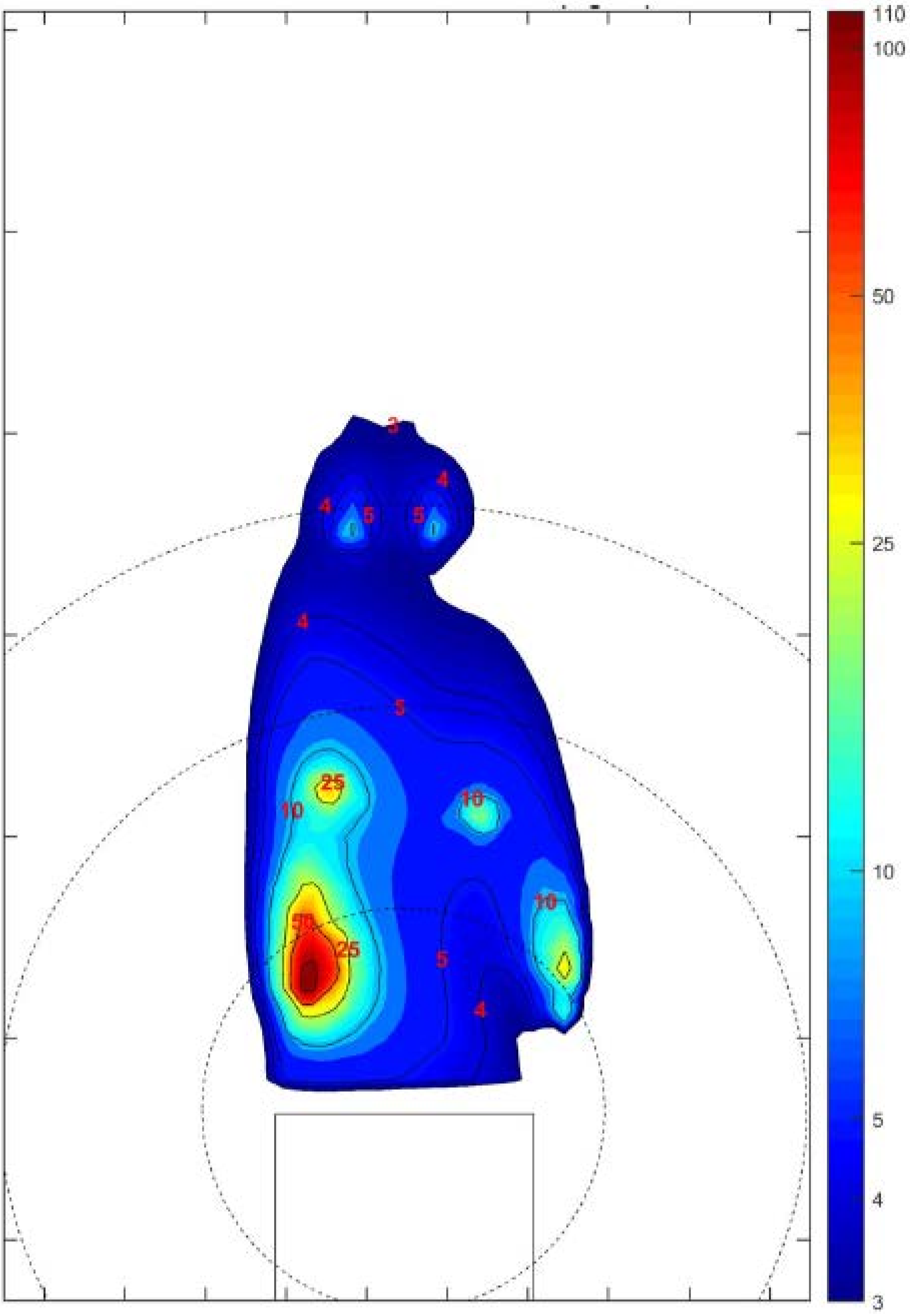


Figure 9-9: Calculation for the combined distribution of free chlorine in the far-field accounting for all water discharges under the 95th percentile current. Range rings mark 50 m increments from the stern. The field of effect is illustrated for concentrations >3 ppb free chlorine. The key shows ppb. The gap between the stern and chlorine distributions represents the near-field zone.

Temperature Modelling Outcomes

The discharge of cooling water near the ocean surface results in a change of surface temperature of the waters surrounding the FLNG facility, which may cause alteration of the physiological processes (especially enzyme-mediated processes) of exposed biota. These alterations may cause a variety of effects, ranging from behavioural response (including attraction and avoidance behaviour), to minor physiological stress, to potential mortality for prolonged exposure if temperatures are sufficiently high.

To examine the behaviour of the outfall plumes, two separate modelling studies have been undertaken to assess the behaviour of cooling water plumes from a temperature dissipation perspective. These studies are summarised below:

1. Deltares Figure 9-10

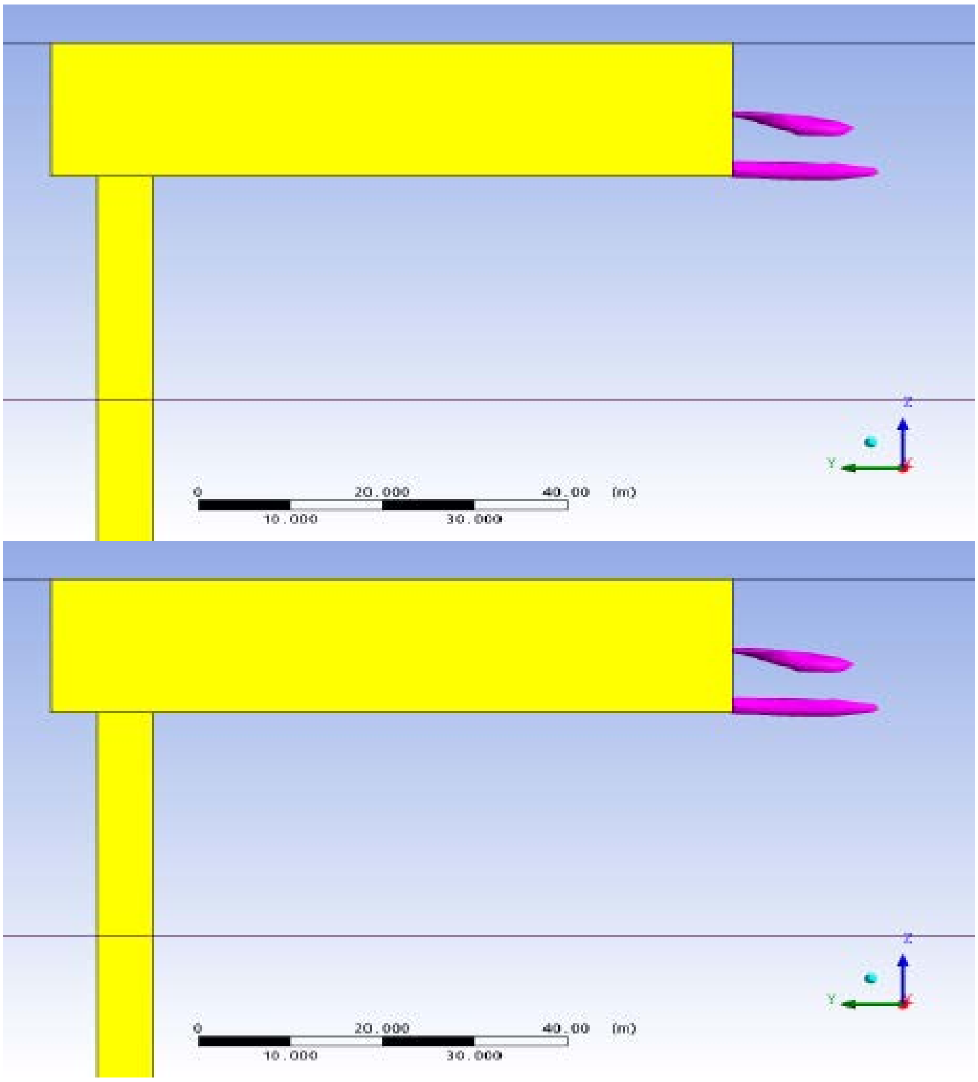


Figure 9-10: Excess temperature larger than 3°C (summer scenario, large flow velocity directed from the outlets)

2. Shell (2019) undertook sensitivity testing using the USEPA supported CORMIX model to assess the worst case scenario of the cooling water plume behaviour from the largest single port discharge rate (SW2 – 14,000m3) releasing water at the maximum piping temperature design integrity envelope upper-bound of 50°C. Although this scenario is highly unlikely, it has been included in this impact assessment to test the maximum design envelope to gain confidence around the extent of the theoretically feasible temperature impacts as an absolute worse-case. The model was applied to determine the dilution profiles, with focus on the near-field effects, and location of excess temperature under different scenarios considering low and high tidal flow velocities, winter and summer water temperatures, and low and high wind velocities representative of the expected environmental ranges. The worst-case scenarios Figure 9-1111). This scenario is highly unlikely though given the cooling water pipes typically discharge water a

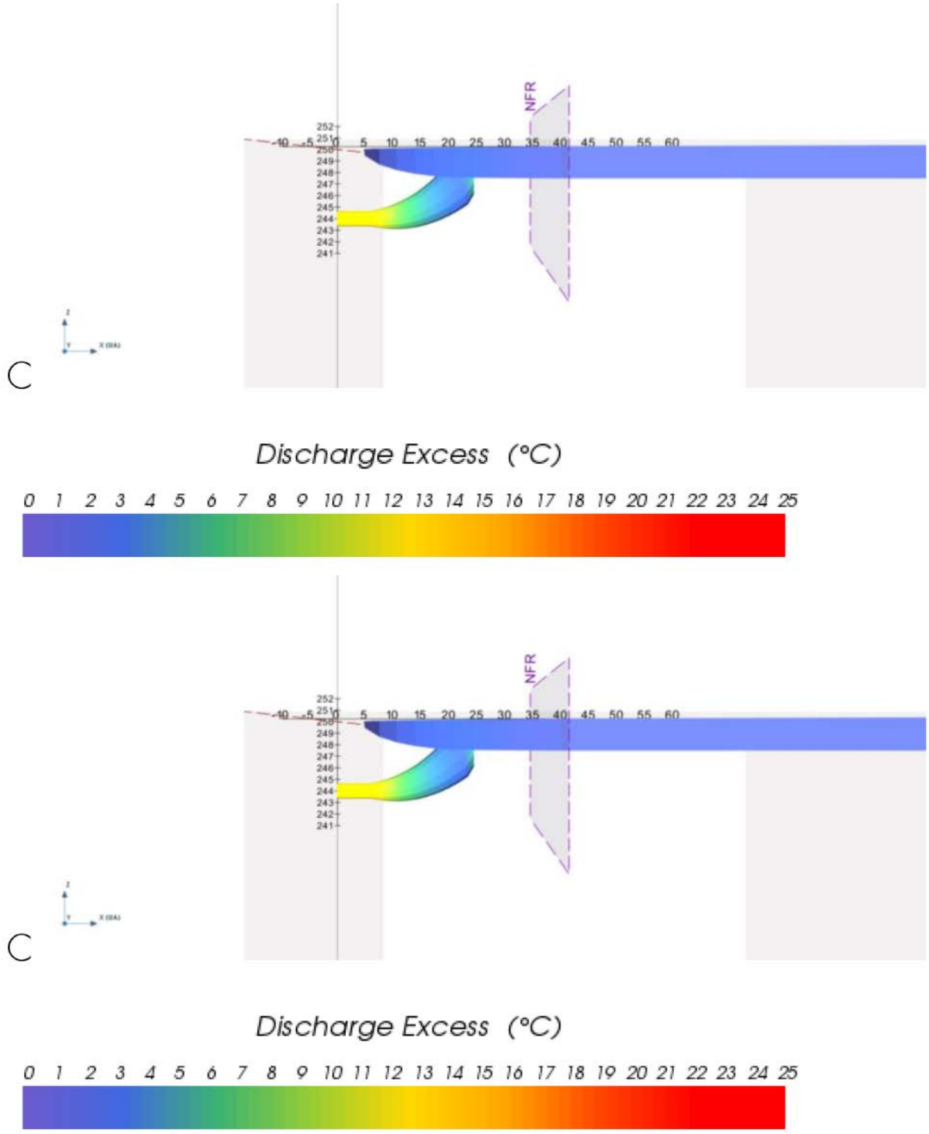


Figure 9-11: CORMIX visualisation plot for worst-case winter scenario (low wind, low flow, downstream). The Near-Field Region (NFR) is indicated in purple.

Given the high volatility state and associated high decay rate of free chlorine, rapid dilution and dispersion and temperature transference in the open offshore deepwater environment, highly localised impact area (<250 m from the FLNG), and distance from the nearest values (Continental Slope Demersal Fish Communities ~ 14 km and Browse Island ~40 km away), the residual impact consequence to water quality associated with cooling water is assessed as slight (Magnitude -1, Sensitivity – L).

<u>Sediment Quality</u>

Shell undertook a preliminary solid precipitation study (2020) to analyse the extent of sediment in the topsides process and precipitates forming following produced water entrainment in seawater following discharge. The data points for the experimental study were gathered from Prelude's LIMS laboratory database, online analyser production data and past project data. Inorganic scale formation was assessed using OLI Studio 9.1 modelling software. Hypochlorite injection was modelled for sodium hypochlorite at a 4 ppm dose. The sediment and water quality of cooling water intake is of sea borne origin as the water is directly drawn up from the sea via the seawater lifting system. For details on sea water quality refer to Physical Environment Section 7.1.4.

It is known that hypochlorite injection in the cooling water can induce seawater scaling of calcium carbonate and magnesium hydroxide due to a change in pH levels. The FLNG seawater system has a scaling tendency of >1 indicating that calcium carbonate (calcite) can be formed. In the case of seawater treated with hypochlorite the scale is formed within the ECU and hypochlorite distribution system before mixing with the ocean as a result of discharging. The model in Figure 9-12 shows the mixing of hypochlorite dosed seawater back into the marine environment. However, it should be noted that the FLNG is still in early operational stages and yet to reach steady state.

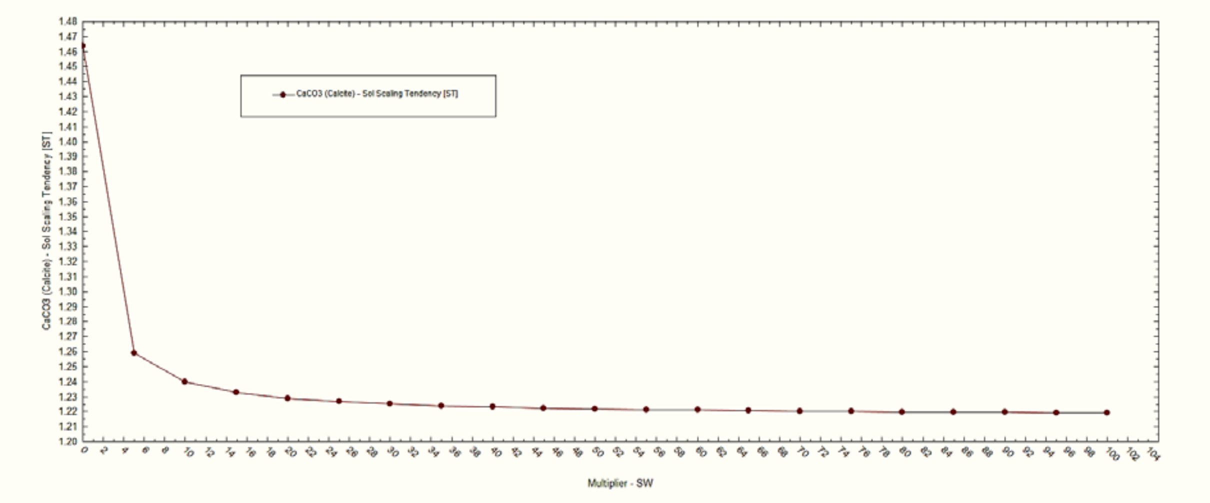


Figure 9-12: Hypochlorite dosed seawater discharge

CW Residual Chlorine Discharge Limit

Sodium Hypochlorite is used in the cooling system to control biofouling, and is expected to readily dissociate and breakdown once discharged. The CW on the FLNG is dosed with hypochlorite; once through the system and discharged, the concentration of free chlorine will not be more than 0.6 mg/l. In all scenarios, the modelled concentrations were below the no-effect threshold concentration of 0.003 ppm at 180 m distance from the discharge point.

An investigation into a power trip on Prelude in February 2020 which resulted in a shutdown of production on the facility, found a key cause of the trip being fouling in the sea water heat exchanger system. A subsequent investigation into the marine fouling of the seawater systems on Prelude revealed that the environment limit that was in place at the time, to not exceed a 0.2mg/l residual chlorine limit on an instantaneous basis was found to be one of the primary causes for underdosing of the system which led to the power trip. The analysis of the field data indicated the following:

1. The ECU is designed to operate with a fixed throughput and has a very small buffer capacity (degassing tank) which require injections into the seawater streams to match the total throughput of the ECU. Therefore, in the cases when the flowrate of one of the seawater streams is reduced or increased, total injection volume into the other seawater systems also has to be adjusted to match the overall ECU throughput.

2. The ECU was being operated on targeted point of 0.1 mg/L in order to maintain a residual (free) chlorine concentration of or less than 0.2 mg/l at the outfall. However, the investigation showed that the online analysers at outfalls could not accurately measure the free chlorine concentrations below 0.12 mg/L. At the time, the analysers were being operated at lower end of their range, 0.03 – 5 mg/L.
3. This subsequently led the operators to operate the ECU system within an extremely small operating window and the residual free chlorine concentration of the 12 different discharge streams, which are supplied by 1 ECU providing hypochlorite, had to be controlled within this small operating window.

This meant that underdosing was not always detected and allowed marine growth to develop in the seawater systems. Furthermore, there are many factors that affect the operating performance of the ECU unit. The amount of hypochlorite generated by the ECU is dependent on the electrical load on the electrolyser. Calcium carbonate and magnesium hydroxide scales are by-products of the electrolysis process. These scales typically precipitate on the electrolyser cells, affecting their efficiency and at times causing blockages in the distribution system. To maintain a high efficiency, acid washes are performed to dissolve the scale. Due to this mode of operation, the electrolysing-efficiency will fluctuate based on the time since last acid wash and will lead to variations in the injection volumes to some of the injection points. The chlorine demand also varies over time and is dependent on the chemical composition of the seawater as well as the amount of biological life.

Given the variables associated with operating this system (analysers detection limits, scaling of ECU and resulting hypochlorite dosing rates, natural variability in seawater biological levels) it has not been achievable to consistently operate between the 0.12 – 0.2 ppm limit. Early operation found that target free chlorine levels should be approximately 0.2 ppm (not limited to 0.2 ppm) in order to ensure appropriate marine biofouling control within the system. Therefore, given the multiple variables associated with operating the system, an appropriate instantaneous performance limit for free chlorine levels has been set at 0.6 ppm, with the aim to operate within 0.12 to 0.43 mg/L limit range. This has been deemed to be an achievable target under all operating conditions, even considering the multiple variables associated with operating the system. It also operates the system in line with the original design intent which is important for the overall integrity of the Prelude FLNG.

Moreover, shock dosing or temporarily elevated target residual free chlorine levels will be required for periodic maintenance of the system or after shut-down/ ECU reliability issues, which will see elevated residual chlorine levels after periods of no hypochlorite injection. These elevated residual chlorine levels from shock dosing will also not be more than 0.6 mg/l. A minimum flow must be maintained through the ECU to ensure safe and reliable operation of the system. In the rare occasions when one or more larger seawater users, such as SW2 and SW4, are not in operation there will be an excess production of hypochlorite available in the system which will need to be managed. The throughput of the ECU system cannot be decreased sufficiently to match the maximum flow capacity of the online seawater system (e.g. SW3). To manage excess hypochlorite, hypochlorite will be discharged to seachests which are not operating. Flow to the online seawater system will always be maximised first to minimise the amount of excess hypochlorite.

In addition, the forward seachest which is used as seawater intake when the firewater system is required during tests or emergencies is continually dosed with hypochlorite at low rates to ensure the seachest does not fowl up with biofouling affecting the integrity of this important safety control. Based on historical operations, this system is dosed with between 50-2000ppm of hypochlorite depending on the state of the ECU cells operating at the time of dosing. This system makes up only a very small percentage of the overall chlorine demand from all seawater systems on Prelude therefore the impacts from this discharge are not assessed any further.

Desalination Brine, Boiler Blowdown and MBP Effluent

Desalination brine discharge is estimated to be up to approximately 1100 m^3/h. Being of greater density than seawater, this will sink and disperse rapidly in the deep water and open oceanic currents. The largest increase of salinity experienced would be approximately 10% in the immediate vicinity of the discharge point.

There are minor amounts of anions, cations (mostly Na+ and Cl-) and residual chemicals associated with MBP effluent resulting from the MBP regeneration process. There will also be residual chemicals additives within the boiler blowdown operational discharges. The potential differences in pH of MBP effluent neutralisation tank and boiler blowdown water (pH range estimated at 6-12) compared to background seawater (pH approximately 8.2) are predicted to resolve very rapidly within a very localised area due to the highly dilutive open offshore deepwater environment and very good natural buffering capacity of the ocean which will quickly bring the discharge back to ambient pH (ANZECC 2000).

The residual impact consequence for water quality as a result of brine, MBP effluent and boiler blowdown discharges is assessed as slight (Magnitude -1, Sensitivity – L). No detectable impacts to marine sediment quality are predicted as a result of brine, boiler blowdown and/or MBP discharges based on the water depth, open ocean currents and low concentration/toxicity of chemical additives.

Produced Water (PW)

<u>Water Quality</u>

PW will be discharged from the FLNG facility and will contain a range of potential inherent and added contaminants, which is expected to include salts, hydrocarbons, metals, phenols, nutrients (e.g. ammonium) and residual production chemicals. Whole of Effluent Toxicity (WET) testing undertaken in 2019 from the MPPE outfall showed the PW had a pH range of 5.5 - 6.1. Concentrations of OIW ranged from 7 -12 mg/L along with trace concentrations of dissolved metals.

It is anticipated that the composition of the PW discharge will vary over time as the reservoir and production characteristics change with variations in reservoir gas permeability. PW generation commonly increases over time as gas is depleted from the reservoir. This may cause the PW flow rates to change, which in turn may cause intermittent fluctuations in PW volumes to the treatment facility and thereby, affects the effluent discharged water concentrations (USEPA, 2010). The FLNG facility is still in early stages of production and produced water consists of condensed water only without formation water, as such any water quality analysis of the PW will not depict the characteristics of PW influent and treated water effluent streams in later operation. Any PW water quality parameter stated in this section should not be used as a benchmark for future performance testing and impact assessment, as true representation of the PW effluent quality can only be determined after reaching steady state operations. Interim testing of the discharged water is undertaken using onboard centrifuges and online analysers to meet and verify the discharge limit of 30mg/L TPH on average of 24 hours and 42 mg/L TPH instantaneous in the discharge. Furthermore, any off-specification PW effluent is stopped and diverted back to PW buffer tank for re-treatment. This would be measured using the online analyser as a basis and monthly lab results as a back-up.

Based on operational experience to-date, potential contaminants such as Naturally Occurring Radioactive Materials (NORMs) and organic acids (e.g. acetic acid) are not expected to occur in quantities that may result in significant environmental impacts and are therefore not discussed further.

Hydrocarbons in the PW will consist of both relatively low and high molecular weight compounds. Dispersion modelling studies carried out in the industry in past have generally predicted a rapid initial dilution of discharged water by 30- to 100- fold within the first few tens of metres of the outfall point (Neff et al. 2011). Hydrocarbon solubility generally decreases with increasing molecular weight, and aromatic hydrocarbons tend to have increased water solubility compared to non-aromatic hydrocarbons of equivalent molecular weight (Neff et al. 2011). As such, low molecular weight aromatic hydrocarbons are typically the most available in PW. The PW sampling performed in 2019 indicates BTEX concentrations to be in the range of 0.01-0.025 mg/l, low-molecular weight PAHs to be less than 3 mg/l, which include naphthalene, phenanthrene and dibenzothiophene (NPD) compounds and pyrene. Low molecular weight hydrocarbons are of particular interest, as these tend to have the greatest potential for toxicity (Neff et al. 2011). Higher molecular weight compounds are largely recovered during the production and PW treatment processes onboard the FLNG facility. However, residual high molecular weight hydrocarbons, such as C10-C40, may still occur in the PW stream as very fine entrained oil droplets.

The PW testing performed indicated a residual concentration of 10 mg/L for total C10-C40 components. PAHs are less volatile and soluble than BTEX and have greater potential to accumulate in the marine environment (Neff et al. 2011). PAHs dissolved in PW are predominantly low molecular weight and, while toxic, they are not typically mutagenic nor carcinogenic (although their metabolic by-products may be) (IOGP 2005). Higher molecular weight PAHs are rarely detected in treated PW due to their low aqueous solubility. These compounds are primarily associated with dispersed oil droplets which are typically removed by the production process and PW treatment systems (Neff et al. 2011; Schmeichel 2017). PAHs are generally removed from the water column through volatilisation to the atmosphere upon reaching the sea surface, particularly the lower molecular weight fractions (Schmeichel 2017). PAHs can also degrade in the water column with half-lives ranging from less than a day to several months, with the more abundant and lower molecular weight compounds being more degradable (IOGP 2002).

BTEX compounds are the most common hydrocarbon component of PW, however, are highly volatile and do not persist in the environment. Evaporation and dilution will rapidly reduce the concentration of BTEX in the receiving environment (Ekins et al. 2005; IOGP 2005; Neff et al. 2011). Other processes such as biodegradation and photodegradation are expected to further reduce BTEX concentrations in the environment (Neff et al. 2000). BTEX is known to be toxic to marine organisms and has been shown to result in developmental defects (Fucik et al. 1995) but does not significantly bioaccumulate (Neff 2002). As such, potential impacts from the decrease in water quality due to BTEX are expected be very localised spatially around the FLNG and more so toward the end of field life operations.

A variety of metals may be present in PW in varying concentrations, some of which have the potential to cause adverse impacts in the marine environment, while others are a necessary component to maintain life with some being essential at low quantities, but potentially toxic at high levels (Khayatzadeh and Abbasi 2010). It should be noted that until breakthrough of formation water which is anticipated to be sometime during year 7-9 following startup (i.e. 2025-2027), inherent reservoir originated levels of metals within PW are expected to be low, which is evident in the MPPE outfall sample testing done in 2019 showing heavy metal concentrations to be less than 0.3 mg/l. Prior to water breakthrough, PW originates primarily from condensation of water vapour entrained within the produced gas stream which is typically free of metal contaminants given it originates from a gaseous phase. While concentrations of trace metals in PW can be greater than those in the ambient marine environment, they are rapidly reduced through dilution and mixing processes, and other physicochemical reactions to levels that pose a nil to slight impact consequence to the receiving environment (IOGP 2005). Azetsu-Scott et al (2007) also found that despite metal concentrations being much higher in PW than those in the natural seawater, no significant correlation between toxicity and metal concentrations was observed in the study, indicating that metal concentrations alone may not be responsible for any observed toxicity.

Mercury levels in the PW to date have been measured at around 2 ppb (wt). Additionally, mercury from the nearby analogous Brewster and Plover reservoirs is elemental mercury (Hg), which is relatively unreactive, and has little tendency to dissolve in water, and readily volatises into the atmosphere (Neff 2002). Conversion of elemental mercury to methylmercury ($MeHg^+$), with a potential to bioaccumulate and to be toxic, does not occur in well-oxygenated environments (Neff 2002), such as those in waters surrounding the FLNG.

A range of process chemicals will be introduced into the hydrocarbon process and may be subsequently discharged to the sea in residual amounts if they partition into the PW and are not removed via the available treatment processes. Some of the process chemicals may be at concentrations that have potential to cause impact or contribute to the toxicity of the PW, such as biocides (Neff 2002). The ecotoxicological impacts of process chemicals in PW discharges was comprehensively investigated in a study by Henderson et al. (1999). The study tested 11 commonly used process chemicals (including biocides, corrosion inhibitors and demulsifiers) for their acute toxicity to marine bacterium, both directly in aqueous preparations and following their partitioning between oil and water phases. The study results indicated that toxicity of the PW was not significantly altered by the presence of most process chemicals used in typical concentrations. A review of the study by Schmeichel (2017) notes that process chemicals make a small contribution to the overall acute toxicity profile of PW discharges and even chemicals which are classified as highly toxic may not actually present an acute toxicity risk at dosages representing normal operating conditions. As such, production chemicals in the PW discharge will not result in more than slight impact consequence to water quality.

MEG is readily biodegradable in the marine environment in aerobic and anaerobic conditions through microbial action, with studies showing degradation to < 10% of the initial concentration occurring with 1 to 21 days (Staples et al. 2001). MEG concentrations in the PW discharged was tested to be in the range of 6400-6900 mg/L based on the samples taken from the MPPE outfall in 2019. MEG does not persist in the environment once discharged and degradation of MEG by microbial action tends to increase with temperature. Therefore, degradation in the warm tropical seawater at the discharge location is expected to occur rapidly. Microbial degradation will account for the fate of almost all MEG discharged. It has been shown to be practically non-toxic (based on US EPA definitions) in relation to aquatic organisms (Staples et al. 2001) and is entirely miscible in water and has low potential to combine with lipids and therefore has very low potential for bioaccumulation (Dobson 2000, Staples et al.

2001). The Oslo Paris Convention (OSPAR) Commission lists MEG as a substance considered to Pose Little Or No Risk to the environment (PLONOR).

PW Modelling Studies

The APASA (2012) modelling study was conducted for PW discharge, which aimed to quantify the field of effect and define threshold concentrations of various constituents in the PW discharge. Note that the standalone PW assessments presented here do not factor in any dilutive or compounding influences presented by other liquid discharge streams that may comingle with the PW following discharge, e.g. cooling water. A liquid discharges cumulative impact assessment was undertaken as a separate study with the results presented primarily in Section 9.9.3. The study also did not consider the presence and influence of the ship's hull in the current regime and resultant dilution/dispersion so therefore may be considered as conservative in its approach.

To investigate the effect of the liquid discharges the total mixing zone was determined and was defined based on the dilution targets set out in the model study. The modelling results indicate boiler blowdown and desalination brine should dilute sufficiently within the near-field zone for concentrations to decrease below the no-effect trigger concentration. Chlorine from the cooling water discharges, TPH, and Trisodium phosphate from the boiler blowdown would require further dilution due to passive dispersion in the far-field. The spatial extent of the defined mixing zone is considered to be 1 km, which is supported by the modelling results predicting 5000 dilutions at a maximum distance of 1030m from the source required to dilute TPH to the required levels. This defined total mixing zone comprises of two major phases, the near-field and far-field mixing zones, in sequence, which are measured from the edge of the FLNG. Details of the two phases are outlined in sections below.

Along with the 1 km mixing zone boundary, a secondary inner boundary is also considered at 350 m distance from the edge of the FLNG. This boundary condition will be applicable for any PW constituent other than the one requiring complete 1 km distance to meet the PNEC limit, i.e. TPH. There is no pre-existing limit / regulatory requirement underlining the offshore produced water discharge mix boundary conditions in Australia. Environmental Quality Management Framework established under ANZG (2018) requires ALARP demonstration for PEC to not exceed the concentration that is protective of 95% (typically) or 99% (for sensitive receiving waters with high conservation value) of species. Other established industrial frameworks, such as International Association of Oil and Gas Producer (IOGP) recognises the taking of a risk based approach depending on the ecosystem, exposure levels outside the mixing zone.

The PW is discharged via a single vertical pipe mounted on the side of the FLNG and near to the bow (49 m from the turret along the centreline) therefore, the allowable effect area for PW discharge was judged to be 99 m wide. provides a graphical summarisation of the maximum effect distance rule for the PW discharge.

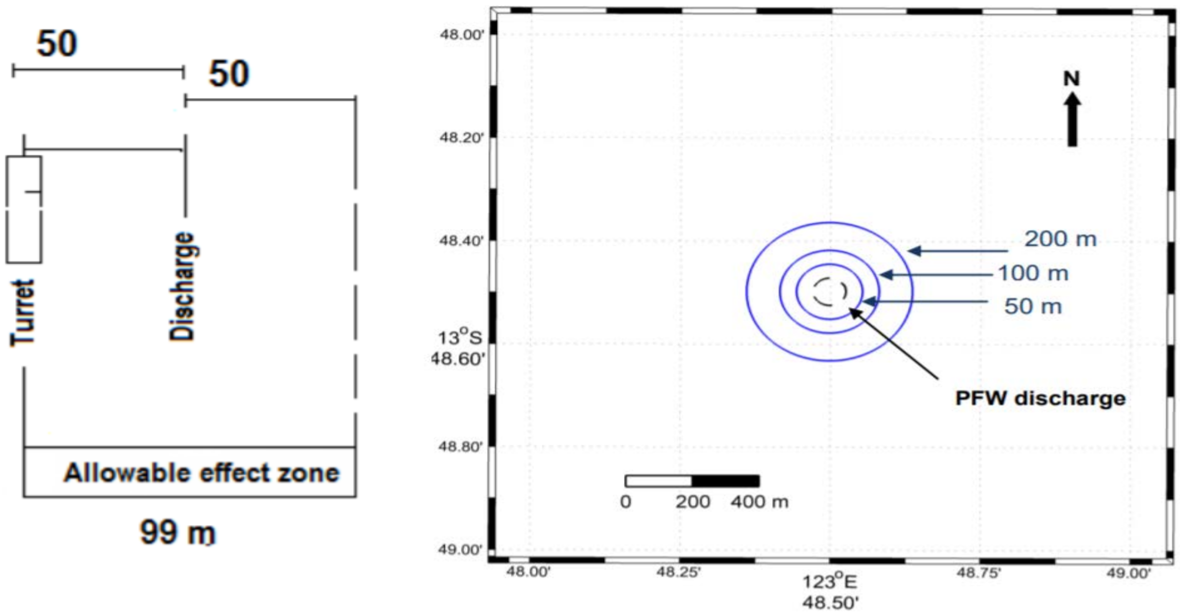


Figure 9-13: Designation of the allowed effect distances for the PFW. The left panel shows the calculation of the effect zone, along the central axis of the vessel. The right panel shows a plan view of the circles (around the turret) described for the PFW discharge (dashed black lines). The blue lines designate effect distances of 50, 100 and 200 m from these discharge, as marked.

The study considered processes occurring at two different scales: “near-field” processes generated by the discharges and “far-field” processes generated by the ambient current field and ocean turbulence. The near-field mixing zone refers to the region where the plume’s momentum or buoyancy (or both) are the strongest influence on the dilution process. Therefore, in this near-field mixing zone, the rate of dilution is controlled by the engineering design of the discharge, including aspects such as the discharge velocity, discharge buoyancy and orientation. Further away, where the plume has lost momentum and achieved neutral buoyancy with the ambient water, dispersion will occur due to turbulent dispersion and entrainment of the ambient water at its edges. Thus, the local dynamics of the ocean become a dominant influence on the dilution process in the far-field mixing zone.

The near field plume for PW discharge from the FLNG is dominated by the downward momentum of the jet and the difference in temperature and salinity between the PW discharge and the receiving water. The temperature and salinity at the site varies therefore, to be conservative, the month with the lowest surface temperature (August) and the largest difference between PW temperature and ambient temperature was used in the modelling study (temperature 26.8°C and salinity 34.4 ppt at surface). The discharge for the near-field case was run for the 5%, 50% and 95% current exceedance scenarios.

The near field modelling study indicated that relatively high levels of dilution would be achieved through the jet phase and buoyant entrainment phase of the discharge (87 - 187-fold depending upon the prevailing current speed applied).

The far-field modelling assessed the dispersal of the PW plumes beyond the near-field accounting for the time-varying nature of local currents and assessed the potential for recirculation of the plume back to the discharge location, in which case the near-field concentrations might be increased beyond those indicated in the near-field modelling. This may be a potential source of episodic increases in concentration in the receiving waters. A horizontal dispersion rate of 1 m^2/s was applied, and a typical value of 0.0001 m^2/s was set for the vertical dispersion coefficient with no decay or volatilisation included.

3-D stochastic far-field modelling of the PW discharge was then completed using the CHEMMAP model treating the discharge as a moving source incorporating the results from a long term heading analysis. Five hundred replicate short-term simulations were completed with metocean conditions randomly sampled from the 39-year hind cast data set. The far-field study also assessed the potential for recirculation of the plume back to the discharge location, in which case the near-field concentrations might be increased beyond those indicated in the near-field modelling. The results are summarised below:

- About 99% of the time the PW discharge plume would be diluted approximately 100-fold by the time it travelled 50 m from the discharge location and over 400- fold by the time it reached 100 m, as shown in Figure 9-14;
- At 200 m from the source, exceedance of the defined thresholds was not predicted for any of the specified constituents except for TPH; and
- TPH discharged at 30mg/L requires a minimum of 4,286 dilutions to meet the highly conservative threshold of 0.007mg/L, this was predicted to occur at a maximum of 1,030m from the discharge point during all modelled scenarios as shown in Table 9-40.

Table 9-40: Maximum distances forecast for far field PW dilution levels

Dilution level	Maximum distance to reach dilution level (m)
×5000	1030
×3000	746
×1000	355

In order to assess the risk on ecotoxicological effects from the produced water discharge WET testing was conducted. WET testing assesses the toxicity risk by direct testing of PW samples. It provides direct information on potential toxic effect concentrations while the effluent is evaluated as a whole, incorporating risks from known and any unknown toxic components. It also accounts for potential additive, synergistic and/ antagonistic effects. Furthermore, an analysis of the PW Q2 2019 WET sample was performed and evaluated based on the ANZECC (2018) methodology and a statistical assessment using the Burrlioz software package to determine the required number of dilutions to meet both the 95% and 99% species protection levels. The assessment suggested that:

- To achieve 95% species protection, a dilution range of 100-102 fold was required based on the samples collected; and
- To achieve 99% species protection, a dilution of 204 fold was required based on the samples collected.

Thereby, indicating that both 99TH and 95TH species protection criteria is met for PW discharged constituent concentration dilution within the defined mixing zone. However, the defined threshold for TPH is a highly conservative and chronic value taken from ANZECC 2000 (As derived from Tsvetnenko [1998]). Given the conservative thresholds established for TPH and the conservatism built into the model, it is reasonable to assume that suitable dilutions would occur >99% of the time within total 1 km mixing zone from the FLNG to meet the 99% species protection level. This is supported by the modelling results which predicts 5000 dilutions at a maximum distance of 1030m from the source (refer Table 9-40).

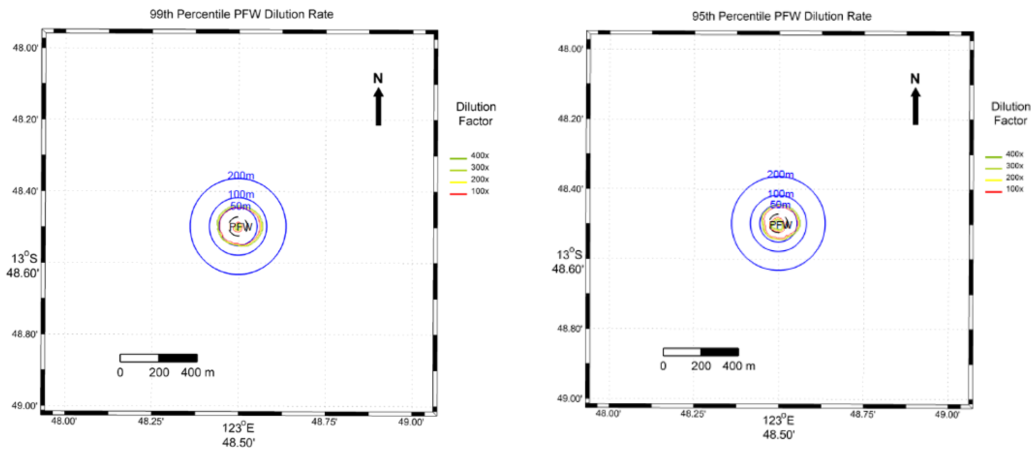


Figure 9-14: Predicted 95th percentile PW dilution (Left) & Predicted 99th percentile PW dilution (Right) from APASA (2012)

The proposed mixing zone extent is supported by an additional modelling study undertaken by RPS (2019a) which assessed the PW plume behaviour if PW is dosed with 20% MEG to assess density effects on the number of dilutions required to meet the defined threshold of 7 ppb TPH. In this study, the worst-case linear distance calculated for the end of the effect zone (4300 dilutions required) from any location on the hull was calculated at 667 m (Figure 9-15) indicating that applying a 1 km mixing zone for the impact assessment of PW is sufficiently conservative.

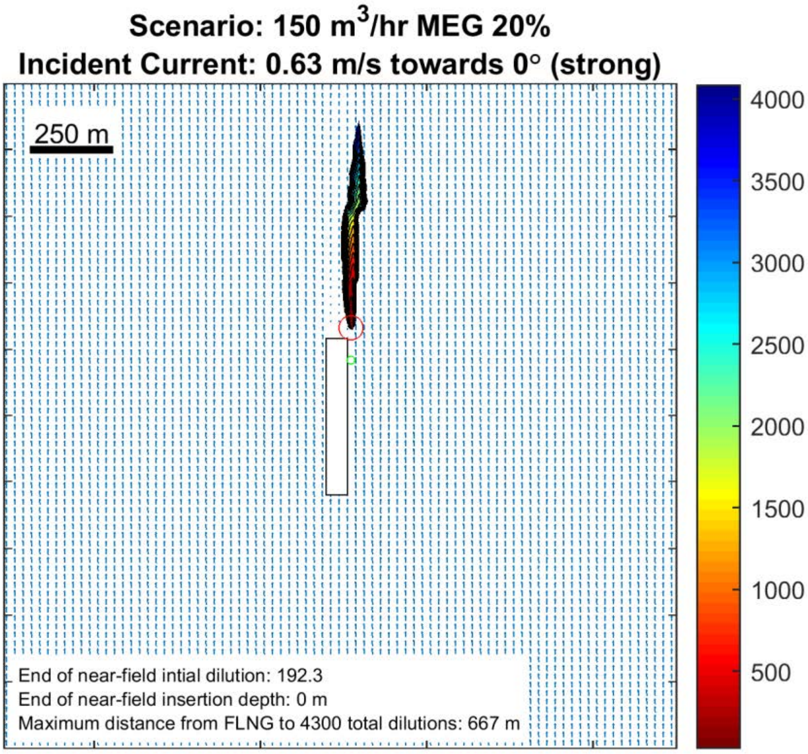


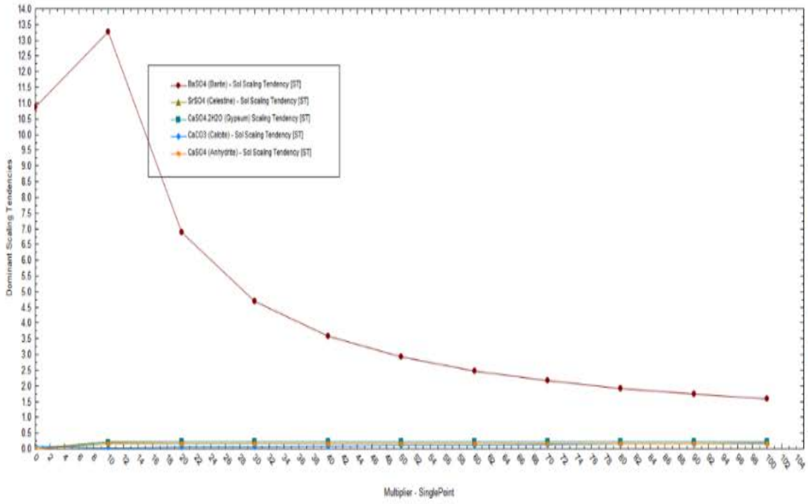
Figure 9-15: Dilution fields calculated for discharge into the wake zone of the FLNG (strong current, 20% MEG)

For short duration and infrequent periods when discharged TPH levels may be up to 100mg/L (well clean-up) as described in Section 9.9.1.5 Produced Water (PW), extrapolating the information from Table 9-40, it is reasonable to expect at least 15,000 dilutions will occur within 2000 m of the source. In support of this prediction, literature reviews undertaken showed that at 500-1000 m of the discharge points, dilution rates of 1,000 – 100,000 are typical (IOGP 2005; Neff et al., 2011). Therefore, beyond 2000 m, there are predicted to be no exceedances of the adopted 7ppb TPH threshold for these short term and once-off events per well.

Given the short-term and infrequent elevations associated with well clean-up activities, within the dispersive offshore marine environment, any impacts are not considered significant in a local or regional context and are not predicted to alter the residual risk ranking.

<u>Sediment Quality</u>

The PW discharge will contain a range of potential residual constituents as discussed in the water quality section above. Since start up Prelude has observed condensed water production from the subsea wells. Low chlorides are indicative of water as a result of depressurising natural gas. Early lab samples indicated a low base sediment and water (BS&W) at the receival high pressure separator, downstream in natural gas condensate storage tanks and within PW tanks. Inorganic scaling risk has been determined as low risk with barite as the dominant species on the Prelude FLNG. When the stream is discharged to the ocean this risk is minimised. The model below shows the mix of produced water into seawater.



Scaling Tendencies

Row Filter Applied: Values > 1.0e-4

Solids	Post-Scale
BaSO4 (Barite)	10.8661
CaCO3 (Calcite)	0.0797259
FeCO3 (Siderite)	0.0595942
CaCO3 (Aragonite)	0.0336444
SrCO3 (Strontianite)	0.0111763
SrSO4 (Celestine)	8.24797e-3
CaSO4.2H2O (Gypsum)	3.44624e-3
NaHCO3 (Nahcolite)	2.68229e-3
CaSO4 (Anhydrite)	2.54587e-3
NaCl (Halite)	5.20838e-4

Figure 9-16: Mix of produced water discharge modelling

Once steady state is reached solids influx in the PW stream is expected to increase. The preliminary solid precipitation study (2020) concluded that upon reaching steady state production another study will be undertaken to understand the full extent of PW discharge impact on the marine environment.

There are several processes by which potential PW residual constituents could become incorporated into the sediment if conditions were suitably conducive, including:

- Sedimentation of inherent solids in the PW.
  - The production process onboard the FLNG will remove most inherent solids from the PW prior to discharge. Therefore, the mass of solids discharged in the PW is expected to be very low. The remaining solids will be very fine in size, and hence will have low settling velocities. Given the water depth at the discharge location (> 230 m), the predicted behaviour of the plume, the discharge depth, and the low settling velocities, inherent solids will disperse widely and will not result in impacts to sediment quality surrounding the discharge location within the currency period of this EP.
- Dissolved contaminants forming precipitates, which settle to the seabed.
  - Dissolved constituents (particularly metals) in the PW may form precipitates once released into the environment due to changes in pH and availability of reactants (e.g. oxygen, sulphide etc.). Metals commonly encountered at elevated levels in PW that may form precipitates include barium, iron and manganese (Neff et al. 2011). Solids formed by precipitation are initially very fine and will have low settling velocities. As with inherent solids released within the PW, formed precipitates are unlikely to be deposited near the discharge location and will disperse widely. Therefore, precipitates will not result in impacts to sediment quality at or surrounding the discharge location during the currency period of this EP.
- Adsorption of contaminants onto natural suspended solids, which then settle to the seabed.
  - Some of the potential constituents in the PW, such as metals and hydrocarbons, may also become adsorbed onto the surface of suspended solids present in the receiving environment. Water quality studies in the project area have shown that natural suspended sediment levels are low (Shell 2009). This is consistent with the

low observed rates of natural deposition in the region as per Glenn (2004) which states that sediments locally derived from the water column are generally very fine (i.e. silt and clay sized particles). The low natural suspended sediment load indicates the potential for adsorption of potential contaminants is limited. Due to the small particle size, the potential for adsorbed contaminants to be deposited at and concentrated around the discharge location is low; particles with adsorbed contaminants are expected to be widely dispersed, resulting in no impact to sediment quality in the surrounding area.

As particles pass through the water column they will be subject to natural dispersion through oceanographic processes. In the deep waters around the FLNG (>230 m), Stokes' Law indicates a settlement time of approximately >600 days for a 70 µm particle. Therefore, all anticipated particles which will range up to a maximum size of <70 µm, will not settle locally around the FLNG facility and are likely to be dispersed throughout the broader Browse Basin. Even once settled, if at all, finer fraction particles are likely to be transported further afield via resuspension, resulting in secondary further dispersion until they assimilate into the resident sediments, if at all.

Each of the mechanisms discussed above by which contaminants in the PW may settle and be incorporated into sediments is considered to result in no environmental damage or effects on sediment quality around the FLNG facility. This is consistent with monitoring results for other offshore facilities, which generally show that natural dispersion processes appear to control the concentrations of potential contaminants from PW in sediments to slightly above background concentrations and below levels known to cause deleterious effects (Neff et al. 2011; Barnes et al. 2019). The discharge volumes of PW are expected to be relatively low for the majority of the production period, before increasing as the reservoir becomes depleted. Therefore, the period with the credible potential for sediment quality impact is concentrated at the end of field life for the Prelude reservoir which is beyond the spatial scale of this EP's currency period.

<u>Summary</u>

Given the rapid dilution and dispersion in the open offshore deepwater environment, highly localised impact area, and distance from the nearest high value sensitive receptor (Continental Slope Demersal Fish Communities ~ 14 km and Browse Island ~40 km away), the residual impact consequence to water quality associated with PW is assessed as slight (Magnitude -1, Sensitivity – L).

Given the water depth (>230 m), low inherent and ambient solids, low predicted rates of precipitation, small particle size and highly dispersive environment, the residual impact consequence to sediments as a result of PW discharge is expected to be no impact (Magnitude 0, Sensitivity – L). This impact ranking will be reassessed with each mandatory re-submission of this EP to ensure currency.

Use and Discharge of Ad-Hoc Chemicals

The infrequent release of minor quantities of chemicals and production fluids due to planned ad hoc discharge activities may result in a localised and temporary reduction in water quality around the discharge which has the potential to impact on marine fauna (discussed further in Section 9.9.2.2 Biological Environment). Discharge of small volumes of these fluids are predicted to disperse and dilute rapidly with the spatial extent of any impacts likely to be limited to the water column, and very localised around the discharge point. Therefore, the residual impact consequence is assessed as slight (Magnitude -1, Sensitivity – L).

9.9.2.2 Biological Environment

Drainage (Slops) and Bilge Effluent

Discharges of oily water will be treated to <15 ppm (v) in accordance with MARPOL requirements. The discharge of these effluents have the potential to adversely affect water quality which may impact some biological receptors in the immediate area through acute or chronic toxicity. The potential biological impacts of these discharges are addressed further in the broader PW assessment within this Section and the liquid discharges cumulative impact assessment in Section 9.9.3. This is given the similarities in the cause and effect pathways and that impacts are not anticipated to be greater than those presented in the PW assessment from these smaller volume and infrequent discharge streams.

Most threatened fauna species potentially exposed to drainage (slops) and bilge effluent discharges are air breathing vertebrates, which are unlikely to be directly affected as their skin is relatively impermeable. Given the low concentrations of oil (<15 ppm) no surface expressions is expected and therefore damage to eyes and lungs from exposure to oil on the sea surface is not anticipated. Overall, the residual impact of the discharge of treated drainage (slops) and bilge effluent to the biological environment with the stated controls in place is considered to be of slight impact consequence (Magnitude – 1, Sensitivity – L).

Food Waste, Sewage and Greywater

Nutrients in sewage greywater and food waste, such as phosphorus and nitrogen can contribute to eutrophication of receiving waters. However, this is only likely in still, calm, inland waters, where it can cause algal blooms, which in turn degrades aquatic habitats by reducing light levels and producing certain toxins, some of which are harmful to marine life and humans. The low level of nutrient outputs as shown in Table 9-37 are not expected to result in levels or conditions that could result in excessive algal, phytoplankton or cyanobacterial growth or associated depletion reduction in oxygen levels. Sewage and greywater can also contain hazardous pathogens (including faecal coliform bacteria), intestinal parasites and viral agents that, if released, may cause contamination to the food chain and/or other marine users. This is further addressed in Section 9.9.2.3 Socio-Economic Environment, under the socio-economic environment impact assessment and will not result in environmental damage or effects.

The overboard discharge of sewage and food wastes creates a localised and temporary increase in particulates on or near the surface waters. This may in turn act as a food source for scavenging marine fauna and seabirds, whose numbers may temporarily increase as a result. The ingestion of small (macerated or reduced to <25mm) particle sizes within the effluent is not anticipated to have an adverse physical or toxic impact on resident and transient marine fauna, including listed threatened and migratory species, e.g. cetaceans or whale sharks.

Open marine waters are typically influenced by regional wind and large scale current patterns resulting in the rapid mixing of surface and near surface waters where sewage, greywater and food waste discharges will occur. Therefore, nutrients from these discharges will not accumulate or lead to eutrophication due to the highly dispersive environment. As such, the receptors with the greatest potential to be impacted are those in the immediate vicinity of the discharge. Effects on environmental receptors along the food chain, namely, fish, reptiles, birds and cetaceans are therefore not expected beyond the immediate vicinity of the discharges.

Although the Timor Sea is characterised as a low nutrient environment (Brewer et al, 2007), natural seasonal upwelling can result in localised and sporadic high phytoplankton productivity along the Sahul Shelf including immediately offshore of the shelf. The estimated daily loading from sewage, grey water and food waste (Approximately 37 kg/day of TN and 7 kg/day of TP) is considered inconsequential in comparison to the daily turnover of nutrients in the area.

The rapid consumption of macerated food and sewage waste by scavenging fauna, combined with physical and microbial breakdown, ensures that any impacts of sewage, greywater and food waste discharges are short-lived, localised and negligible. There are no nearby sensitive or high environmental value habitats or biological communities that are at risk from temporary increases in nutrient levels, particulates and/or increased numbers of scavenging fauna. The volume of these discharges is small relative to daily nutrient turnover in the given area of ocean and the associated assimilative capacity of the receiving offshore environment. Therefore, the environmental impact associated with the discharge of sewage, greywater and food waste is considered to be slight (Magnitude -1, Sensitivity – L).

Cooling Water

The effect of chlorine on marine organisms is well known, given its widespread use as a biocide (Abarnou and Miossec 1992). Sublethal effects of chlorine on marine biota include growth reduction in some invertebrate larvae (Best et al. 1981), alteration of membrane permeability, modification of blood composition, and reduction in primary producer productivity (Best et al. 1981; Abarnou and Miossec 1992). Concentrations of free chlorine in seawater that can trigger lethal and sub-lethal response have been shown to vary among different species and are also dependant on water quality, being affected by:

- pH
- concentrations of ammonia
- negatively charged inorganic compounds
- Various organic compounds.

Guidelines for the maximum discharge concentrations in marine waters have been set by a number of authorities around the world, which differ widely in both the levels that are set and the reactants that are considered. ANZECC (2018) does not specify any set threshold for chlorine or chlorine products in marine water for Australia, citing a lack of evidence required to set a meaningful limit, but suggests using 3ppb as a Low Reliability Value (LRV) in association with other appropriate lines of evidence. Although this 99% species protection level is relatively close to the acute toxicity value for the most sensitive of the tested species, this was considered sufficiently protective, due to its short residence time, the narrow difference between acute and chronic toxicity and the lesser sensitivity of data for other tested species (ANZECC 2018).

The intent of LRVs are to provide guidance in the absence of any higher reliability guidelines being available and are derived by applying larger application (safety) factors to the toxicological data to account for the greater uncertainty associated with the limited database (DWER 2017). The ANZECC LRV for chlorine is therefore considered as conservative and may not necessarily reflect concentrations above which toxic effects would occur. ANZECC & ARMCANZ (2000) cautions that LRVs should not be used as default guideline trigger values, but further states that ‘it is reasonable to use them in the risk-based decision scheme to determine if conditions at the site increase or decrease potential risk'. In other words, it is reasonable to assume that if ambient concentrations fall below the LRV then there is a low potential of ecological impact. However, if concentrations are above the LRV, it does not necessarily mean an impact is a given, rather that further investigation and adaptive management may be required.

Assessment of water quality guidelines for chlorine from a number of other jurisdictions have also been provided in Table 9-41 to demonstrate that the proposed trigger level of 3 ppb at the edge of the defined mixing zone is consistent and comparable.

Table 9-41: Guidelines for chlorine concentration in water

Authority	Guideline, Limit, or Trigger (ppb equivalent)	Comments
DWER (2017) for Cockburn Sound, Western Australia	3	Taken directly from the ANZECC (2000) LRV.
British Colombia (Water Protection & Sustainability Branch [2018]) (Chronic)	3	Based on average continuous exposure.
Canadian Council of Ministers of the Environment (CCME) (2008)	2	This is the freshwater guideline for this jurisdiction.
USEPA (Chronic) (2019)	7.5	Derived from 24 marine species in 21 genera. The sensitivity results were very similar to that observed in freshwater species and fish and invertebrate species had similar sensitivities.
USEPA (Acute) (2019)	13	

Toxicity assessments undertaken for specific marine species indicate that a 3 ppb trigger level affords sufficient protection by a factor of 6-62 times that of the available chronic NOECs (ANZECC 2018):

- Marine fish: Two species, 48 to 96-hour LC50 128 to 250 µg/L (2 to 8 hours/day intermittent to continuous dosing). Chronic NOEC (7-day growth), *Menidia beryllina*, 87 to 186 µg/L.
- Marine crustacean: one species, *Mysidiopsis bahia*, 96-hour LC_{50}, 73 to 268 µg/L (2 to 8 hours/day intermittent to continuous dosing). Chronic NOEC (7-day reproduction), M. bahia, 20-87 µg/L.
- The 24-hour LC_{50} for the marine prawn, *Penaeus plebejus*, was 180 µg/L.

An additional assessment for chlorine was also undertaken during the development of this EP to develop a Species Sensitivity Distribution (SSD) curve and associated levels of species protection utilising the CSIRO hosted Burrlioz statistical analysis software in accordance with Warne et al. (2018) and CSIRO (2019). The data utilised for the assessment were the LC_{50} values listed above for marine species in ANZECC (2018) as well as appropriate data for marine species obtained from the USEPA Ecotox database (https://cfpub.epa.gov/ecotox//search.cfm) accessed on 29 July 2019 where this data passed the screening tests as described in Warne et al. (2018). Data filters were applied to select the appropriate values to assess through the Burrlioz software package which included:

- Retention of data for marine species only
- Removal of all data derived earlier than 1980
- Retention of available data for EC/IC/LC_{50} tests only
- Utilisation of the geometric mean where data were provided for the same species and ecotox test methodology/duration
- Selection of the lowest value per species
- Application of an Acute to Chronic Ratio (ACR) of 10 as per the default value recommended in Warne et al. (2018).

The assessment described above yielded the following results:

- 95% Species Protection Level = 13 ppb
- 99% Species Protection Level = 11 ppb.

Given these values were derived from relatively limited data sets in terms of sample size, they are not being suggested to replace the ANZECC LRV of 3 ppb as the trigger level (LRV) but rather are provided as an additional line of evidence to demonstrate that managing to this concentration is a conservative approach that should afford sufficient ecological and species protection.

Effects of elevation in seawater temperature may include a range of behavioural responses in threatened and migratory species such as localised attraction and avoidance behaviour. There are no BIAs or aggregation areas in proximity to the cooling water discharges from the Prelude FLNG with the closest BIAs relating to green turtle foraging/interesting buffer at Browse Island (23 km), whale shark foraging (33 km) and blue whale migration (78 km) as described in Table 7-7. As a benchmark for this impact assessment, cooling water discharge predictions were compared to the IFC (2015) guidelines for water temperature. The guidelines suggests discharges should not result in a temperature differential of greater than 3°C relative to the ambient temperature at the edge of a defined mixing zone which suggests a default distance of 100m.

The modelling studies undertaken have indicated that the IFC guidelines will be met under all seasonal conditions within this defined mixing zone which is appropriate due to the lack of sensitive receptors within such a small localised area. In addition, given that cooling water is discharged on a continual basis, free swimming organisms within the water column are expected to perform avoidance behaviours towards plumes outside of their tolerable ranges. Therefore, from a temperature only perspective, cooling water is assessed as having no residual impact consequence (Magnitude 0, Sensitivity – L).

In terms of vertical distribution of the cooling water plumes in the far-field, given the significant water depth and positive buoyancy of the plumes, dilution is predicted to be such that there will no effects on sediments and/or marine biota associated with the seafloor such as demersal fish or invertebrate assemblages.

Overall, given the highly dispersive nature of the receiving environment, positive buoyancy of the plumes, the rapid dilution following discharge, that free chlorine does not persist long in the marine environment and the lack of resident sensitive and/or high value receptors, cooling water is not expected to result in credible impacts to higher order organisms such threatened or migratory species that may intersect the plumes and at worst is assessed as presenting a residual impact consequence of slight to pelagic communities (Magnitude -1, Sensitivity – L). Anecdotal observational evidence from the FLNG indicates there have been no obvious impacts or behavioural changes to pelagic communities to-date, with marine fauna such as fish, present in the immediate vicinity of the cooling water discharges with no apparent stress or behavioural related responses.

Desalination Brine, Boiler Blowdown and MBP Effluent

The potential impacts of desalination brine have been subject to a considerable amount of study due to the large number of high-volume desalination plants in operation within Australia. As a result, the potential impacts are well known. Marine organisms exist in osmotic balance with their ocean and exposure to a rapid change in salinity has the potential to result in the dehydration of cells, decreasing turgidity with potentially lethal consequences. Most marine species are able to tolerate short-term fluctuations in the order of 20% to 30% (Walker and McComb 1990), and it is expected that all resident and transient species would tolerate any exposure to the slightly increased (approximately 10% above background) salinity plume caused by the discharged FLNG brine prior to dilution to ambient levels. Therefore, the impact of incremental salinity increases within the discharge stream is not considered further as there will be no related environmental effects or damage.

The chemicals used in all three systems typically have low inherent toxicity, low residual discharge concentrations and/or the active ingredients are consumed through the process for which they are utilised. Based on the available chemical ecotox reports and associated conservative estimated end-of-pipe discharge concentrations, it was estimated that the required number of dilutions for each discharge stream to reach its Predicted No Effect Concentration (PNEC), as calculated using the CHARM methodology (CIN 2017), were approximately:

- Desalination Brine: 1.25 – 240 dilutions required
- Boiler Blowdown: 400 – 839 dilutions required
- MBP Effluent – N/A PNEC could not be calculated due to inability to undertake meaningful ecotox tests on the associated products given the need to neutralise samples to undertake such tests. However, both HCl and NaOH are ranked E under the OCNS grouping system which represents the least hazard potential and therefore any impacts are considered negligible due to the rapid buffering capacity of the open ocean.

The number of dilutions provided above is considered highly conservative as these additives are typically ‘consumed’ in the process, with much lower or no residual levels remaining upon consumption or discharge (HydroBiology 2006). As discussed further in Section 9.9.3.4 Desalination Brine, MBP Effluent and Boiler Blowdown Discharges, the required level of dilution for all three streams is predicted to be achieved within 80m of the FLNG facility under the 95th percentile current regime.

Based on the discussion above, the residual impact as a result of the discharge of desalination brine, MBP effluent and boiler blowdown are considered to be of slight impact consequence (Magnitude -1, Sensitivity – L).

Produced Formation Water (PW)

Benthic Communities

Given the water depth that Prelude is moored in, and the analysis conducted on the discharge streams, there will be no direct interaction of the plume with the benthic environment. The only potential impact pathway is likely to be via inherent solids, precipitates or adsorbed particles settling onto the seabed over time. This may include metallic mercury, chlorides or other unknown contaminants if they have the potential to form due to plume interactions or other processes. Due to the considerable water depth highly dispersive currents, small particulates, low particle concentrations and likely resuspension and further dispersion of the finer fractions, the time for particulates to settle will be such that any settlement will likely be spread over a widespread area of the seabed (10s-100s of km). This will take a considerable amount of time (10s of years) to accumulate into detectable limits above background, if at all, and levels attributable to planned discharges will not reach levels that are known to cause deleterious effects on the benthos.

Therefore, the residual impact consequence of PW discharge on benthic communities for this revision of the EP is assessed as no impact (Magnitude 0, Sensitivity – L). This impact assessment and resultant ranking will be revisited upon future mandatory revisions of the EP.

<u>Pelagic Communities</u>

The decrease in water quality from potential contaminants in the treated PW discharge stream may result in localised acute impacts to plankton. Research indicates that zooplankton exposed to low molecular weight hydrocarbons can exhibit acute toxic effects (Almeda et al. 2013; Jiang et al. 2010) and developmental defects in fish (Fucik et al. 1995). In particular, PAHs are of concern due to their solubility, toxicity and relative persistence compared to BTEX. The concentrations and durations of exposure required to induce such effects on plankton populations will be short-lived and highly localised due to the rapid dilution and decay of PW constituents, well mixed open offshore ocean environment and transient nature of planktonic communities.

Pelagic fish attracted to and organisms attached to the FLNG hull structure may be exposed to low but potentially toxic concentrations of contaminants within the PW mixing zone. However, some free swimming species are expected to move away from the area if they are able to detect nuisance concentrations of PW constituents, which will be localised to the vicinity of the release location.

Fish can also bioaccumulate heavy metals through food and via water, but uptake by individuals and by different species of fish is dependent on many factors including the metal's form (inorganic versus organic), water chemistry and behavioural traits (feeding, range) of the fish species in the receiving environment. Atchison et al. (1987) reviewed acute and chronic toxicity of metals relating to a variety of fish species and found mercury (inorganic and methyl) and copper to be the most toxic. Some heavy metals, such as mercury are persistent and can bioaccumulate (Nigro and Leonzio 1996), however some fish species may be able to metabolise metals potentially further reducing the already slight impact profile (Hodson 1988).

Some fish are able to metabolise and excrete hydrocarbons, potentially reducing physiological effects to fish exposed to PW hydrocarbons (Bakke et al. 2013). For example, King et al (King et al. 2005) reported hydrocarbon-degrading bacteria in the liver and bile of fish collected from their study on the North West Shelf (NWS). Bakke et al. (2013), who reviewed individual, population and ecosystem level biological responses to PW further concluded that the spatial scale of impact from PW discharge was insufficient to impact populations of marine organisms.

Initial WET testing was undertaken on treated PW samples collected on 29 April and 6 May 2019, for details refer PW water quality section above. Although it should be acknowledged that not all listed process chemicals were being dosed at this time, regardless the results still provide an indication of the effluent toxicity presented by the PW originating from the reservoir. This provides a high level of confidence around the predicted impacts associated with PW discharges. The following toxicity tests were undertaken for each of the sampling and analysis events:

- 72-hr marine algal growth
- 48-hr oyster larval development
- 1-hr sea urchin fertilisation success
- 72-hr sea urchin larval development
- 48-hr acute copepod survival
- 96-hr acute amphipod survival.

The methods described in Warne et al. (2018) and CSIRO (2019) were applied to the relevant data to generate SSD curves (Figure 9-17) and associated levels of species protection utilising the CSIRO hosted Burrlioz statistical analysis software.

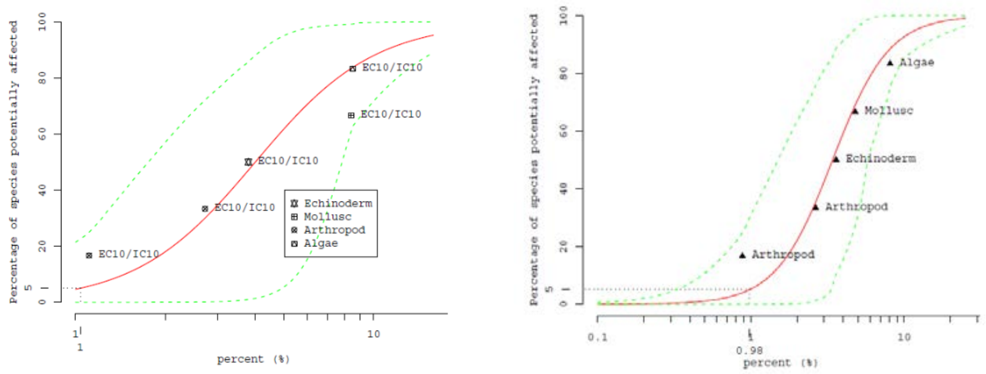


Figure 9-17: SSD curves developed from the PW WET testing results from samples collected from the Prelude FLNG on 29 April (left) and 6 May 2019 (right)

This calculated that 99% species protection was provided by 0.49% PW for the respective sampling events, i.e. 204 dilutions were required for each of the samples to protect 99% of species. This required level of dilution is expected to be achieved in the near-field or very rapidly within the far-field but within 100 m of the discharge point if utilising the predicted 95th percentile dilution predictions.

A literature review undertaken showed that at 500-1000 m of the discharge points, dilution rates of 1000 – 100 000 are typical (Neff et al., 2011). This further provides a high level of confidence that the defined impact threshold (99% species protection) for PW will be maintained within 1 km of the FLNG greater than 99% of the time. This recognises that there will be a potential gradient of impact with receptors within this mixing zone subject to higher concentrations of contaminants closer to the discharge release point. However, impacts to the identified receptors with be managed to ALARP and acceptable levels through implementation of the identified controls and associated EPSs.

In summary, exposure of pelagic communities to PW, could result in localised environmental effects on individual organisms, but with no ecosystem function changes or chronic level impacts to populations. The impact on pelagic communities is therefore assessed to be Slight (Magnitude -1, Sensitivity – L).

Threatened and Migratory Species

As the plume is dynamic and moving constantly depending on the tides, currents, winds and internal waves, transient biota such as migrating whales or whale sharks, are unlikely to be exposed to elevated contaminant concentrations for extended durations. Noting that there are no BIAs or aggregation areas in close proximity to the Prelude FLNG that may result resulting in sedentary marine fauna behaviour. The closest BIAs relate to green turtle foraging/interesting buffer at Browse Island (23 km), whale shark foraging (33 km) and blue whale migration (78 km) as described in Table 7-7.

Most threatened and migratory fauna species with the potential to interact with the PW plume are air breathing vertebrates, whom are typically not affected as their skin is relatively impermeable and they breathe air. Indirect impacts, such as altered prey abundance or ingestion of bioaccumulated toxic compounds is considered to be of no effect given the localised area predicted to be impacted by PW, the typically temporary or transitory presence of threatened and migratory fauna species, and the nature and scale of impacts to the marine ecosystem within the PW discharge plume (i.e. slight impacts to food sources such as plankton and pelagic fish species).

Given the absence of impacts to higher order marine fauna, limited spatial extent of water quality impacts (within 1 km from the FLNG), the infrequent and short interaction duration (i.e. minutes at a time) with the PW plume, and that only a very small proportion of the migrating/foraging population would intersect the discharge plume if at all, there are no predicted residual impacts to these receptors (Magnitude 0, Sensitivity – M).

Use and Discharge of Chemicals in Ad-Hoc Discharges

Chemicals used on the facility could cause impacts for specific biota when released to the environment depending on the nature and degree of exposure received by a particular receptor. Given the short-term durations and low frequencies of the discharges described in this section, any potential effects are likely limited in duration to a matter of minutes after the release, and confined to a small area in the water column, and therefore only to a low number of individuals that may intersect the discharge plumes prior to sufficient dilution. No adverse environmental effects are expected at a community or habitat level for any species. Many chemicals selected for use subsea (e.g. control valve fluid) or on the facility are water-soluble. As such, emphasis is placed on minimising/optimising volumes stored, used and discharged wherever practicable given the inability to recover these substances once released.

Chemicals present within these discharge streams are predicted to have slight residual impact consequence at worst (Magnitude – 1, Sensitivity – L) given the typically low toxicity of chemicals selected through the Shell Chemical Management Process (Section 10.1.10), distance to sensitive habitats, lack of sensitive receptors and high inherent rates of dilution and dispersion.

9.9.2.3 Socio-Economic Environment

Impacts on social receptors such as recreational users and commercial operators of fishing, aquaculture, diving and boating operations, are not predicted nor are credible due to exclusions in place via the gazetted PSZ, the localised nature of the discharges and the rapid dispersion and dilution in open offshore waters.

There are no known sensitive receptors to human pathogens in the vicinity of the liquid discharges location. It is expected that any discharged pathogens will be susceptible to rapid mortality following exposure to natural levels of UV radiation, oxygen, increased salinity and natural predation resulting in their reduction and ultimate destruction

(ANZECC & ARMCANZ 1997). Regardless, transference of human pathogens into marine fauna resulting in adverse impacts to the organism itself, fishermen or consumers is not anticipated to occur and/or is not considered a feasible cause and effect pathway due to the inherent biological and physiological differences in the host species' and is therefore considered to present a non-credible impact. There are no identified recreational uses within the vicinity and therefore any impacts associated with human primary/secondary contact and the presence of 'nuisance' organisms is considered as non-credible.

9.9.3 Cumulative Impact Assessment

The Prelude FLNG routine planned liquid discharge types and rates are typical of most manned offshore facilities and the specific characteristics of each are summarised in Table 9-36. Many design considerations were made in the location of individual discharge ports and intakes, including potential for interaction and recirculation. However, as the FLNG facility sits in an open offshore environment where current conditions may be highly variable and omni-directional, there is a potential for interaction between some different discharge plume types.

Interactions of the various liquid discharge plumes may be possible under the following circumstances:

- The discharges are located in sufficient proximity so that the dynamic plumes may overlap (Refer to Figure 9-7);
- Certain or changing ambient current directions bring the plumes of the same or other discharges into the discharge path of a plume; and/or
- Severe conditions create substantial turbulence that allows interaction of plumes that are normally at different depths.

As discussed earlier in Section 9.9.2, detailed impact assessments of the individual discharge stream types have been undertaken as standalone reviews. However, as the FLNG includes multiple, proximal located discharges that may comingle following release (Figure 9-7), a study of the potential for these plumes to interact, and the likely level of common constituent intersection and associated constituent compounding was undertaken (RPS 2019b) to inform a cumulative impact assessment. This study calculated the defined fields of effect (impact area) of wastewater discharges from the Prelude FLNG, taking account of any co-mingling or cross-contamination potential. Such fields of effect were calculated as the maximum distance from the FLNG where concentrations might exceed Predicted No-Effect Concentrations (PNECs) for each constituent of concern calculated using available ecotoxicity data and applying the CIN (2017) methodology.

Liquid discharges undergo dilution through multiple processes:

- Turbulence generated by the momentum of the water passing through a restricted port
- Turbulence generated by the discharge jet penetrating the receiving water due to viscous resistance
- Dispersion occurring as the plume rises or sinks due to relative buoyancy
- Dispersion due to advection and turbulence present in the water column.

The first three processes are dominated by the characteristics of the discharge, including the flow rate, port size, orientation and water density, relative to the receiving water, and is complete within relatively short time and space scales. Hence, are commonly referred to as “near-field” processes. The fourth process will occur later and will be dependent upon the levels of mixing energy that are set up by ambient current and wave action around the discharge location. This fourth process occurs over longer time and space scales and is commonly referred to as the “far-field” process. PW, Treated Drainage and Bilge (Slops) Discharges Treated drainage (slops) and bilge waste flows are expected to be relatively low volume and frequency, and at a much lower order than PW and cooling water in particular. The PW, drainage (slops) and bilge waste flows are grouped in this cumulative assessment given that all three discharge streams are expected to contain oil in water (TPH).

Allowing for the dilutive influence of other discharge plumes (e.g. CW) and cases where the PW stream angles away from the hull when the discharge location is in the lee of the hull (when the current is towards the port bow), the adopted threshold is predicted to be achieved before it departs the lee of the FLNG under the 95th percentile current regime.

Given the PW discharge is located some distance (>400 m) from the other two hydrocarbon influenced discharge ports (slops and bilge), any influence of PW stream on the physical or chemical behaviour of these other discharge plumes is predicted to have no effect. By this point the PW stream is predicted to have diluted in the order of thousands of times already which will result in all defined constituent PNECs being achieved prior to any plume intersection (Refer to Figure 9-18 and Figure 9-19).

Any interaction with or flow past the main cooling water discharges will result in entrainment within the cooling water plume and accelerated dilution due to increased energy and turbulence. In the case of interaction with SW2 in particular, where the flow rate is significant, the PW plume would be completely disrupted and entrained into the cooling water plume, dramatically increasing the effective dilution of the PW plume as it undergoes a secondary nearfield phase. Contaminants already at very low concentration are then further diluted. As indicated in Figure 9-18 and Figure 9-19, there are no significant TPH compounding effects predicted between the PW and bilge/drains(slops).

As shown in Figure 9-19, the treated bilge and drainage (slops) discharge plumes are anticipated to comingle but the resultant plume TPH concentration is predicted to be diluted to within the defined 7 ppb PNEC within 150 m of the FLNG under the 95th percentile current regime. Allowing for the 99th percentile current, the field of effect could extend to 200m from the FLNG facility.

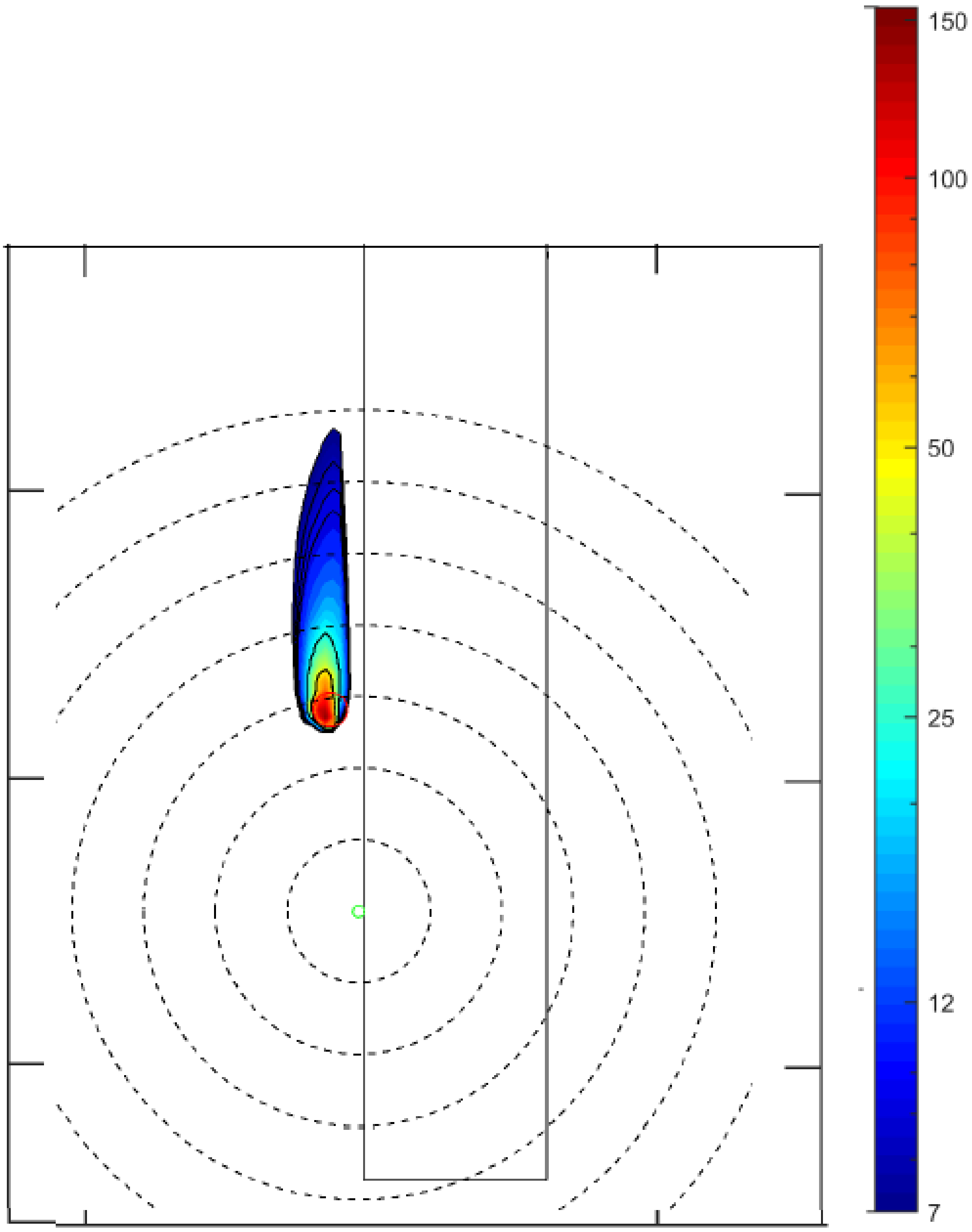


Figure 9-18: Calculation for the field of effect of TPH in the far-field resulting from the PW discharge. The field of effect is illustrated for concentrations > 7 ppb TPH. The key shows ppb. Range rings mark 25 m distances from the source. The red circle indicates the end of the near-field zone. The green circle indicates the location of the PW discharge.

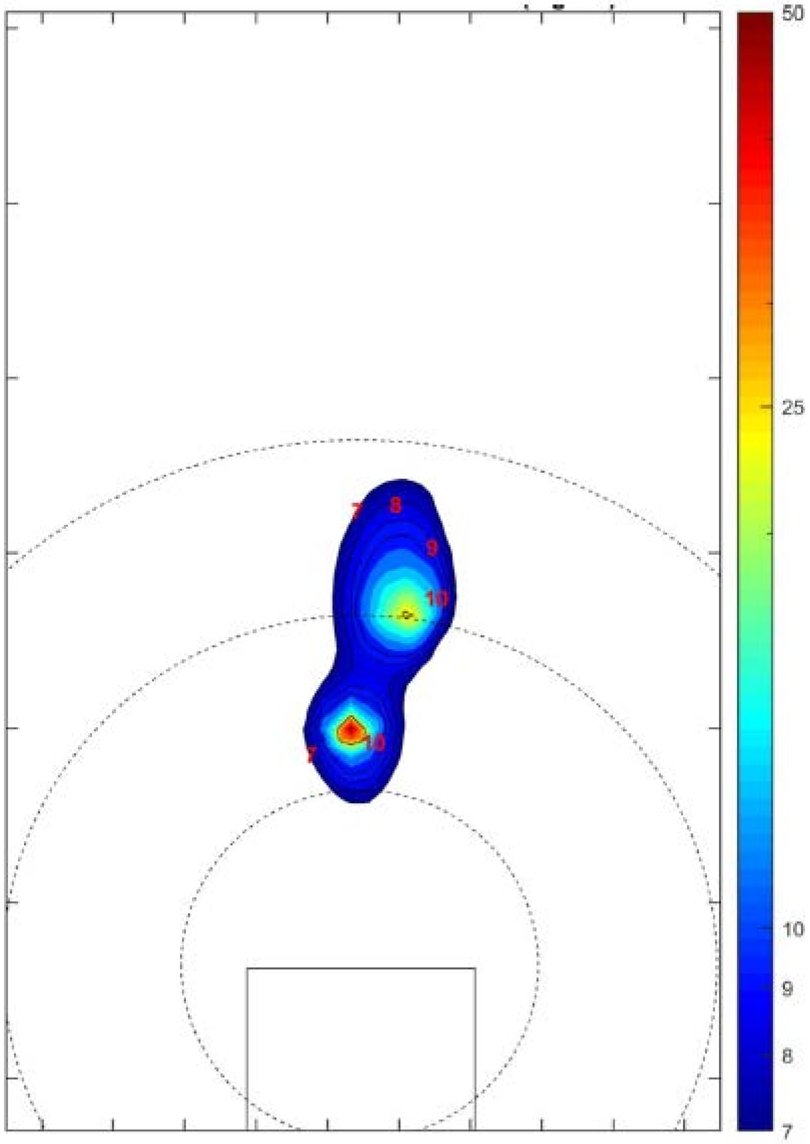


Figure 9-19: Calculation for the field of effect of TPH in the far-field resulting from slops and bilge discharge occurring with all other discharges. The field of effect is illustrated for concentrations >7 ppb. The key shows ppb. Range rings mark 50 m distances from the stern. The gap from the stern represents the length of the near-field zone.

9.9.3.2 Food wastes, sewage and grey water

Discharges will be relatively fresh (less saline) compared with the receiving waters, and therefore positively buoyant and may reach the surface under weaker current conditions. As the plumes will be situated in the upper layer of the ocean, there is potential for the resultant plumes to interact with each other and some of the other defined liquid discharges. Given the high dilution, low volume and low toxicant concentrations, it is not anticipated that food, sewage or greywater discharges would result in any cumulative impacts amongst each other or any other liquid discharge streams.

9.9.3.3 Cooling Water

Generally, the weathervane movement of the FLNG with wind and currents is expected to result in the cooling water flows moving predominantly away from the stern of the FLNG, and therefore with limited potential for interaction with the PW discharge port. The cumulative field of effects and achievement of the defined thresholds for all CW ports is previously discussed in Section 9.9.2.1 Physical Environment and is not repeated here.

In rare cases where the plume may be flowing towards the PW discharge port, the dilution over the >390 m distance prior to interaction will be significant. The plume is likely to be mixing vertically during this flow, and the PW discharge will jet through the cooling water plume, entraining some of the remnant cooling water plume. This may provide an opportunity for constituents in each stream to mix. In particular there may be potential for the formation of chlorides that may precipitate. Chlorine reacts with most metals to form metal chlorides, and so free chlorine has the potential to interact with some constituent metals in the PW discharge should the plumes cross paths under particular current conditions. There is also a possibility of free chlorine reacting with the dissolved aromatic hydrocarbons in the PW discharge. The complexing of metals such as cadmium, lead and nickel with chloride compounds can act to increase or decrease their toxicity to aquatic organisms and the rates of uptake by those organisms, effects which also depend on temperature and salinity. The formation of metal chloride complexes is also affected by salinity, with increasing salinity generally leading to both increased formation and reduced toxicity. Chlorinated aromatic hydrocarbons (such as chlorobenzene) will tend to adsorb to suspended sediments and other matter, and may also bioaccumulate in aquatic organisms.

While these chemical complexes are a potentially toxic hazard to marine organisms, the likelihood of metal chlorides or chlorinated aromatic hydrocarbons being present in significant concentrations beyond the immediate vicinity of the discharge source is considered to be non-credible when the initial pollutant concentrations in the respective discharges and subsequent dilutions prior to interaction are taken into account.

9.9.3.4 Desalination Brine, MBP Effluent and Boiler Blowdown Discharges

As per Section 9.9.2.2 Biological Environment, these discharges are likely to dilute and disperse rapidly. As the plumes are expected to resolve in the upper layer of the water column, interaction with other near-surface discharges and plumes may be possible. However, there will not be any considerable cumulative impacts associated with co-mingling due to the different additives and physical properties not presenting a feasible multiplication effect. RPS (2019b) shows that due to dilutive influences from other larger discharge streams (e.g. cooling water) and low inherent toxicity of any additives, the defined PNEC thresholds are predicted to be met:

- For boiler blowdown and desalination brine, 108 m and 96 m from the discharge location respectively and <80 m from the FLNG).
- For MBP effluent <65 m from the FLNG).

9.9.3.5 Subsea Valve Discharges

Given the subsea system is located in deep water and a considerable distance from the FLNG, valve actuation discharges are not expected to interact with any other planned discharges and are therefore not considered further from a cumulative impact perspective.

Cumulative Liquid Discharges Impact Summary

The RPS (2019b) modelling assessment shows that the potential cumulative impacts of all liquid discharges released simultaneously are not expected to exceed the predicted impact footprint of the worst-case discharges when assessed in isolation as described earlier in Section 9.9.2, i.e. slight impacts will be contained within the 1 km mixing zone from the FLNG described and assessed for PW as a standalone discharge stream.

Given the open offshore location and absence of particularly sensitive or high-value marine ecosystems or habitats at the FLNG location and within the Operational Area, predicted cumulative impacts to water quality are considered slight (Magnitude -1, Sensitivity - L). Bakke et al. (2013) states that typically no impacts are detected beyond 2 km from offshore facilities around the world noting that the nearest potentially high environmental value habitats that could potentially be affected in proximity to the FLNG are:

- Browse Island (approximately 39 km from the Operational Area)
- Echuca Shoal (approximately 61 km from the Operational Area)
- Continental Slope Demersal Fish Communities (approximately 14 km from the Operational Area).

Conservation values are defined as those elements of the region that are:

- key ecological features (KEF) of the Commonwealth marine area
- species listed under Part 13 of the EPBC Act that live in the Commonwealth marine area or for which the Commonwealth marine area is necessary for a part of their life cycle
- protected places including marine reserves, heritage places and historic shipwrecks in the Commonwealth marine area

The nearest island to Prelude FLNG location is Browse Island, which lies approximately 39 km to the southeast, and nearest MPA is Kimberley. The AMP provides protection for two KEFs; an ancient coastline (a unique seafloor feature that provides areas of enhanced productivity) and continental slope demersal fish communities, the distance of the said Demersal Fish Community group is estimated to be 14 km away from Prelude (refer table 7-1). While, the closest site recognised under the Convention on Wetlands (referred to as Ramsar wetlands) having International Importance, protected under Part 3 of EPBC Act and are MNES, was approximately 162 km away from Prelude, Ashmore reef national nature reserve.

Within the operational area and ZPI observed fauna groups such as whale sharks, several cetacean species and marine turtles, are listed as threatened and / or migratory under the EPBC Act. Threatened species are protected under Part 3 of the EPBC Act and are MNES, with most relevant being the whale sharks and sea turtles which have been seen near the facility. The nearest sea turtle BIA of green turtles is the internesting habitat around Browse Island; this habitat lies approximately 23 km south-east of the Prelude FLNG facility at the closest point, for detailed summary refer section 7.2.8. While the whale shark BIA does not overlap the Operational Area, it does extend through the ZPI, and whale sharks are known to occur within the Operational Area. However, the exposure time for these species within the effected liquid discharge mixed area is considered short term and periodic with no long-term impact being associated. Regardless, due to the complex nature, acute impact can be considered leading to short lived distress or in the worst case, lead to fatality. These instances are taken to be extreme cases since both the species are very wide ranging with no overlapping BIA and the liquid discharge mixing zone area is not recognised as their important habitat. Negligible impact is considered due to the widespread range relative to the mixing zone radius of up to 1 km. Given the localised area of impact, 99% species protection safe dilutions will be achieved by the boundary. Considering the distance of the nearest ecological and commonwealth significance site, the PW discharged constituent will be further diluted providing additional protection layer.

In Australia, chronic ecotoxicity data on local species based on WET testing is used as a basis for Species Sensitivity Distribution (SSD). For SSD, the hazard concentration depends on the ecosystem. Exposure levels outside the mixing zone should not exceed the concentration that is protective of 95% (typically) or 99% (for sensitive receiving waters with high conservation value) of species (Environmental Quality Management Framework established under ANZG (2018)). The Browse Basin is subject to considerable exploration activity and the closest operating facility, Ichthys LNG, is located approximately 17 km from Prelude FLNG. The dilutions required to protect 99% of species is considered to maintain a high level of ecological protection at the boundary of the mixing zone. All constituents achieved 99% species protection guideline values within the mixing zone of 1km. Routine WET testing as per the Table 10-6 will be completed to validate compliance with the species protection safe dilution requirements. There have been no further opportunities to analyse PW from the reservoir to date. Dilutions to reach ANZECC 99% species protection guideline values are provided where applicable.

9.9.4 Impact Assessment Summary

Table 9-42 lists the highest residual impact consequence rankings of the relevant environmental receptor groups.

Table 9-42: Liquid Discharges Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	-1	L	Slight
Biological Environment	-1	L	Slight
Socio-economic and Cultural Environment	NA	NA	NA

9.9.5 ALARP Assessment and Environmental Performance Standards

Table 9-43: Drainage (Slops) and Bilge Waste Discharges ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Eliminate discharges from FLNG by storing all open drainage and bilge effluent to be transported and treated /disposed onshore.	No	There are significant costs and HSE risks associated with storing and transporting onshore all open drainage and bilge effluent on the marine support vessels and the FLNG. It is grossly disproportionate to the environmental impacts of onboard treatment prior to discharging overboard.	N/A	N/A	N/A
Substitution	Alternative technology to oil-water separator system.	No	The oil-water separator systems on the FLNG and vessels are standard MARPOL-compliant systems for management of accidentally-oil contaminated drainage and bilge in offshore installations and vessels. On the FLNG there is also an option available to direct off-specification drainage effluent through the MPPE system if required.	N/A	N/A	N/A
Engineering	FLNG: Monitoring of drainage and bilge discharges.	Yes	If the online monitor is not functional, manual samples will be taken to facilitate determination of oil in water concentration to allow batch discharges to occur where the batch concentration is confirmed below the limit. Discharges at this level are not expected to cause any significant impact to the marine environment given low flow rates and high dilutions close to the source.	7.1	Drainage effluent will not be discharged via the slops system if 30 mg/L (24 hour average) oil in water limit is exceeded[11].	Records demonstrate no exceedances of the 30 mg/L (24 hour average) oil in water discharge limit.
				7.2	Bilge effluent will not be discharged if the 15 mg/L oil in water limit is exceeded.	Records demonstrate no exceedances of

[11] Advice from the Recognised Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			If the slops open drainage system cannot meet the discharge limit, the effluent can also be routed to the Produced Water Treatment System (MPPE) for further treatment prior to discharge. The Slops Tanks can also act as a further separation mechanism for treating Produced Water which has a limit to 30 mg/L oil in water over a 24hr average. Oil in water analysis requirements is defined in Prelude FLNG Oil in Water Analysis Terminology and Methodology (HSE_PRE_16227).			the 15 mg/L oil in water discharge limit.
Engineering	Marine support vessels and Prelude FLNG Compliance with Marine Order 91 (International Oil Pollution Prevention [IOPP] certificates).	Yes	The marine assurance system is administered by Shell's Marine team and, amongst other requirements, ensures compliance of contract vessels with MARPOL and Marine Order 91. This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and the relevant AMSA Marine Orders.	7.3	Assurance will be undertaken for Prelude FLNG and marine support vessels, including a check for valid and in date International Oil Pollution Prevention (IOPP) certificates as required by vessel class requirements[12].	Assurance records
Administrative and Procedural Controls	Spill kits onboard the FLNG and marine support vessels.	Yes	Storage and use of spill adsorbent and clean-up kits are inexpensive and low-maintenance. Accumulations of oil, grease and other contaminants will be collected and removed from the decks.	7.4	Spill kits are available on the FLNG and marine support vessels to clean up small accumulations of contaminants.	Records indicating spill kits are in place.
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Shell has adopted a chemical selection and approval process in accordance with Shell's chemical selection and approval guidelines as indicated in	7.5	Chemicals selected for use in accordance with the Shell Chemical Management	Records demonstrating the chemical

[12] Advice from the Recognised Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			Shell Chemical Management Process (HSE_GEN_007879) and Shell Global Product Stewardship guidelines to assess chemicals than may pose environmental impact via planned discharges.		Process to minimise potential environmental risks.	selection process outlined in the Chemical Management Process have been followed.
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Following the chemical management process as detailed within Section 10.1.10 will minimise the impact of those chemicals which are used and discharged to ALARP levels.	7.6	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have a complete ALARP assessment.	Records demonstrating the chemical selection process outlined in the Chemical Management Process have been followed.

Table 9-44: Sewage, Grey Water and Food Waste Discharges ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	On board storage of sewage, greywater and food wastes for transport to and disposal at an onshore facility.	No	Offers limited environmental benefit, as any changes to water quality beyond a localised mixing zone are likely to have no environmental effect. Is likely to increase operational costs associated with additional transits to and	N/A	N/A	N/A

			from port and introduce additional safety and environmental risks related to increased transit time and operation of additional vessels, plant and equipment.			
Substitution	Use of sewage treatment system to treat all sewage prior to disposal	No	Offers limited environmental benefit, as the addition of chemicals (such as flocculants and defoaming agents) would be required to treat the effluent. Though some reduction in area impacted may occur this benefit is offset against the detrimental addition and increased cost of refined chemicals. Therefore, the available environmental impact reduction is negligible to non-existent.	N/A	N/A	N/A
Substitution	Use of alternative treatment technologies	No	• Requires additional cost due to the space requirement onboard vessels and FLNG to enable installation. • Increases operational costs for maintenance and staffing due to performance challenges associated with these technologies (e.g. clogging of membranes/screens). Also increases potential exposure of the workforce to pathogens associated with these waste streams.	N/A	N/A	N/A
Engineering	FLNG: Food waste will be reduced to <25mm particle size prior to discharge to sea	Yes	Food wastes are macerated to less than 25mm diameter prior to discharge within 500 m of the FLNG.	7.7	Food macerator is maintained in accordance with the MMS to reduce food waste to < 25 mm particle size prior to discharge to sea.	Maintenance Records
Engineering	FLNG: Vacuum Toilet System	Yes	The vacuum toilet system reduces the particle size to aid in the rapid dispersion and biodegradation of this waste stream.	7.8	Vacuum toilet system is maintained in accordance with the MMS to reduce	Maintenance Records

					sewage particle prior to discharge to sea[13].	
Engineering	Further treatment e.g. disinfection of the waste-stream prior to discharge	No	There are no known sensitive receptors to human pathogens in the vicinity of the discharge location that may be impacted therefore disinfection of the waste stream is not considered to provide a reduction in the impact. Additionally, not dosing the waste stream with a disinfectant such as chlorine will avoid potential cumulative impacts with other chlorine dosed streams such as cooling water. Furthermore, the consumption of disinfection chemicals, the resources consumed to transport the chemicals, and the risk of excess chlorine being released into the sea outweighs the negligible environmental benefits of disinfecting treated sewage effluent prior to discharge.	N/A	N/A	N/A
Engineering	Marine support vessels and Prelude FLNG Compliance with Marine Order 96 (International Sewage Pollution Prevention [ISPP] certificates) as relevant to vessel class, size and type.	Yes	This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and the relevant AMSA Marine Orders.	7.9	Assurance will be undertaken for Prelude FLNG and marine support vessels to check for valid and in date International Sewage Pollution Prevention (ISPP) Certificates (or equivalent voluntary statement of compliance audits where relevant) , as required by vessel class requirements[14].	Assurance records

[13] Advice from the Recognised Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

[14] Advice from the Recognised Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

Administrative and Procedural Controls	Required marine support vessels and Prelude FLNG will maintain a Garbage Management Plan (or equivalent) as required by vessel class, size and type.	Yes	Each required vessel has its own Garbage Management Plan/Procedure (or equivalent) to manage wastes generated and stored onboard. All wastes that are not permitted for discharge are sent ashore for reuse, treatment, recycling and/or disposal as appropriate. This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and AMSA Marine Order 95. The Recognised Organisation will be engaged to check on application of this requirement to Prelude FLNG. Advice from the Recognised Organisation will be followed.	7.10	Marine support vessels (to which MARPOL Annex V / Marine Order 95 applies) have a current Garbage Management Plan (or equivalent)[15].	Garbage Management Plan (or equivalent) is sighted onboard marine support vessels and are maintained up to date.

[15] Advice from the Recognised Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

Table 9-45: Cooling Water Discharges ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	Cooling is required for the FLNG facility from a safety and technical integrity perspective as part of the hydrocarbon production process and associated utilities for personnel. As such, cooling water discharge cannot be avoided. Collecting, storing, and transporting all CW discharges to shore is not a reasonably practicable alternative, due to technical, financial, and health and safety costs.	N/A	N/A	N/A
Substitution	Use of air-cooling instead of cooling water	No	Although air cooling is a technology tested for most onshore LNG facilities, water cooling is assessed as more efficient for the offshore FLNG facility. Air-cooling would require additional energy (fuel gas burnt) and equipment which will not fit on the FLNG from a structural perspective. The discharge of recycled seawater poses minimal environmental impact vs. burning more fossil fuels. The use of air for cooling also doesn’t completely eliminate the requirement for seawater discharges.	N/A	N/A	N/A
Substitution	Use alternatives to hypochlorite	No	Hypochlorite is produced on the platform from seawater via the seawater intakes and is used to prevent biofouling to ensure the continued operability and integrity of the seawater system. Other chemicals were considered during the design phase of the Project but ruled out for technical, commercial, logistical and safety risk associated with transporting, handling and storing the quantity of chemicals required. This transporting, storing and handling risk is grossly disproportionate to the negligible environmental gain of substituting the hypochlorite discharge for a different chemical.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			Hypochlorite is be readily generated from seawater which eliminates this risk.			
Substitution	Use of alternative systems for biofouling control	No	Copper-chlorine system: This process utilises sodium hypochlorite (generated as for electrochlorination) with the toxicity to fouling organisms boosted by copper ions generated in a dosing chamber from sacrificial copper electrodes. The copper and chlorine act on the cell membranes of the fouling organisms. Due to the synergy of their action, dosage requirements are significantly reduced (approximately 5 ppb copper and 50 ppb hypochlorite). Levels of copper from anti-biofouling systems have been measured by the US Uniform National Discharge Standards (UNDS) Program (US EPA [1999]). Their research has shown that the concentration of copper discharged from anti-biofouling systems is between 0.52 and 0.69 ppb which is above the ANZECC (2018) DGV for copper which may introduce additional environmental risk in isolation or cumulatively with chlorine as an additive effect. Copper-aluminium-chlorine system: This process is similar to the copper-chlorine process. The major difference is that the seawater is passed through an ion vessel that uses an impressed current method to selectively dissolve copper and aluminium. This is again mixed with sodium hypochlorite prior to dosing the system. So, although the concentration of residual chlorine could be reduced by the use of copper-chlorine or copper-aluminium-chlorine systems, there is potentially no environmental	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			benefit gained as it introduces additional contaminants that are toxic.			
Engineering	Chlorine neutralisation (Dechlorination)	No	Dechlorination is the process of removing residual (free) chlorine from disinfected wastewater prior to discharge into the environment. This process reduces the effect of potentially toxic disinfection by-products by removing the free/residual chlorine remaining after chlorination. Further engineering changes to provide additional treatment prior to the final discharge, would require additional equipment, imposing significant additional space and weight requirements, which are not available on the FLNG from a structural perspective. Furthermore, with major financial costs, for negligible environmental benefit at this location given the slight residual environmental impact presented by the resultant plume. Treatment of the CW prior to discharge introduces additional safety risk associated with transporting, handling and storing the quantity of de-chlorination chemicals required which is grossly disproportionate to the negligible environment benefit that may be gained.	N/A	N/A	N/A
Engineering	Chlorine Adsorption	No	Carbon adsorption is usually implemented when total dechlorination is desired. Carbon adsorption can be an effective dechlorination method, but is impractical on an FLNG scale whereby numerous carbon filters would be required to treat a throughput of ~80,000m^3/hr. Not only will this be impractical from a space / structural perspective on the FLNG, filtering seawater (which contain salts and impurities) would constantly block the filters, requiring frequent change outs and generation of additional waste.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			Furthermore, this option introduces capital, ongoing costs and waste grossly disproportionate to the negligible environmental gain of further reducing chlorine concentrations in the CW streams.			
Engineering	Additional residence time and/or treatment prior to discharge	No	Further engineering changes to provide additional treatment and/or storage prior to the final discharge, would require additional equipment, imposing significant additional space and weight requirements. Based on the residence time required in a vessel, with the throughput of ~80,000m^3/hr, a vessel of 320,000m^3 (greater than the volume of all of Prelude's 6 LNG Tanks) is required on which is not feasible to retrofit onto the FLNG for negligible environmental benefit at this location given the predicted impact footprint is already small and very localised.	N/A	N/A	N/A
Engineering	Supply of colder seawater sourced from 150m water and use as a cooling medium for the main process cooling requirements.	Yes	At a depth of 150 m, the sea water supply for SW2 is nearly constant at a temperature of 21-22°C resulting in a lower temperature delta for discharges from this system relative to ambient seawater temperature compared to the scenario of warmer CW being drawn from nearer the surface. Taking this quantity of seawater 150m below surface rather than at surface is novel for FLNG from a design, construction and installation perspective and enhances the energy efficiency of the facility (i.e. reduction in the GHG emissions footprint, refer to Section 8.12).	N/A	N/A - The design features of the CW system were selected, installed and commissioned at the time this EP commenced, and are therefore not described in further detail here as an EPS.	N/A
Engineering	Electro-Chlorination System (ECU)	Yes	The ECU is maintained to ensure the chemical dosing of the cooling water system is undertaken in	7.11	The ECU is maintained in accordance with the MMS to minimise the risk of system	Maintenance Records

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			a controlled manner to optimise dosage to the amount required to achieve treatment efficiency. This will include flushing lines as part of ECU shutdown operations. A trial of line flushing as part of an ECU shutdown operation was completed on 25 Aug 2019 to prevent the build-up of hypochlorite in the system and prevent blockages. The associated re-start on 4 Sep 2019 showed no exceedances as part of the restart sequence. This practice will be carried forward to future ECU shutdown operations and documented in the Seawater Fouling Inhibition Shutdown for Maintenance Procedure.		failures such as line blockages.	
Engineering	Online chlorine analysers planned maintenance	Yes	Online chlorine analysers are maintained to ensure availability and measurement accuracy is within acceptable tolerance limits.. If the zero on zero solution is greater than +/- 0.05 mg/L the online analyser is re-zeroed. If the difference between the lab portable and online analyser is greater than 0.05 mg/L then the online analyser is recalibrated.	7.12	Seawater outfall online chlorine analysers are maintained in accordance with the MMS and where required adjusted in accordance with required tolerances and corrective actions	Maintenance Records including validation, lab readings and calibration records.
Engineering	Online Chlorine analyser alarm system	Yes	As per the Alarm Management Manual, Critical Alarms are red flashing with an audible tone and the response principle is "Immediate emergency corrective actions for the operators to perform to get the variable back within its Critical Limit as stored in the Variable Table (VT)." For residual chlorine alarms, examples of the VT operator actions may include:	7.13	Online analysers for the seawater outfall free chlorine concentration will have critical alarms set at 0.43mg/l on them, which require response within 15 minutes to address the trending exceedance.	Control logic documentation and monitoring records

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			1. Confirm shock dosing is not in progress 2. Adjust injection rate if required 3. Verify hypochlorite injection control valve on SW1/2/3/4 inlet is functioning correctly. With a desired target bandwidth of 0.12 and 0.43 mg/l under normal operating conditions (which includes the variations in the systems). High level alarms will be set at 0.43 mg/l. Setting the critical alarm at this point will ensure the 0.6 mg/l limit is not exceeded (EPS 7.14). Given the complexity of the system and manual operation of the system by panel operators, a significant amount of time and effort would be required to actively manage residual chlorine levels at the 0.2 mg/l desired target operating point. A significant project would be required to automate this system, if it was even deemed to be feasible. The difference in environmental impact between residual chlorine discharge being around 0.2 mg/l or 0.43 mg/l is minimal given NOEC concentrations are reached at 100m - 180m for 0.2 and 0.6 mg/l modelling results respectively. Operating within a broader range from 0.12 and 0.43 mg/l allows operators to limit time spent adjusting the system to meet a single target level. This issue has been highlighted through operation of the system under the previous requirement to not exceed 0.2 mg/l, which has come at a great cost. Therefore, it is grossly disproportionate to the environmental benefit gained. Operator response to critical alarms on the seawater outfall hypochlorite concentration will			

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			involve taking measures to reduce the outfall concentration on the outfall line. Given the multiple ways in which changes to system performance can occur within the seawater system, it is not practicable to create a performance Given the multiple ways in which changes to system performance can occur within the seawater system, it is not practicable to create a performance standard which will ensure the chlorine levels return to levels below the alarm limit in a defined period of time such as 15 minutes. However, it is Shell's intent to strive for this to occur within this period of time. The likely response to an exceedance of the critical alarm will be a reduction in rates through the ECU, which should result in a reduction in chlorine discharge concentrations in a matter of minutes from executing the action.			
Engineering	Inlet hypochlorite injection concentration control	No	A change in control philosophy based on a fixed target hypochlorite injection concentration was considered. However, due to fluctuating efficiency of the ECU, mostly attributed to acid washing, would result in providing a fluctuating ECU outlet stream. Furthermore, the chlorine demand is dependent on the chemical composition of the seawater and the amount of biological life, both of which are affected by multiple factors requiring varying chlorine demand over time. It is highly unlikely to achieve a constant residual chlorine concentration at the outfall discharge point. To ensure a positive range of free residual chlorine concentration at any given time, a relatively high injection concentration would	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			have to be applied, which will result in higher concentration of chlorine in discharged effluent. Thus, to ensure a constant injection concentration, analyser equipment would have to be retrofitted on the facility, downstream of the ECU.			
Engineering	Decrease ECU throughput to manage excess hypochlorite	No	A minimum flow must be maintained through the ECU to ensure safe and reliable operation of the system. In the rare occasions when one or more larger seawater users, such as SW2 and SW4, are not in operation there will be an excess production of hypochlorite available in the system which will need to be managed. The throughput of the ECU system cannot be decreased sufficiently to match the maximum flow capacity of the online seawater system (e.g. SW3). To manage excess hypochlorite, hypochlorite will be discharged to seachests which are not operating. Flow to the online seawater system will always be maximised first to minimise the amount of excess hypochlorite.	N/A	N/A	N/A
Engineering	Control and minimise use of shock dosing and associated residual free chlorine outfall from the seawater system	Yes	Shock dosing is not anticipated to be used regularly for the Prelude seawater system. However, during certain circumstances such as following extended shutdowns or known biofouling building during normal operations, there may be a need for shock dosing to help manage the ongoing control of biofouling within the seawater system. During normal operations of the seawater system, shock dosing would only be considered when normal targeted dosing rates are found to be still resulting in an increase in the differential pressure in the heat exchangers which is symptomatic of fouling in the heat exchangers. Planned and unplanned shutdowns of the seawater systems is a very	7.14	Shock dosing in the seawater system will not exceed 1 hour per 24 hours and shock dosing will not exceed an instantaneous limit of 0.6 mg/L.	Pi records of chlorine discharge concentration
				7.15	Shock dosing will only be initiated when biofouling is likely or known to be increasing within the seawater system under shutdown or normal seawater	Pi records of differential pressure

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			infrequent event and would normally not be expected to occur more than once or twice per year.		system operating circumstances.	
Administrative and Procedural Controls	Prelude FLNG Liquid Discharge Monitoring and Management Procedure	Yes	Monitoring of cooling water and adaptive management will be undertaken to ensure that the chlorine concentration targets and limits are met or exceedances are appropriately managed. Surveillance monitoring of environmental discharge limits with pre-determined troubleshooting actions will help reduce the frequency and duration of any exceedances. Based on operational experience and investigation studies on biofouling issues in the sea water heat exchanger, the free residual chlorine discharge limit was revised to 0.6 mg/L instantaneous. The limit is revised to avoid recurrence of biofouling issue therefore, requiring increased hypochlorite dosing of the seawater system.	7.16	Conduct online monitoring or manual sampling (once per 24 hours providing access is safe for sampling and analysis) to confirm chlorine discharge does not exceed an instantaneous limit of 0.6 mg/L (calculated per discharge port).	Monitoring records
Administrative and Procedural Controls	Decreasing the chlorine dosing level of the CW	No	The hypochlorite dosing range and subsequent residual chlorine discharge typical concentration target of 0.2 mg/L with routine shock dosing of up to 0.6ppm is selected to ensure the chlorine concentration is sufficient to prevent biofouling throughout the seawater system. Decreasing the dosing concentration can potentially allow biofouling to proliferate in the seawater system. This can compromise the integrity and functionality of the water systems, leading to significant technical issues, and increased risk of loss of hydrocarbon containment scenarios, with intolerable safety risks, as well as increased potential environmental release scenarios to the marine environment. Fouling of the system would also decrease the	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			energy efficiency of the facility resulting in higher volumes of GHG production.			

Table 9-46: Desalination Brine, MBP and Boiler Blowdown Effluent Discharge ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	The use of the seawater distillation system and discharge of boiler blowdown water are common and accepted practice for vessels and offshore oil and gas facilities. Offshore activities cannot operate without fresh water.	N/A	N/A	N/A
Substitution	Source all freshwater from onshore.	No	The elimination of the desalination plants to prevent the generation of brine water and MBP effluent would shift the sourcing of water to an onshore resource to 100%. This would increase demand on onshore water supply sources (e.g., Darwin or Broome). It would also result in a high number vessel movements between the FLNG and port, resulting in increased personnel hours (and therefore cost) and increased diesel use (increased air emissions, waste water discharges [including brine water] and cost). The increased financial and environmental cost of this substitute measure is not commensurate with the low environmental impact of brine and MBP effluent discharges.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Engineering	Storing waste effluent onboard and transporting for onshore treatment and/or disposal.	No	Storing on-board and then transferring it to shore results in increase personnel and environmental costs associated with more vessel movements (as outlined in 'substitute'), and is not possible given that the required storage space would not be available on the FLNG and marine support vessels.	N/A	N/A	N/A
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Shell has adopted a chemical selection and approval process in accordance with Shell's chemical selection and approval guidelines as indicated in Shell Chemical Management Process (HSE_GEN_007879) and Shell Global Product Stewardship guidelines to assess chemicals than may pose environmental impact via planned discharges.	7.5	Chemicals selected for use in accordance with the Shell Chemical Management Process to minimise potential environmental risks.	Records demonstrating the chemical selection process outlined in the Chemical Management Process have been followed.
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Following the chemical management process as detailed within Section 10.1.10 will minimise the impact of those chemicals which are used and discharged to ALARP levels.	7.6	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have a complete ALARP assessment.	Records demonstrating the chemical selection process outlined in the Chemical Management Process have been followed.
Administrative and Procedural Controls	The boiler blow-down and neutralisation tank discharges are monitored either by online analyser or manually for pH.	Yes	pH is monitored to measure the efficiency of each system and to understand neutralisation requirements prior to discharge.	7.17	The boiler blow-down and neutralisation tank discharges are discharged within a pH 6-12 range. These pH analysers are maintained in accordance with the MMS	Pi system records online monitoring of pH when analyser is available or laboratory records

Table 9-47: PW Discharge ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Re-injection of produced water.	No	Assessment of onboard treatment and overboard disposal versus produced water re-injection was undertaken during the design phase of the project. The assessment supported the use of the onboard treatment based on the following: • Produced water reinjection systems require significant additional capital and operational expenditure with an associated increase in manning levels. • Produced water re-injection pumps are a source of high noise levels in their immediate vicinity and contribute to the overall noise footprint. • Lower power demand for the onboard treatment versus reinjection, therefore lower CO2 emissions. • For the reinjection option, the produced water treatment facilities remain the same, in line with overboard disposal, due to capability of overboard disposal in case the water re-injection system is down, therefore, there are no equipment reduction benefits for the re-injection option. According to other facilities worldwide, re-injection facilities have on average 80% availability. • There is potential risk of reservoir souring/scaling due to water re-injection. The availability of reservoir for re-injection near the Prelude field without fracking or souring is very limited. • Only slight residual environmental impact exists from the onboard treatment and overboard disposal due to high quality water treatment technology chosen.	N/A	N/A	N/A
Elimination	Storage, treatment and disposal (without discharging)	No	All feasible alternatives/options would result in significant additional safety, environmental, logistical, operational and financial costs. These costs would primarily relate to the storage requirements of the well clean-up fluids on the FLNG (as opposed to discharging), prior to transport to shore. To enable storage, extra tanks would be required	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	during well clean up.		on the FLNG, imposing additional space and weight requirements for the well clean-up fluids. Modifying the FLNG to allow temporary storage of well clean-up fluids, would require significant financial expenditure. Transferring the tanks to support vessels would require increased handling and lifting operations, therefore exposing personnel to health and safety risks. Additionally, limited onshore facilities are available to treat, recycle, and/or dispose of such fluids. The potential environmental benefit is the elimination of the temporary and short-term changes to water quality around the FLNG and therefore reducing the potential exposure to pelagic communities (note the clean-ups are typically one to four days per well). However, this environmental benefit is considered disproportionate to the (technical, financial and safety) costs associated with engineering extra storage or additional treatment facilities requirements on the FLNG, the additional transfers and the burden of onshore treatment, at limited facilities. Therefore, the significant costs of storing, additional treatment and/or disposing of the fluids are grossly disproportionate to the negligible environmental gain (of avoiding the short-duration well clean-up discharges) and are not considered a reasonably practicable alternative.			
Substitution	Alternative technology to MPPE system.	No	The MPPE technology was chosen based on a Best Available Technology (BAT) assessment during the design phase of the project. Alternatives to MPPE are steam stripping, adsorption to activated carbon, advanced filtration, bio-treatment, the use of hydrocyclones, Induced Gas Floatation (IGF), advanced oxidation or sent to shore. The MPPE was listed as BAT by the OSPAR convention for the protection of the marine environment of the North-East Atlantic (1999) for produced water management on offshore oil and gas platforms based on the following:	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			• Unlike other methods, MPPE technology removes dispersed and dissolved components effectively • The effective reclamation procedure of the MPPE material makes it suitable for removal of high quantities of dispersed and dissolved hydrocarbon from wastewater but without the generation of significant waste streams (e.g. spent adsorbents). • The MPPE technology has an effective regeneration process such that one column can operate automatically while another column is regenerating at the same time. • The MPPE unit operates automatically and operator attention is limited.			

Engineering	MPPE Treatment System	Yes	The produced water treatment system is designed and warranted by the vendor to meet a limit of 30 mg/L TPH over 24hr average and 42 mg/L TPH instantaneous. Given the slight predicted residual impacts of these concentrations and alignment with international standards, it is an appropriate maximum limit for TPH for Prelude. High availability of the system ensures that incidents of non-compliant discharge are minimised if not prevented. The change-out of the MPPE columns is included in the maintenance program. Two by 100%-capacity MPPE systems are installed on the FLNG (one in extraction, one in regeneration and two in stand-by) to ensure high availability of the system. MPPE columns are anticipated to be sent onshore for media replacement every 2 to 4 years during normal operations. Furthermore, a buffer tank with ~5400 m^3 capacity is also provided in case of system downtime or if re-treatment of off-specification water is required. Further redundancy is provided by the option to route the PW to the Slop system in the event that the MPPE system is not available. The system is implemented on two conditions during normal operations (i.e. not during well clean-up activities); 30 mg/L (24hr average) and 42 mg/L (instantaneous). The automatic switch-off within the system allows for the daily average limit to be met. Off-specification water is redirected inboard when predefined alarm limits are reached. Shell will review PW baseline data in 2021 once the PW system has sufficient operational history. The purpose of this review will be to set a ‘target[16]’ PW OIW discharge concentration, potentially less than 30mg/l, at least during the early years of operation before formation water breakthrough. The purpose of the target is to internally drive further improved OIW performance for PW discharge.	7.18	The discharge of the produced water shall have a TPH not exceeding 30 mg/L (24-hour average) and 42 mg/L (instantaneous), except during well clean-ups.	Records of TPH in PW maintained to verify that the concentration of TPH in PW meets requirements.

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Engineering	MPPE Treatment System	Yes	Well clean-up: The TPH content of the PW is not to exceed 100mg/L instantaneous during well clean-ups. The 100 mg/L is the expected worst-case discharge during these clean-up periods given the PW water is settled in the buffer tank to remove most dispersed oil from the PW before treatment discharge overboard. By-passing the MPPE will only occur in well clean-up events where the risk of damage to the MPPE is deemed unacceptable and not ALARP. Otherwise, the MPPE will be used as in normal operations during well clean-up events which will result in treatment levels consistent with normal operations (i.e. not exceeding 30 mg/l TPH (24 hour average) or 42 mg/l TPH (instantaneous) also.	7.19	During well clean-up activities the produced water shall have a TPH not exceeding 100 mg/L (instantaneous) only where by-passing the MPPE.is demonstrated to be ALARP in reducing the risk of PW discharge.	Records of TPH in PW maintained to verify that the concentration of TPH in PW meets requirements. ALARP note for file.
Engineering	Online OIW Analyser: Verification and validation of the OIW analyser.	Yes	The online OIW monitor provides information on the performance of the PW treatment system needed to help ensure discharge limits are being achieved. Verification, validation and maintenance of the OIW analyser ensures that the monitor is operating within an acceptable tolerance of accuracy. Oil in water analysis requirements is defined in Prelude FLNG Oil in Water Analysis Terminology and Methodology (HSE_PRE_16227). To ensure a discharge limit of 30mg/L TPH (PW) is maintained, validation of the analyser (PFW) will be done in accordance with the MMS which is set at monthly. The frequency of the validation was revised and decreased after 12 months of operation based on performance and trends generated. When OIW analysers (primary measurement) are not available due to maintenance reasons, back up sampling and analysis will be used. Internationally recognised method such as ASTM, ISO or equivalent for TPH determination will be used for routine oil in water determination in the lab.	7.20	Validation of the PW online analyser will be done in accordance with the MMS.	OIW analyser verification records
Engineering	Manual PW Sampling Procedure	Yes	There may be cases when OIW analysers may not be available due to maintenance or downtime. Back up manual sampling and analysis will be required in these situations. This will be covered by the laboratory sampling and analysis regime defined in Prelude FLNG Oil in Water Analysis Terminology and Methodology (HSE_PRE_16227). An internationally recognised method such as ASTM, ISO or	7.21	When discharging PW, if online analyser is not available; conduct manual lab analysis approximately 6 hourly. Results will be used to verify that the PW TPH	Sample records

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			equivalent for TPH determination will be used for routine oil in water determination in the lab. 6 hourly sampling during discharge is deemed representative as well as considered a practicable level to ensure sampling and analyses personnel are able to fulfil all of their other roles and responsibilities. Depending on the result from manual testing, operations will decide whether to continue operation or to stop discharge and operate the system in a batch process. The PW will be collected in the buffer tank, and appropriate number of samples (based on the total volume) will be collected and analysed to ensure compliance with the limits before discharging. Note that if batch process is undertaken, no further sampling will be done during discharge, provided aforementioned testing is completed and concentrations are deemed acceptable for discharge.		concentration does not exceed the defined limits.	
Administrative and Procedural Controls	Prelude FLNG Liquid Discharge Monitoring and Management Procedure	Yes	The procedure provides for implementation of a risk-based adaptive monitoring and management program for liquid discharges. It relates to the adaptive monitoring and management framework described in Section 10.4.2. The program comprises several components for PW, including: • Topsides monitoring, analysis, and review • Whole Effluent Toxicity (WET) testing • Field monitoring	7.22	Liquid discharges will be monitored and managed in accordance with Section 10.4.2 to minimise potential environmental risks.	Completed records demonstrate implementation of the FLNG Liquid Discharge Monitoring and Management Procedure

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			• Model prediction verification • Contingency/management actions, as required The program ensures the extent and effect of the PW discharge and associated contaminants are assessed, and where practicable, allows adaptive management changes to occur.	7.23	No impact from PW discharges beyond defined mixing zone[17] boundaries: 1. 350 m from the edge of the Prelude FLNG for PW constituents requiring less than or equal to 1000x dilution level to meet 99% species protection limit 2. 1000m from the edge of the Prelude FLNG for PW constituent requiring between 1000 - 5000x dilution level to meet 99% species protection limit	Monitoring, modelling, adaptive management and/or other assessments demonstrate that 99% species protection is maintained 99% of the time outside of the defined overall PW mixing zone.
Administrative and Procedural Controls	Conduct annual water quality monitoring	No	Shell monitors many aspects of liquid discharge water quality on the Prelude topsides through ongoing online analysers, lab analysis and periodic produced water WET testing and chemical characterisation. Using this information, Shell is able to understand very well with significant conservatism, the likely levels of environmental impacts on the receiving environment from these discharges. Considering Prelude is in its early production years between now and 2025, it is unlikely formation water breakthrough will occur in this time. Until such time as the formation water breakthrough occurs to the Prelude FLNG, there is a high degree of certainty that the impacts to water quality from PFW will be negligible as condensed water which will	N/A	N/A	N/A

[17] The mixing zone distance will be measured from the edge of the FLNG. For example, if discharges are moving along the hull from fore to aft, then it would be measured from the aft (rear) of the FLNG.

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			make up almost 100% of the PFW during this time is pure water with very minor potential hydrocarbon contamination and no other potential contaminants which are not already known (such as use of production chemicals in certain circumstances). In addition, given water quality monitoring is a very time consuming and expensive activity, it is not appropriate to carry out water quality monitoring in field more than once during the 5 year life of this EP given the low risk nature of PFW over this period.			
Administrative and Procedural Controls	'Mixed discharges' WET testing	Yes	The RPS (2019b) modelling assessment shows that the potential cumulative impacts of all liquid discharges released simultaneously are not expected to exceed the predicted impact footprint of the worst-case discharges when assessed in isolation. Given the open offshore location and absence of particularly sensitive or high-value marine ecosystems or habitats at the FLNG location and within the Operational Area, predicted cumulative impacts to water quality are considered slight (Magnitude -1, Sensitivity - L). The results confirmed that in comparison to the PFW WET testing, that there were no additive or synergistic impacts resulting in increased toxicity. Therefore, future WET testing will be undertaken only on the PFW stream and not on the commingled stream. However, given the uncertainty associated with modelling, a mixed discharge WET test will occur to confirm if the modelling is conservative in line with Table 10-8.	7.22	Liquid discharges will be monitored and managed in accordance with Section 10.4.2 to minimise potential environmental risks.	Completed records demonstrate implementation of the FLNG Liquid Discharge Monitoring and Management Procedure
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Shell has adopted a chemical selection and approval process in accordance with Shell's chemical selection and approval guidelines as indicated in Shell Chemical Management Process (HSE_GEN_007879) and Shell Global Product Stewardship guidelines to assess chemicals than may pose environmental impact via planned discharges.	7.5	Chemicals selected for use in accordance with the Shell Chemical Management Process to minimise potential environmental risks.	Records demonstrating the chemical selection process outlined in the Chemical Management

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
						Process have been followed.
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Following the chemical management process as detailed within Section 10.1.10 will minimise the impact of those chemicals which are used and discharged to ALARP levels.	7.6	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have a complete ALARP assessment.	Records demonstrating the chemical selection process outlined in the Chemical Management Process have been followed.
Administrative and Procedural Controls	Maintenance of PW System	Yes	Documented maintenance program is in place for key PW equipment on facilities that provides a status on the maintenance of equipment. Through ongoing maintenance, the operability of the relevant systems and equipment is optimised, reducing the risk of inadequate PW treatment, monitoring and management. Equipment which is critical to maintaining environmental barriers are logged as ECE and are prioritised above all other activities other than safety critical within the Maintenance prioritisation process.	7.24	The following PW related equipment is maintained as per the MMS: • MPPE columns • OIW online monitor • PW Flowmeter.	Maintenance of PW System

Table 9-48: Use and Discharge of Ad-Hoc Chemicals ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	The use of chemicals cannot be eliminated from the operation, preservation and maintenance of the FLNG, subsea facilities and support vessels.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Substitution	Selection of alternate chemical products	Yes	Chemicals planned for discharge have been selected for inclusion based on safety, technical, environmental and commercial performance. The purpose of the review is to formally consider the use of alternative chemicals on an annual basis as part of the Chemical Management Process (Section 10.1.10). If technically sound, lower cost and lower environmental risk chemicals can be identified as possible options for future use, then they will go through the assessment process and be selected for use where practicable. In addition to the annual review, an assessment to consider alternative chemicals may be triggered through the adaptive management framework (Section 10.4.2) as a result of potential changes in chemical additive profiles (Table 10-) such as a requirement to increase chemical concentrations or dosing frequency.	7.25	Annual review of chemicals potentially discharged.	Record of annual production chemical review
Engineering	The subsea facilities are designed to minimise release of fluids to the environment	Yes	Because of the design, only incidental releases during valve actuations, tie-ins and connections and during subsea interventions are expected.	7.26	Subsea actuation valves are maintained per MMS	Records from MMS
Engineering	Equipment to capture or collect subsea discharges	No	No practicable engineering controls are available that are proven to be able to capture or contain subsea discharges. Designing and installing a temporary capture system would result in significant financial costs, with technical uncertainty, grossly disproportionate to any slight increase in environmental benefit of preventing small and infrequent discharges.	N/A	N/A	N/A
Administrative and Procedural Controls	Shell MOC Manual	Yes	Re-processing or onshore disposal of chemically dosed liquids may be a practicable control measure for certain activities or circumstances. This will be	7.27	Ad Hoc/Non-routine discharges with chemical additives are assessed and approved through	Records of completed and approved MOCs

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			assessed on a case-by-case basis and documented accordingly via the MOC process (Section 10.1.9). Any fluid discharges as a result of the activities would be controlled and minimised through the system isolations prior to conducting the activity, thereby limiting the potential discharge volumes to that which is contained within the targeted and isolatable section of the containment vessel. The MOC will detail any isolation steps for the specific components of the system before activities commence to reduce resultant discharge volumes to ALARP.		the Shell MOC Manual prior to release.	
Administrative and Procedural Controls	Infield water quality monitoring of Ad-Hoc, IMR, installation and/or commissioning based discharges	No	Infield water quality monitoring could be used to verify the predicted low risk associated with minor amounts and low frequency of IMR, installation and/or commissioning fluids planned to be discharged to the ocean. Monitoring could not be used to inform adaptive management of these discharges due to their intermittent/infrequent occurrence over short periods (typically minutes to hours). Given the typically low volumes, concentration and frequencies of the discharges and the slight associated residual impacts, it is not considered to be practicable to undertake infield monitoring as the cost (financial and safety) of implementation is grossly disproportionate to any potential further reduction in environmental impact.	N/A	N/A	N/A
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Shell has adopted a chemical selection and approval process in accordance with Shell's chemical selection and approval guidelines as indicated in Shell Chemical Management Process (HSE_GEN_007879) and Shell Global Product Stewardship guidelines to assess chemicals than	7.5	Chemicals selected for use in accordance with the Shell Chemical Management Process to minimise potential environmental risks.	Records demonstrating the chemical selection process outlined in the Chemical

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			may pose environmental impact via planned discharges.			Management Process have been followed.
Administrative and Procedural Controls	Shell Chemical Management Process	Yes	Following the chemical management process as detailed within Section 10.1.10 will minimise the impact of those chemicals which are used and discharged to ALARP levels. All chemicals planned for discharge will be selected, assessed, approved and managed on a case-by-case basis in accordance with the Shell Chemical Management Process to ensure they present the lowest environmental risk practicable. This process is used to demonstrate that the potential impacts of the chemicals selected are acceptable, ALARP and not contrary to this EP, as detailed further in Section 10.1.10. Additionally, non-routine, temporary, ad-hoc and/or contingency chemical discharges associated with the FLNG, subsea facilities or support vessels will also be subject to application of the Shell MOC Manual detailed in Section 10.1.9 as a further control. This will ensure that additional focus is provided on such discharges to ensure they are ALARP, acceptable, optimised and the available alternatives are adequately considered.	7.6	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have a complete ALARP assessment.	Records demonstrating the chemical selection process outlined in the Chemical Management Process have been followed.

9.9.6 Acceptability of Impacts

Table 9-49: Acceptability of Impacts – Discharge of Liquid Effluent

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	Water Quality	No significant impacts to water quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Yes	Liquid discharges have the potential to result in reduced water quality in the immediate vicinity of the discharge location, however discharges will rapidly dilute and disperse in the open ocean environment. Modelling studies indicate impacts to water quality are likely to be highly localised around the discharge locations, which is consistent with industry monitoring studies and demonstrates high confidence in the assessment that ecological integrity, social amenity and human health values will not be significantly impacted. Liquid discharges from the FLNG cannot be avoided. However, the area influenced from routine operational discharges is expected to be limited to within 1 km of the liquid discharge locations. The potential magnitude of impacts to marine ecosystems is slight. Given the offshore location and absence of particularly sensitive marine ecosystems at the FLNG location and immediate surrounds, potential impacts within 1 km of the FLNG are considered acceptable.
	Sediment Quality	No significant impacts to sediment quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Yes	Liquid discharges may result in a slight decrease in sediment quality at locations around the FLNG over a long timeframe (in the order of 10's of years). For the duration of this EP though, elevations of contaminants in sediments surrounding the FLNG will not be detectable with statistical certainty beyond background levels. Therefore, there is high confidence in the assessment that biodiversity, ecological integrity, social amenity and human health values will be protected at all times. Liquid discharges from the FLNG cannot be avoided. However, the area influenced from routine operational discharges is expected to be limited to within 1 km of the liquid discharge locations. The potential magnitude of impacts to marine ecosystems is slight. Given the offshore location and absence of particularly sensitive marine ecosystems at the FLNG location and immediate surrounds, potential impacts within 1 km of the FLNG are considered acceptable.
Biological Environment	Benthic communities	No significant direct impacts to bare sediment benthic habitats as a result of the petroleum activities which adversely effects biological diversity or ecological integrity. No direct impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.	Yes	
	Pelagic communities	No significant adverse effect on pelagic	Yes	Modelling studies indicate that impacts to water quality will be localised around the

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
	(Non-Threatened or Migratory)	communities, populations, habitats or spatial distribution of a species.		FLNG which is characterised as open offshore waters, typical of the offshore Browse Basin. Given the transient nature and absence of important habitat and ecological assemblages of pelagic species, there is high confidence that potential impacts to pelagic communities within a 1 km mixing zone are considered acceptable given there will not be any significant adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.
	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations (Refer to Table 8-1).	Yes	Most threatened and/or migratory fauna species within the area predicted to be influenced by the planned liquid discharges are air breathing vertebrates, which are unlikely to be directly affected as their skin is relatively impermeable and they breathe air. Hence, direct impacts are not considered credible. Non-air breathing species are not anticipated to be present in significant numbers nor be exposed to levels that may adversely impact on individuals and therefore there will be no significant impacts.
	Commonwealth Marine Area	No significant impacts to the Commonwealth Marine Area (Refer to Table 8-1).	Yes	Liquid discharges may result in a slight decrease in water quality in the immediate surrounds of the discharge points and sediment quality at locations around the FLNG over a long timeframe (in the order of 10's of years). For the duration of this EP though, elevations of contaminants in sediments surrounding the FLNG are not predicted to be detectable with statistical confidence beyond background levels and hence remain well below levels known to cause deleterious effects. Therefore, there is high confidence in the assessment that the following relevant significant impact criteria will not be breached: • Substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or • Persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected. Hence, the highly localised impacts predicted from liquid discharges will not credibly exceed the MNES significant impact criteria for the Commonwealth Marine Area as listed in Table 8-1.
Socio-economic	N/A	N/A	N/A	N/A

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
and Cultural Environment				

The assessment of impacts from liquid discharges determined the residual impact consequence of slight for physical environment and biological environment (per Table 9-42). As outlined above, the acceptability of the impacts from liquid discharges associated with the petroleum activity have been considered in the context of:

Principles of ESD

The impacts from liquid discharges are consistent with the principles of ESD based on the following points:

- The environmental receptors within the Operational Area and defined mixing zones are not expected to be significantly impacted; and
- The precautionary principle has been applied, and studies (e.g. modelling assessments, WET testing, literature reviews and statistical data analyses) undertaken where knowledge gaps were identified.

Relevant Requirements

Management of the impacts from liquid discharges are consistent with relevant legislative requirements, including:

- Compliance with international maritime conventions, including:
  - MARPOL:
    - Annex I: regulations for the prevention of pollution by oil
    - Annex II: regulations for the control of pollution by noxious liquid substances in bulk
    - Annex III: regulations for the prevention of pollution by harmful substances carried by sea in packaged form, and
    - Annex IV: regulations for the prevention of pollution by sewage from ships
    - Annex V: (regulation for the prevention of pollution by garbage from ships).
- Compliance with Australian legislation and requirements, including:
  - Navigation Act 2012 and Protection of the Sea (Prevention of Pollution from Ships) Act 1983:
    - Marine Order 91 (Marine pollution prevention – oil)
    - Marine Order 93 (Marine pollution prevention – noxious liquid substances)
    - Marine Order 94 (Marine pollution prevention – packages harmful substances)
    - Marine Order 95 (Marine pollution prevention – garbage)
    - Marine Order 96 (Marine pollution prevention – sewage).
- Management of impacts and risks are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (Table 9-50)

- Implementation of recognised industry standard practice, such as:
  - Treatment of PW to the defined limit of 30 mg/L daily average exceeds the performance recommended by the IFC EHS guidelines for Offshore Oil and Gas Development (2015) where discharge to sea is allowed if oil and grease content does not exceed 42 mg/L daily maximum, i.e. mean level for any given day in the month assessed does not exceed 42 mg/L.
  - Treatment of collected drainage bilge water to < 15 mg/L residual oil.
  - IFC (2015) standard for water temperature which requires that the effluent should not result in a temperature increase of greater than 3°C compared to the ambient temperature at the edge of a defined mixing zone (100 m in this EP).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of liquid discharges impacts indicates significant impacts to threatened and migratory species will not credibly result from the liquid discharges aspect of the Prelude petroleum activities.

Alignment of the Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-50.

Commonwealth Marine Area

The impacts and risks from the liquid discharges aspect of the Prelude field on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 9-50.

Table 9-50: Summary of Alignment of the impacts from the Liquid Discharges Aspect of the Prelude Petroleum Activities with Relevant Requirements for MNES

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species Table 8-1)	The application of the Shell Chemical Management Process and proposed management controls for liquid discharges reduces the impact of toxic pollutants being introduced into and/or persisting in the marine environment. An environmental monitoring adaptive management program has been developed for liquid discharges as described in Section 10.4.1. This program will seek to demonstrate that the actual levels of recorded impacts for key discharges do not exceed those which were predicted within the impact assessment presented in this EP. If recorded impact levels do exceed those described, this would trigger the adaptive management process and assessment under the Shell MOC Manual (Refer to Section 10.1.9)
	Conservation advice on Balaenoptera borealis (sei whale) (DoE 2015c)	
	Conservation advice fin whale (Balaenoptera physalus) (DoE 2015d)	
	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017a)	
	Conservation advice on Rhincodon typus (whale shark) (DoE 2015e)	

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Wetlands of International Importance	N/A	N/A
Commonwealth Marine Area	Significant impact guidelines for Commonwealth marine environment (Table 7-3)	Water quality impacts by planned liquid discharges are expected to be limited to within 1 km of the FLNG for all collective discharge streams. Impacts confined within this area are not considered to be significant in the context of the significant impact criteria for the Commonwealth Marine Area given the nature and scale of the impacts and the characteristics of the local receiving environment (open offshore waters with regionally well represented soft and bare sandy sediments). The impact assessment indicates the impacts associated with the discharge of liquid discharges will not result in a significant adverse impact on marine ecosystem functioning/integrity, social amenity or human health. Shell has sought to reduce potential impacts through the selection and implementation of the controls and EPSs listed in Section 9.9.5.

External Context

There have been no objections or claims raised by Relevant Persons in preparation of this EP around the liquid discharges aspect. Shell's ongoing consultation program will consider objections and claims made by stakeholders when undertaking further assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from liquid discharges determined the residual impacts rankings were slight or lower (Table 9-42). As outlined above, the acceptability of the impacts have been considered in the context of:

- The established acceptability criteria for the liquid discharges aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the liquid discharges aspect.

The evaluation above in section 9.9.2 and 9.9.3 provide high confidence that any cumulative liquid discharge impacts within 1 km of the FLNG facility will afford sufficient and acceptable ecological protection.

Based on the points discussed above, Shell considers the impacts from liquid discharges associated with the Prelude project to be acceptable.

9.9.7 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No significant impacts to water quality from liquid discharges from the Prelude asset.	Demonstrated implementation of EPSs for discharge of liquid effluents
No impacts to sediment quality from liquid discharges from the Prelude asset.	
No impact to water quality beyond 1 km from liquid discharges from the Prelude asset.	
No impacts to any KEFs surrounding the Prelude FLNG.	
No injury or mortality of listed Threatened or Migratory MNES species as a result of discharge of liquid effluent.	
No impacts to coral reefs occurring at Browse Island or nearby Shoals (Echuca/Heywood).	

9.10 Atmospheric Emissions

9.10.1 Aspect Context

Emissions of atmospheric pollutants (e.g. nitrogen oxides, sulphur oxides, carbon monoxide and particulate matter (PM, PM_{10} and $PM_{2.5}$), air toxics which includes mainly volatile organic compounds (VOCs) (e.g. benzene, toluene, ethylbenzene, xylenes (BTEX), formaldehyde, etc) and other harmful to human health gases (e.g. hydrogen sulphide) have the potential to impact local and regional air quality. The list of sources of such emissions for Prelude FLNG include:

- Combustion of fuel for power generation
- Flaring of hydrocarbon for process safety purposes
- Venting of reservoir carbon dioxide
- General leaks
- Combustion of fuel for transportation purposes – e.g. vessels supporting FLNG operations.

Sources of internal combustion emissions in the Operational Area include:

- Propulsion and electricity generation engines on marine vessels and helicopter operations supporting Prelude. Operations support marine vessels include dedicated supply vessels, infield support vessels/ pilot tugs and campaign specific vessels (e.g. Inspection, Maintenance and Repair vessels).
- Propulsion and electricity generation engines of LNG, LPG and condensate carriers.

- The seven (7) 200 MW Marine Boilers on Prelude can operate on fuel gas or diesel. In normal operations, the boilers run on fuel gas in a 6 + 1 configuration. The boilers produce high pressure steam which is routed to the process for heating or to the steam turbine generators (STGs) for power generation and low pressure steam production.
- The three (3) Essential 7.68 MW Essential Marine Diesel Generators (EDGs) providing power for black start operations and to bring the process to a safe condition during any major power upsets and supply essential power consumers in the event of a complete plant shutdown. These are offline during normal operations and has a sparing philosophy of 2+1.
- The two (2) SOLAS (safety of life at sea) designated Emergency Diesel Generators (EMGs) (1 x 1250 KW and 1 x 750 KW) which supply electricity to SOLAS critical equipment (e.g. control and safety systems, navigational aids, fire-fighting pumps, etc.). These are offline during normal operations.
- Additional sources of internal combustion emissions over the life of the facility and field include accommodation support vessel(s) during maintenance shutdowns and additional vessel visits supporting these campaign events. These will occur periodically and result in additional emissions for the duration of the campaign.

Flaring emissions include the following point sources:

- Warm Wet High-Pressure Flare (FWH Flare) (A-63001)
- Cold Dry High-Pressure Flare (FDH Flare) (A-63002)
- Cold Dry Low-Pressure Flare (FDL Flare) (A-63003)
- Warm Wet Low-Pressure Flare (FWL Flare) (A-63004).

The expected emissions from combustion emission sources are shown in Table 9-51.

Table 9-51: Expected Gaseous Emissions from Combustion Sources of the FLNG

System	Flowrate of Discharge	Composition of Discharge
HP steam (marine) boilers A-40010~70 (6+1) (running with fuel gas)	1 360 000kg/h	N_2 – 71.40 %wt H_2O – 10.86 %wt O_2 – 2.17 %wt CO_2 – 14.46 %wt NO_x – 240mg/Nm^3 SO_x – NA PM – 50mg/Nm^3
HP steam (marine) boilers A-40010~70 (for one boiler running with marine diesel at 100% load)	266 000kg/h	N_2 – 73.20 %wt H_2O – 5.5 %wt CO_2 – 19.14 %wt O_2 – 1.95 %wt NO_x – 400mg/Nm^3 SO_2 – 1500mg/Nm^3 PM – 50mg/Nm^3
3 Essential generators 7.68 MW Marine Diesel Generators	168 000kg/h	CO_2 – 8.24 %wt CH_4 – 5.67E-04 %wt N_2O – 7.68E-05 %wt CO – 4.71E-02 %wt NO_x – 2.14E-01 %wt SO_x – 1.05E-01 %wt PM – 6.14E-03 %wt TVOC – 5.43E-03 %wt
1250kW SOLAS designated Emergency diesel generator	9010kg/h	NO_x – 0.21 % wt CO_2 – 8.00 %wt

		CO – 0.05 %wt SO_2 – 0.10 %wt PM_{10} – 0.01 %wt
750kW SOLAS designated Emergency diesel generator	5406kg/h	NO_x – 0.21 % wt CO_2 – 8.00 %wt CO – 0.05 %wt SO_2 – 0.10 %wt PM_{10} – 0.01 %wt

Note:1. PM = Particulate Matter
2. PM_{10} / $PM_{2.5}$ = Particulate Matter with aerodynamic diameter less than 10 microns or 2.5 microns respectively

The additional air emissions from the accommodation vessel and broader turnaround activities are intermittent, temporary in duration and will comprise a minor and immaterial addition to the overall air emission profile for the Prelude FLNG and are therefore not assessed any further in this section.

The environmental basis of design (2000-110-G000-GE00-G00000-HX-7704-62001_05A_1) for Prelude outlined that vents were designed to meet the recommendations for Good International Industry Practice (GIIP) for Natural Gas Processing Plants and the requirements from the Integrated Pollution and Control (IPPC) Reference Documentation on Best Available Techniques for Mineral Oil and Gas Refineries. These guidelines require that in all vents the VOC content is <150mg/Nm3 for a continuous vent and <10g/Nm3 for a non-continuous vent. During design, the acid gas vent (A63008) had been identified as exceeding the 150mg/Nm3 limit. The design document stated exceeding is acceptable if ALARP.

As a participating organisation to The World Bank Global Gas Flaring Reduction (GGFR) Partnership, Shell Group has committed to the Zero Routine Flaring by 2030 initiative. Although this initiative is focused on oil producing assets with associated gas, Shell adopted this philosophy in the environment basis of design applying a ‘no flaring or venting’ of hydrocarbon streams principle. This principle states that for any source resulting in more than 1000 tpa of GHG production, no continuous feed to flare or vent should be included in the design unless flaring or venting is specifically required for safety reasons. If flaring or venting is required for safety reasons an ALARP justification was developed.

Flaring on Prelude is designed to be smokeless in accordance with the requirements outlined in Shell Design Engineering Practice (DEP) 80.45.10.10 (2012). This document outlined that:

- FWH Flare: Smokeless for operational case, Start-up and Shutdown;
- FDH Flare: Smokeless for operational and EDP case (not simultaneous with operational case);
- FDL Flare: Not smokeless as relief gas content is mostly methane; and
- FWL Flare: Not smokeless (emergency events).

Under routine operating conditions and without any process upsets or passing valves, the flares burn a small stream of fuel gas intended to maintain flares lit at all times (i.e. fuel gas to flare pilots). This stream is estimated at ~2000 kg/h in total for all Prelude flares. The fuel gas to maintain flare pilots and any flaring considered necessary to address safety concerns does not constitute routine flaring as defined by the GGFR Partnership. The key pollutant emissions from flaring include NO_x, SO_x, CO, $PM_{2.5}$ and PM_{10}, as well as air pollutants such as benzene, toluene and formaldehyde (VOCs).

Removed reservoir carbon dioxide (acid gas) is disposed continuously through the dedicated Prelude acid gas vent whilst the facility is producing. Per the base case design, the acid gas composition consists of more than 98% CO_2, with the remainder, being minor quantities of CH_4, H_2S and BTEX (benzene, toluene, ethylbenzene and xylenes). However, feed gas sample testing performed in August 2020 showed no traces of BTEX in Prelude's feed gas with almost negligible quantities of H_2S. As pollutants in the feed gas are lower than the base case design, the emissions profile is expected to have less impact than originally modelled.

Sources of volatile organic compounds (VOC) emissions include condensate loading operations and fugitive emissions / general leaks.

Condensate loading operations, scheduled to occur once every two weeks, will initially result in emissions of inert gases (CO_2 and N_2) displaced from the condensate offtake tanker's cargo storage tanks by the loaded condensate liquid and in the later stages of loading, emissions of volatile organic compounds (VOCs) evolving from the condensate itself and emitted via the tanker deck vent(s). Fugitive emissions from the FLNG are expected to be occasional only, minor in volumes and dispersed in location.

The design standard pollutant concentrations for the steam boilers as compared to actual emissions from stack testing results are summarised in Table 9-52 below. Notably, the measured concentrations of NO_x and PM for boilers running on fuel gas were well below the original design standards.

Table 9-52: Measured Emission Rates for the HP Steam Boilers at FLNG

Combustion Source	Average Dry Standard Stack Flow Rate per boiler (Nm^3/min)	Average Measured during Sep 2019 Stack Test	Design Standards or Predicted Design Levels[18]
Steam boilers A-40010 to A-40070 (running on fuel gas)	3,508	NOx – 147mg/Nm^3 SO_2 – 1.2mg/Nm^3 PM – 3.3mg/Nm^3	NOx -240mg/Nm3 SOx - Not applicable[19] PM -50mg/Nm3
Steam boilers A-40010 to A-40070 (running on diesel)	3,629	NOx – 269mg/Nm^3 SO_2 – 1.2mg/Nm^3 PM – 2.3mg/Nm^3	NOx- Not applicable. SOx - Fuel used shall be maximum 1000ppm PM – Not applicable

There are no emissions monitoring ports available on the essential and emergency power generation systems, therefore no air monitoring results for these systems available. However, these other power systems are designed to meet MARPOL annex VI specifications as a minimum. Project specifications for these systems included:

- For NO_x, a marine diesel greater than 130KW constructed between 2011 and 2016:
  - g/kWh = 45*n-0.2
  - (n<130rpm) g/kW = 17

[18] Values sources from Prelude Environment Basis for Design 2000-110-G000-GE00-G00000-HX-7704-62001

[19] Meaning no project design specification was put in place for this parameter.

  - (n>2000rpm) g/kW = 9.8
  - Note – N = rated engine speed (crankshaft RPM)
- For SO_x, 1000ppm Sulphur content of fuel
- For PM, Not applicable.

Whilst the boilers will be operational at all times when the facility is producing, the essential and emergency diesel generators will be used only in the event of planned/unplanned and emergency non-routine operations and when tested as integrity-critical equipment. The volumes of flared gas will also fluctuate above the baseline flaring rates (i.e. pilot gas only) as a result of potential process upsets and plant shutdowns and restarts. Acid gas venting will occur continuously whilst producing; however, the rates and composition of the gas may change depending on the feed gas composition.

A representative atmospheric pollutant and air pollutants inventory has been compiled using production and mass balance data for the highest expected production year and is presented in Table 9-53. Since emissions data has been estimated using a combination of vendor emission guarantees where available and NPI and US EPA AP-42 emission factors, as well as assumptions about production rates and facility uptime for that year, the quoted numbers should be viewed as an order of magnitude estimate only. Furthermore, emission rates provided in 2021-2025 planning range tend to have negligible maximum Ground Level Concentration (GLC) when screening assessments such as USEPA SCREEN are used. Table 9-55 has been developed to indicate conservative values (based on emission inventory during design) for the purpose of the screening assessment. The screening assessment indicates that even when the emission rates are set to conservative values, the predicted maximum Ground Level Concentration (GLC) are within prescribed Ambient Air Quality Limits (AAQ) at identified receptors (FPSO@17km and Browse Island@40km). Hence, Table 9.55 values form an appropriate basis for the screening assessment using USEPA SCREEN approach.

During normal operation, the boilers are designed to be running on fuel gas with six or seven boilers being online. During abnormal (emergency or upset) conditions, Prelude is designed to have a maximum of two boilers online as the boilers are not used to continue production but rather provide sufficient electricity to power emergency systems and basic utilities. In these situations, the boilers may run on fuel gas or diesel depending on whether the warm end of the facility has been shut down. If boilers are unable to run, the facility may run entirely on EDGs for small periods of time until the boilers can be operationalised.

Air emissions predicted in the Prelude Environmental Impact Assessment included a total NO_x – 2,278 tpa and VOC – 1,799 tpa. The estimates provided below provide a more detailed prediction of air emissions ranges which could be expected over the next 5 years of operations which will likely include the peak production year in the latter half of the forecast range (2023/2024).

There was no feed gas throughput during 2018 NPI reporting year, and therefore no emissions associated with boiler fuel gas combustion, acid gas venting, or fugitive general leaks. The majority of emissions in 2020 were associated with diesel combustion for electricity production used for lighting or motive purposes (producing physical or mechanical motion). Electrical motive equipment includes pumps, fans compressors, conveyor belts etc. Electrical non-motive equipment includes arcing furnaces, heaters, ovens etc.).

Table 9-53: Prelude FLNG Atmospheric Emissions Inventory

2020 NPI Air Emissions Actuals			**Emissions Rates (tonnes/a)**				
#	**Emission Source**	**Approx. Fuel Consumption Rate (tonnes/a)**	**NO2**	**SO2**	**CO**	**PM**	**VOC**
1	Steam Boiler (Fuel Gas)	160,000	565	0.5	80	24	18
2	Steam Boiler (Diesel)	19,000	50	0	12	0.5	0.5
3	Essential Diesel Generators	3,500	174	0	46	5	4
4	Flaring	300,000	412	0	2,391	16	4,122
5	Acid Gas Vent	200,000	0	0	0	0	0
6	Fugitive Emissions	200	0	0	0	0	37
	Total		1,201	0.5	2,529	45.5	4,181.5
2019 NPI Air Emissions Actuals			**Emissions Rates (tonnes/a)**				
#	**Emission Source**	**Approx. Fuel Consumption Rate (tonnes/ a)**	**NO2**	**SO2**	**CO**	**PM**	**VOC**
1	Steam Boiler (Fuel Gas)	200,000	594	4	182	14	8
2	Steam Boiler (Diesel)	50,000	281	1.2	78.9	2.4	1.8
3	Essential Diesel Generators	500	10	4.8	2.1	0.3	0.2
4	Flaring	600,000	900	0	5220	33.6	9000
5	Acid Gas Vent	1,000	0	0	0	0	20
6	Fugitive Emissions	100	0	0	0	0	100
	TOTAL		1785	10	5483	50.3	9130
2018 NPI Air Emissions Actuals			**Emissions Rates (tonnes/a)**				
#	**Emission Source**	**Approx. Fuel Consumption Rate (tonnes/ a)**	**NO2**	**SO2**	**CO**	**PM**	**VOC**
1	Steam Boiler (Fuel Gas)	0	0	0	0	0	0
2	Steam Boiler (Diesel)	66,313	180	1.2	45.1	11.2	1.8
3	Essential Diesel Generators	2,621	164	0	43.8	10.2	4.1
4	Flaring	4,705	7	0	40.9	0.6	70.5
5	Acid Gas Vent	0	0	0	0	0	0
6	Fugitive Emissions	0	0	0	0	0	0
	TOTAL		351	1.2	129.8	22	76.4

Emissions Rates (tonnes/a)		2021 – 2025 business planning forecast range					

#	Emission Source	Approximate Fuel Consumption/Venting Rate 2020 – 2025 (tonnes/annum)	NO_2 t/pa	SO_2 t/pa	CO t/pa	PM t/pa	VOC t/pa
1	Steam Boilers (Fuel Gas)	130,000 - 760,000[20]	478 – 2,797	3 - 18	68 - 395	21 - 122	16- 90
2	Steam Boilers (Diesel)	5,000 - 15,000[21]	14 - 41	0.1 – 0.3	3 - 10	0.7 – 2	0.1 – 0.4
3	Essential Diesel Generators	200 – 1,000[22]	13 - 63	0.004 – 0.02	3 - 17	0.4 - 2	0.3 - 2
4	Flaring	180,000 - 370,000[23]	270 - 555	-	1,566 – 3,219	21- 42	2,700- 5,550
5	Acid Gas Vent	175,000 – 725,000[24]	-	-	-	-	-
6	Fugitive emissions (general leaks)	10,000 - 60,000[25]					1955 – 11,730

Table 9-54: Range of utilisation days per year from planning assumptions of emissions forecasts in 2019

Range of Utilisation Days Per Year in Planning Assumptions in Emission Forecasts (2019)			
Year	On Stream Days	Off Stream Days	Turnaround Days
2020	104 - 229	136-261	0
2021	195 - 261	104-170	50[26]
2022	294 - 315	50-71	0
2023	278 - 295	70-87	36
2024	310 - 328	37-55	0
2025	224 - 245	66-87	54

Notes: Boiler emissions were estimated based on the October 2019 Stack Testing Results. Other emission rates were based on NPI default values and design datasheets.

The inventory indicates that emissions from the Prelude FLNG are comparable in magnitude to emissions from other oil and gas facilities, specifically the INPEX Ichthys

[20] During normal operations and highest expected production year, the consumption/venting rate will be on the high side.
[21] During normal operations the consumption/venting rate will be on the low side.
[22] During normal operations the consumption/venting rate will be on the low side.
[23] During normal operations and highest expected production year, the consumption/venting rate will be on the low side.
[24] During normal operations and highest expected production year, the consumption/venting rate will be on the high side.
[25] During normal operations and highest expected production year, the consumption/venting rate will be on the high side.
[26] In the business planning process for 2020, the planned shutdown for 2021 has been rescheduled to 2022.

FPSO (Inpex Browse Ltd, 2008). Emissions from Prelude FLNG and the Ichthys FPSO and supporting marine vessels contribute to pollutant levels in the local marine environment airshed. The impacts of these combined emission sources on the air quality of the airshed has been examined in a screening air quality modelling study and is discussed in section 9.10.2 below.

9.10.2 Description and Evaluation of Impacts

Based on a conservative, screening-level assessment, maximum predicted concentrations of combustion-related pollutants at identified receptors and attendant ambient air quality impacts associated with the Prelude FLNG facility are concluded to be of low magnitude. The maximum predicted concentrations of NO_x, SO_2 $PM_{2.5}$,CO and VOC at Browse Island are well below the associated ambient air quality standards for all the scenarios examined.

Ambient air quality impacts were assessed based on a comparison with human health-based standards. Air emissions from the Prelude FLNG facility will lead to increased deposition of NO_x, SO_2 and $PM_{2.5}$ on the water surface and potential impacts on seawater and seabed sediments and other habitats for aquatic vegetation. However due to the low levels of the contaminants, expected water column dilution and buffer capacity of sea water, it is unlikely that deposition emissions will cause a change in acidity/basicity (pH) to the extent that marine life is affected.

In addition to the above study, modelling of the emissions from the FLNG was done for safety and occupational health purposes to assess potential impacts to workers aboard the FLNG facility. These modelling studies include the following:

- Atmospheric Dispersion Study Report (2000-110-G000-GE00-G00000-HX-7180-62101) determined if there is any occupational health and environmental impacts from long term point source emissions: boiler exhaust during normal operations.
    - CO_2, H_2S and SO_2 health requirements are met in all cases for both working and residential areas.
    - NO_2 occupational limits (in working areas, i.e. process decks and LERs) are also not exceeded.
- Flare Flame-Out and Venting Atmospheric Dispersion Study (2000-110-G000-GE00-G00000-HX-7180-19163) which was carried out to assess extent of hazard associated with gas dispersion with regards to flammable and toxic risks from the flare and vent sources.
    - It is confirmed that the vents and flares height/ location is found to be safe to avoid any flammable or toxic impact on the facility.
- PEPCI FLNG Atmospheric Dispersion Study (2000-110-G000-GE00-G00000-HX-7180-62101) modelled the safety and health impacts of the emissions from the boilers when running using diesel during the hook-up and commissioning phase.
    - The issue of NO_x is prevalent only when boilers and EDG are running on diesel fuel. During this time, the 1 hr residential limits are exceeded for a short percentage of time, but the occupational health limits are not exceeded.
    - Prelude uses low sulphur diesel, therefore any concern associated with SO_x has been eliminated.

The occupational health modelling results indicate that the emissions will not result in health and safety issues within the FLNG process area and living quarters. This provides further evidentiary support that emissions from the facility are not likely to impact environmental sensitive receptors further afield.

Given the above studies, no adverse environmental effects are anticipated and the associated impacts are expected to be slight, therefore the residual risk is assessed to be low.

Given the offshore remote context, environmental sensitivities that may be impacted by emissions of atmospheric pollutant include only the physical environment (air quality and visual amenity). No impacts on the socio-economic and cultural environment are reasonably foreseeable. Impacts on the physical environment can be summarised as:

- Planned emission of atmospheric pollutants to Prelude airshed under routine and non-routine (planned and emergency) operating conditions
- Routine and non-routine flaring resulting in smoky flare and impact on visual amenity.

Occupational health effects associated with emissions of air pollutants are excluded from the scope of the EP and covered in the Prelude Safety Case and supporting occupational health management program and procedures. These have been extensively modelled in the design phases of the Project and mitigated through design and operating procedures.

Physical Environment

Air Quality

A screening level air dispersion modelling assessment for NO_X, SO_2, $PM_{2.5}$, CO and VOC emissions was undertaken for the Prelude FLNG facility based on a conservative approach using the US EPA SCREEN3 model. Three different operating scenarios were examined: Normal Operations, Exceptional Case, and Worst Reasonable Exceptional Case.

Maximum predicted ground-level concentrations were predicted at distances of 17 km and 40 km from the Prelude FLNG representing the locations of the nearby Ichthys FSPO facility and Browse Island respectively, and compared to the Australian Ambient Air Quality Standards (AAQS)[27] for NO_2, SO_2, $PM_{2.5}$ and CO. As the AAQS does not list criteria for VOC this parameter was compared against criteria referenced in Oman Air Quality Protection Note (AQP)[28]. The modelling results indicated that ground-level concentrations of NO_2, SO_2, $PM_{2.5}$,CO and VOC at these distances were predicted to be well below the AAQS and AQP note. As a result, ambient air quality impacts associated with the Prelude FLNG facility were concluded to be of low magnitude.

Deposition levels could not be estimated using the screening modelling approach. Intensity of deposition and local mixing conditions will determine whether temporary, local pH changes are likely to occur. However due to the expected water column

[27] National Environment Protection Measure for Ambient Air Quality (the 'Air NEPM'). Australian Department of the Environment.

[28] Air Quality Protection Technical Note: https://www.duqm.gov.om/upload/files/air-quality-protection.pdf

dilution and buffer capacity of sea water it is unlikely that deposition emissions will cause a significant change in pH affecting marine life.

Modelling Scenarios and Inputs

Three (3) different operating scenarios were considered as follows:

- Normal Operations Case:
  - 6 Boilers running on natural gas.
- Exceptional Case:
  - 3 Boilers running on diesel;
  - 2 Essential Diesel Generators;
  - Wet HP Flare: 30% of gas feed.
- Worst Reasonable Exceptional Case:
  - 5 Boilers running on diesel;
  - 2 Essential Diesel Generators;
  - Wet HP Flare: 50% of gas feed.

As opposed to the Normal Operations case, the Exceptional and Worst Reasonable Exceptional Cases are intermittent and associated with commissioning, start-up and shut down conditions.

Model input data such as stack height, diameter, exit velocity, and emission rates were compiled from design data and previous modelling assessments, or calculated based on available information . Modelling input values used from design documents are more conservative than the values for relevant cases outlined in Table 9-53. Modelled emissions included combustion-related emissions from the above sources:

- Nitrogen oxides (NO_x);
- Sulphur dioxide (SO_2), ;
- Particulate Matter less than 2 microns aerodynamic diameter ($PM_{2.5}$).
- Carbon Monoxide (CO);
- Volatile Organic Compounds (VOC's)

A summary of modelling inputs for the FLNG emissions is provided in Table 9-55 Input parameters for Air Modelling have been compared from the previous study (2016) with the latest study (2020) for easy reference (additional pollutants such as CO and VOC are included in 2020). Note that in the latest study (2020), site specific monitored emissions data have been used where possible (e.g. Boilers Stack Monitoring Data).

Table 9-55: Air Modelling Inputs[29] (on a per stack basis)

Source	Stack Ht (m ASL)	Stack Diameter (m)	2016 Study						2020 Study							
			Exit Velocity (m/s)	Exhaust Temp (K)	Gross Heat Release Rate (10^6 cal/s)	NO_x (kg/hr)	SO_2 (kg/hr)	$PM_{2.5}$ (kg/hr)	Exit Velocity (m/s)	Exhaust Temp (K)	Gross Heat Release Rate (cal/s)	NO_x (kg/hr)	SO_2 (kg/hr)	$PM_{2.5}$ (kg/hr)	CO (kg/hr)	VOC (kg/hr)
Boilers NG	94	2.8	11.6	453	-	33	0	6.8	21.12	365.29	NA	41.9	0.004	0.012	0.215	0.007
Boilers Diesel	94	2.8	15.2	468	-	56	293	12	21.25	427.15	NA	77.5	0.004	0.009	0.363	0.007
Diesel Generators	94	1	35.6	638	-	22	12	3.4	21.25	427.15	NA	154.9	0.008	0.017	0.726	0.014
Wet HP Flare 30%	147	-	-	-	630	77	9.1	26	-	-	1.82E+08	442.4	43.5	-	2565.7	4423.6
Wet HP Flare 50%	147	-	-	-	1054	129	15	44	-	-	3.04E+08	737.3	72.5	-	4276.2	7372.7

[29] Sources:

- Prelude EPCI Floating LNG Project, Gaseous Effluent List. TSC, 2011
- Prelude EPCI Floating LNG Project, Atmospheric Dispersion Study Report. TSC, 2012.
- Prelude EPCI Floating LNG Project , Flare Flame-Out and Venting Atmospheric Dispersion Study. TSC, 2013
- Physical dimensions of stack are from relevant engineering documents (in line with 2016 study).

Model results were extracted for two (2) specific receptors distant from the Prelude FLNG facility:

- Nearby facility (FPSO of other operator), 17 km.
- Browse Island, 40km.

Maximum predicted concentrations at the two identified receptors scenarios are provided in Table, Table 9-57 and Table 9-58. The results show that the maximum predicted concentrations at the identified receptors are well below the associated ambient air quality standards for all the scenarios examined. As noted, once steady state operations are reached, normal operations maximum scenario is expected the vast majority of time, whilst the exceptional case maximum scenario is expected to occur seldomly each year and the worst reasonable exceptional case scenario is considered very rare and unlikely to occur during the life of the facility.

Table 9-56**:** Normal Operations Maximum Predicted Concentrations

		FPSO (17km)		Browse Island (40km)		AAQS	
		(ppm)	(ug/m3)	(ppm)	(ug/m3)	(ppm)	(ug/m3)
NO_2	1hr	0.002	5.0	0.002	3.60	0.12	246
	Annual	-	0.4	-	0.29	0.03	62
$PM_{2.5}$	24hr	-	-	-	-	-	25
	Annual	-	-	-	-	-	8
CO	8hr	-	0.02	-	0.01	9	-
VOC	3hr	-	0.001	-	0.001	0.24	160

Table 9-57**:** Exceptional Case Maximum Predicted Concentrations

Pollutant	Ave. Time	FPSO (17km)		Browse Island (40km)		AAQS	
		(ppm)	(ug/m3)	(ppm)	(ug/m3)	(ppm)	(ug/m3)
NO2	1hr	0.01	17	0.006	11.29	0.12	246
	Annual	0.001	1.36	0.00	0.96	0.03	62
SO2	1hr	0.001	4.27	0.001	2.27	0.2	571
	24hr	0.001	1.71	0.00	0.91	0.08	228
	Annual	0.00	0.34	0.00	0.18	0.02	57
PM2.5	1hr	0.00	0.06	0.00	0.03	-	25
	Annual	0.00	0.00	0.00	0.00	-	8
CO	8hr	0.013	15.76	0.009	11.19	9	-
VOC	3hr	0.011	34.49	0.008	24.55	0.24	160

Table 9-58**:** Worst Reasonable Exceptional Case Maximum Predicted Concentrations

Pollutant	Ave. Time	FPSO (17km)		Browse Island (40km)		AAQS	
		(ppm)	(ug/m3)	(ppm)	(ug/m3)	(ppm)	(ug/m3)
NO2	1hr	0.01	22.11	0.008	16.15	0.12	246
	Annual	0.001	1.77	0.001	1.29	0.03	62
SO2	1hr	0.002	4.34	0.001	2.31	0.2	571
	24hr	0.001	1.73	0.00	0.92	0.08	228
	Annual	0.00	0.35	0.00	0.18	0.02	57
PM2.5	24hr	-	0.02	-	0.01	-	25
	Annual	0.00	0.00	0.00	0.00	-	8
CO	8hr	0.01	18.68	0.015	12.94	9	-
VOC	3hr	0.01	40.90	0.008	28.40	0.24	160

In addition, a cumulative screening assessment for the Prelude FLNG facility in combination with the Ichthys offshore facility with Browse Island as receptor has been undertaken. In order to combine the concentrations from Prelude and Ichthys, it was conservatively assumed that Ichthys is located 17 km downwind and in the direct trajectory between Prelude and Browse Island (see Figure 9-20).

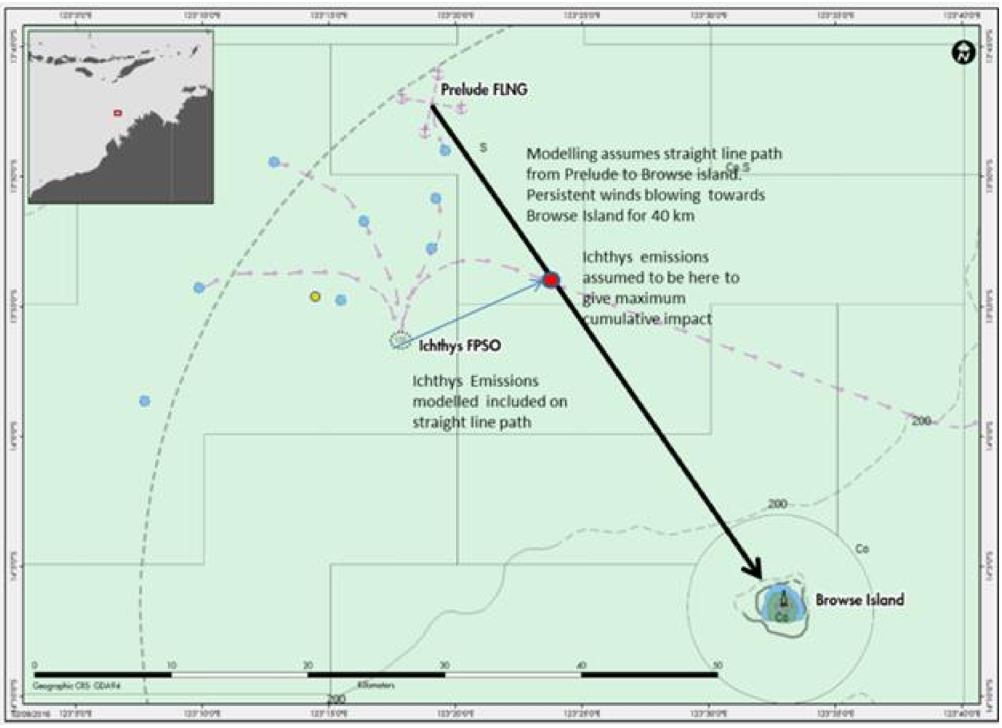


Figure 9-20: Area Map and Modelled Emission Locations

Emissions from the Ichthys project is referenced from the Ichthys EIS which provides an aggregated total of emissions from the offshore facilities. The air emissions data identified in the publicly available EIS is as follows:

Table 5-1: Estimated annual combustion emissions from routine operations of the Ichthys Project

	Ichthys Project emissions* (t/a)	
Air emission	Offshore facilities	Onshore processing plant
NO_x (as NO_2)	5000	2700
CO	5800	Not calculated
SO_x (as SO_2)	16	950
CH_4	8500	10 500
PM_{10}†	Not calculated	150
VOCs	1100	500

* Values are based on normal operating conditions and do not include fugitive or vented emissions.

† PM_{10} from dust is not included in this calculation because quantification of a non-point-source emission is difficult.

Figure 9-21: Excerpt from Ichthys EIS Report indicating emissions volumes

As can be seen above, Ichthys did not report any $PM_{2.5}$ emissions from offshore facilities.

Based on a review of the EIS it is expected that gas powered turbines are the major source of air emissions from the offshore facilities. The EIS does not provide further information on number of generators, how many are located at each facility, nor other sources of information required for detailed air modelling such as stack dimensions, exhaust exit velocity, etc.

Therefore, the source characterization for the emissions from the Ichthys facility has been based on surrogate offshore FPSO facility, and assumes that all emissions are coming from gas turbines (GTs). Due to the lack of detailed information a simplified assumption of all emissions being discharged from one common stack was applied. This is both a simplified and conservative approach to modelling.

Table 9-59 below provides the values used to represent the source characterisation for the Ichthys facility. Input parameters for Air Modelling have been compared from the previous study (2016) with the latest study (2020) for easy reference.

Table 9-59: Ichthys Air Modelling Inputs

Source	Stack Ht (m ASL)	Stack Diameter (m)	2016 Study						2020 Study							
			Exit Velocity (m/s)	Exhaust Temp (K)	Gross Heat Release Rate (10^6 cal/s)	NO_x (kg/hr)	SO_2 (kg/hr)	$PM_{2.5}$ (kg/hr)	Exit Velocity (m/s)	Exhaust Temp (K)	Gross Heat Release Rate (cal/s)	NO_x (kg/hr)	SO_2 (kg/hr)	$PM_{2.5}$ (kg/hr)	CO (kg/hr)	VOC (kg/hr)
FPSO (for cumulative assessment)	58	2.54	30	800	-	570.6	1.8	-	30	800	-	570.6	1.8	-	661.9	125.5

Note: FPSO data is from published EIS (in line with 2016 study)

The screening level assessment was conducted using the SCREEN model (version 13043). SCREEN is the US EPA recommended screening model developed based on AERMOD[30].

SCREEN is a Gaussian plume, steady state model; it assumes constant meteorology and predicts instantaneous concentrations over the modelling domain. For this assessment the model was run with the standard meteorological data set which represents all possible conditions, with the output of a maximum prediction concentration associated with the worst-case weather condition scenario. A review of the maximum predicted concentrations for this assessment indicates that the highest values are associated with low wind speeds of ≤ 1 m/s. Figure 9-22 provides wind speed measurements at Prelude for the 2000-2006 time period. As can be seen, the frequency of occurrence of low wind speeds of ≤1 m/s occur <1% of the time. Therefore, the chance of the highest predicted concentration occurring is low.

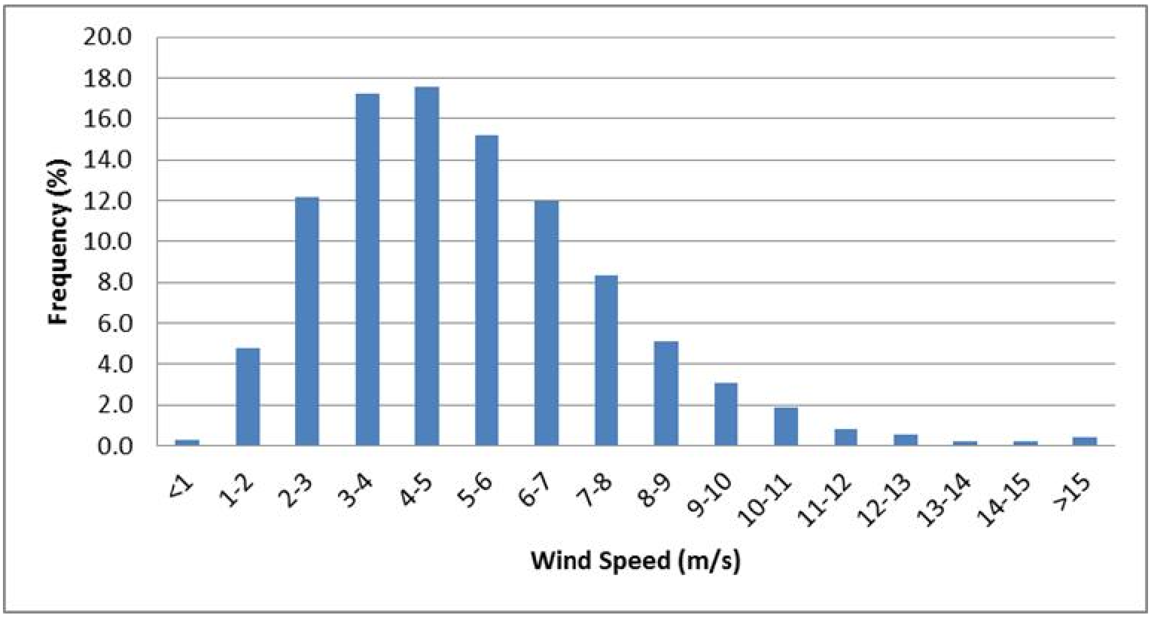


Figure 9-22: Prelude Wind Speed Data (2000-2006)

To illustrate the impact of wind speed on predicted concentrations, the model was run for NO_x emissions from the Prelude boilers during normal operating conditions for the full meteorological data set and various minimum wind speeds. Figure 9-23 shows the maximum predicted concentrations with distance from the source for all wind speeds, and wind speeds greater than 1m/s, 2m/s, 4m/s, and 6m/s. The figure indicates that the higher wind speeds are associated with much lower predicted ground level concentrations. As the winds at Prelude are typically higher, in the 3 to 6m/s range, this figure demonstrates that the model predictions are conservative in comparison to the typical wind conditions expected at the facility. It should also be noted that although the example below is specific with respect to NO_x emissions from the boilers, the same impact of wind speed would be applicable to the other sources and contaminants, including CO and VOC's.

[30] US EPA Technology Transfer Network, Support Center for Regulatory Atmospheric Modeling. https://www3.epa.gov/ttn/scram/dispersion_screening.htm

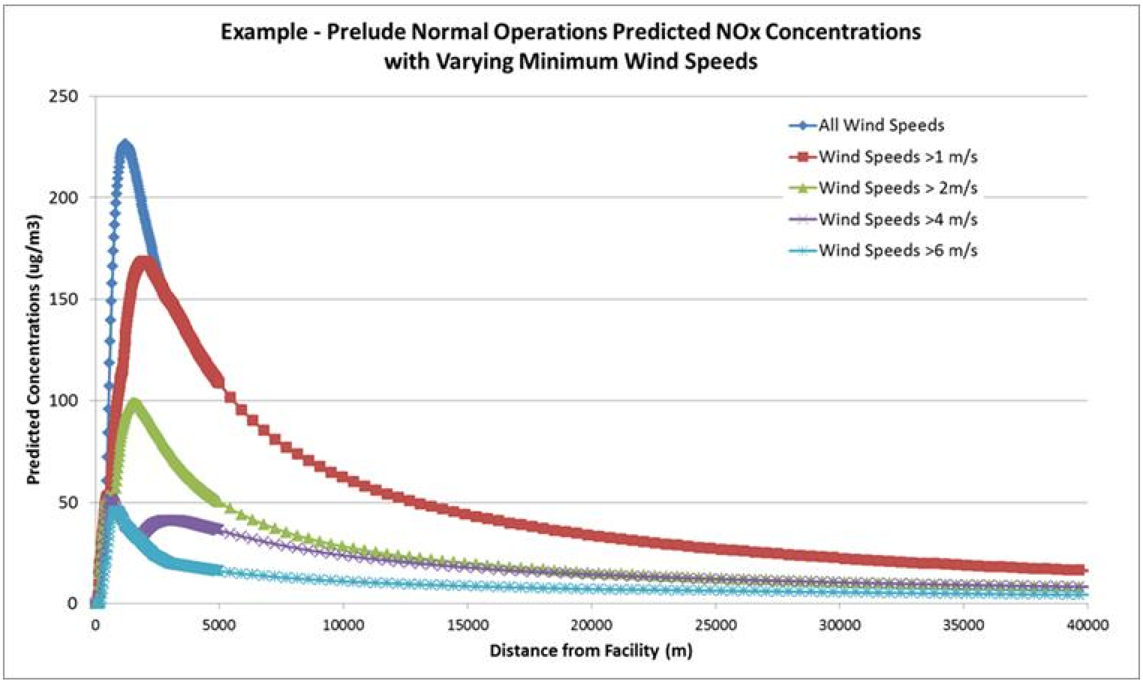


Figure 9-23: Example - Prelude Normal Operations Predicted NOx Concentrations with Varying Minimum Wind Speeds

Screening level models provide conservative values as they provide outputs on the centreline of the plume (where concentrations are highest) at various distances downwind. They do not consider the frequency of these wind conditions nor the location of a specific receptor with respect to predominant wind direction.

As the model assumes steady state, it assumes that the weather conditions are persistent and winds are blowing in the same direction. This approach is deemed to be conservative for receptors distant from the source. For example, the maximum predicted concentration predicted at Browse Island is associated with a wind speed of 1 m/s. In order for the centreline of the plume to reach Browse Island from Prelude would require 11 hours of persistent wind blowing directly towards the island.

An examination of the wind speed and direction data gathered at Prelude indicates that the frequency of winds blowing towards Browse Islands varies between <1% and 15% of the time, depending on season as shown in Figure 9-24 which presents the full year wind speed and direction data for Prelude. As such, emissions from Prelude would predominantly not be blowing towards Browse Island.

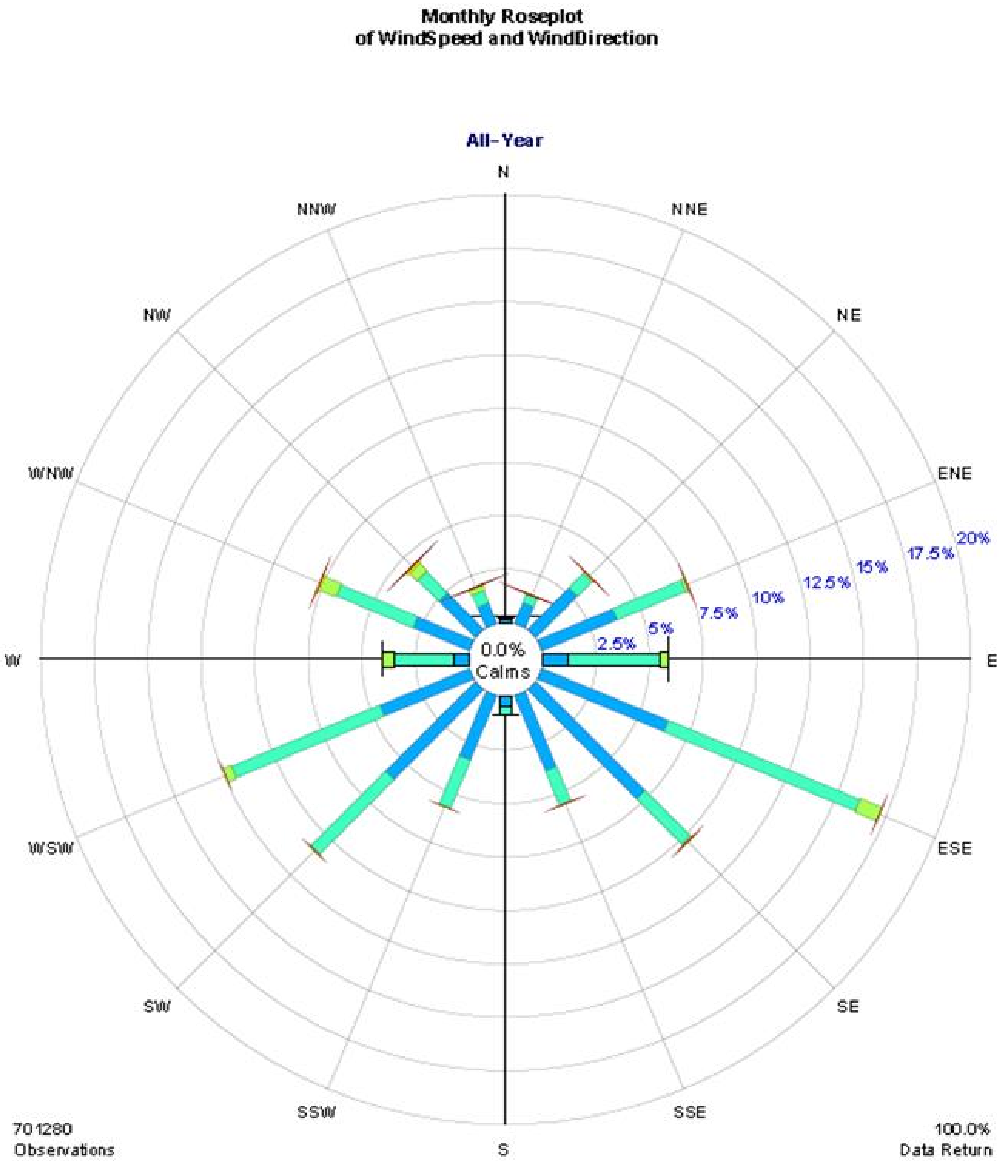


Figure 9-24: Wind Rose for Wind Speed and Direction Data Gathered at Prelude

SCREEN only models one source at a time, therefore, the model was run multiple times for the Prelude and Ichthys facility sources and the concentrations from each run were conservatively summed to provide the maximum predicted concentrations. The maximums are added together, even if they are the result of different meteorological conditions.

In summary, the modelling approach is considered conservative due to the following:

- Highest predicted concentrations are associated with low wind speeds, which occur infrequently at the facility. Higher wind speeds result in lower ground level concentrations
- Wind blowing from Prelude towards Browse Island occur between <1% to 15% of the time, while the modelling assumes that the winds are blowing towards Browse Island 100% of the time.

- For the cumulative scenario, Ichthys was assumed to be in the trajectory from Prelude to Browse Island.

Model Outputs and Assessment Criteria

Predicted 1-hour concentrations were scaled to other averaging periods using the recommended SCREEN scaling factors and compared with the Australian AAQS and international reference for VOC has been sought as it was VOC limits were not listed in Australian AAQS.

Applicable 1-hour, 24-hour and annual concentrations were compared with the standards for the Normal Operations scenario.

The following should be noted with respect to the results presented:

- The direct conversion method was used to convert NO_X to NO_2, this approach assumes that all NO_X emissions will be converted to NO_2, this is a conservative approach as it is expected that not all NO_X will convert to NO_2.
- Sulphur content of the diesel will be a maximum of 500ppm.
- SO_2 concentrations for the Normal operating scenario (Table 9-60) are based on Ichthys emissions alone, as Prelude will not have SO_2 emissions associated with Normal operations.
- SCREEN conversion method was applied to convert from 1 hour to 24 hour and annual values. The conversion factors for 24 hours is 0.4, annual is 0.08, 8 hours is 0.7 (CO only) and 3 hours is 0.9 (VOC only).

The cumulative maximum predicted concentrations predicted at Browse Island are provided in Table 9-60 - Table 9-62**.** The results show that the maximum predicted concentrations at the identified receptor are well below the associated ambient air quality standards for all the scenarios examined.

Table 9-60: Cumulative Prelude and Ichthys Normal Operations Maximum Predicted Concentrations

Parameter		Browse Island (40km)		AAQS	
		(ppm)	(ug/m^3)	(ppm)	(ug/m^3)
NO_2	1hr	0.024	49.20	0.12	246
	Annual	0.002	3.94	0.03	62
SO_2	1hr	-	0.14	0.2	571
	24hr	-	0.06	0.08	228
	Annual	-	0.01	0.02	57
$PM_{2.5}$	24hr	-	-	-	25
	Annual	-	-	-	8
CO	8hr	0.03	35.91	9	-
VOC	3hr	0.003	8.75	0.24	160

Table 9-61: Cumulative Prelude Exceptional Case and Ichthys Normal Operations Maximum Predicted Concentrations

Pollutant	Ave.Time	Browse Island (40km)		AAQS	
		(ppm)	(ug/m3)	(ppm)	(ug/m3)
NO2	1hr	0.03	69.13	0.12	246
	Annual	0.003	5.53	0.03	62
SO2	1hr	0.002	4.43	0.2	571
	24hr	0.001	1.77	0.08	228
	Annual	0.00	0.35	0.02	57
PM2.5	24hr	-	-	-	25
	Annual	-	-	-	8
CO	8hr	0.05	58.08	9	-
VOC	3hr	0.01	44.81	0.24	160

Table 9-62: Cumulative Prelude Worst Reasonable Exceptional Case and Ichthys Normal Operations Maximum Predicted Concentrations

Pollutant	Ave. Time	Browse Island (40km)		AAQS	
		(ppm)	(ug/m3)	(ppm)	(ug/m3)
NO2	1hr	0.036	74.23	0.12	246
	Annual	0.003	5.94	0.03	62
SO2	1hr	0.002	4.50	0.2	571
	24hr	0.001	1.79	0.08	228
	Annual	0.00	0.36	0.02	57
PM2.5	24hr	-	-	-	25
	Annual	-	-	-	8
CO	8hr	0.049	60.99	9	-
VOC	3hr	0.015	51.22	0.24	160

Under normal operating conditions, there will be no SO_2 emissions from the Prelude FLNG. Figure 9-25 shows the predicted SO_2 concentrations are below the AAQS across the domain, including in areas where there are no receptors.

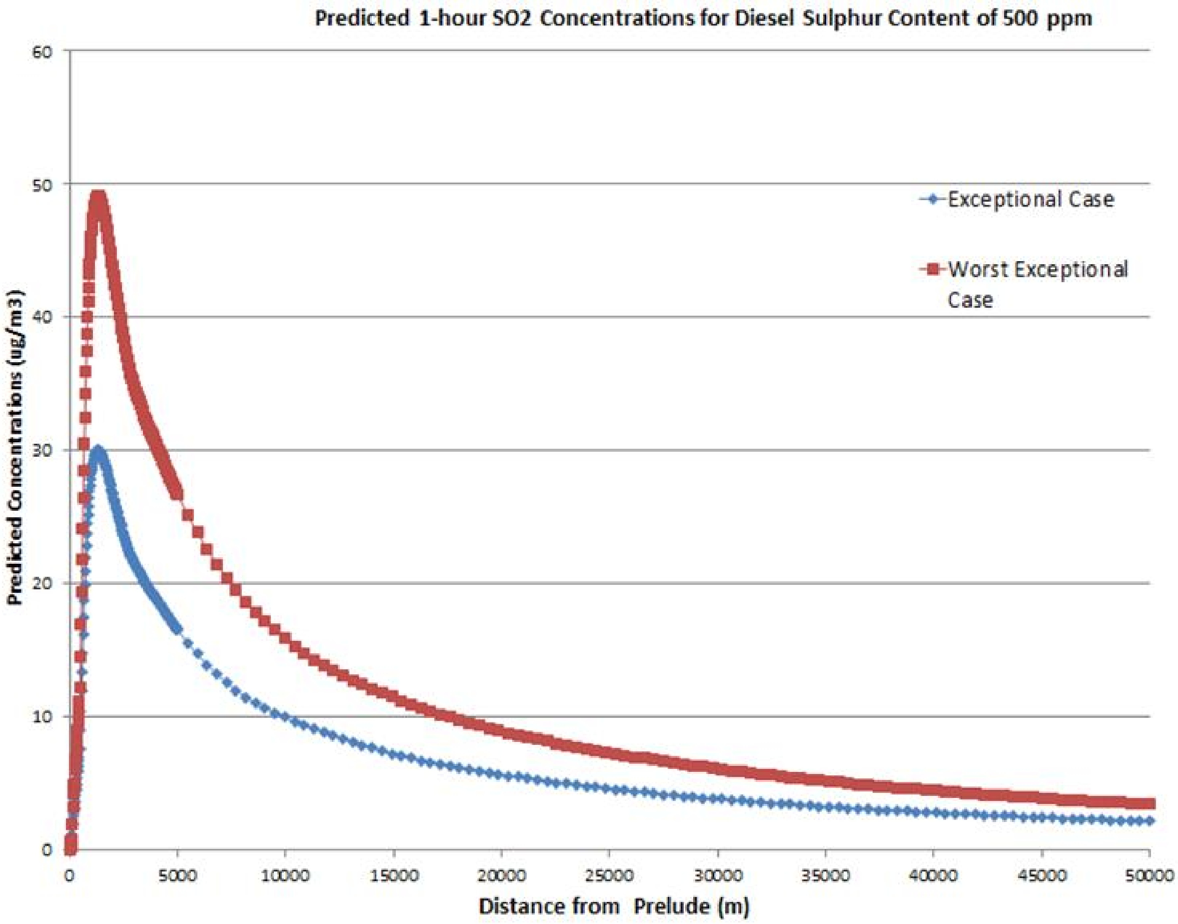


Figure 9-25: Exceptional Case Predicted SO_2 Concentrations based on Diesel Sulphur Content of 500ppm

Visual Amenity (Smoky Flare)

Smoke is visible when there is unburnt cracked carbon (soot) coming out of the flare. To reduce the amount of soot coming out of the flare, a flare steam injection system has been installed on Prelude FLNG. Steam is provided to the high pressure dry and wet flares and the low pressure wet flare to cool the flare tips and prevent thermal cracking.. The steam flow provides the ideal environment for the flare to suck in more oxygen (O_2) to can react with the remaining cracked carbon. This will reduce the amount of visible smoke coming out of the flare. The low pressure dry flare is predominantly methane, which doesn't crack and cause smoke, hence steam is not required for this flare.

Operational experience and vendor data indicate that at the highest flare combustion efficiency (lowest formation of VOC and particulate), the flare is still not completely smokeless. There is a trade-off to consider, more steam will make the flare smokeless and less efficient but will reduce the visible impact. However, the increase in steam production for the flare will also consume more fuel gas, increasing emissions as a result.

Apart from the aesthetic impact associated with a slightly smoky flare, there would be no material environmental impacts to local and regional airshed quality. In terms of health impacts, a Flare Flame-Out and Venting Atmospheric Dispersion Study (Shell Australia, 2013) was carried out to assess the extent of hazards associated with gas dispersion with regards to flammable and toxic risks from the flare sources. The study confirmed that the height and position for each flare was a suitably safe distance to work places and the living quarters to avoid any flammable, acute toxic or chronic exposure impacts at the facility. It is feasible for a flare flame out to occur, however design measures and controls are in place to prevent this occurring. The flare system has an automatic re-ignition control that sparks every 7 seconds, if the flame isn't on after 60 seconds, operator intervention is required to ignite the flame. The flare also has remote manual ignition controls that can be used. The consequence of this event is considered slight due to the infrequency of such an event occurring and the controls in place to manage a flame out. Although this event is heard of in industry, the risk and likelihood for Prelude is low.

9.10.3 Impact Assessment Summary

Table 9-63: Atmospheric Pollutant and Air Toxics Emissions Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment (Impacts on Air Quality)	-1	M	Slight
Physical Environment (Impacts on Visual Amenity)	-1	M	Slight
Biological Environment	N/A	N/A	N/A
Socio-Economic Environment	N/A	N/A	N/A

Table 9-64: Atmospheric Pollutant and Air Toxic Emissions Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Physical Environment	Slight	C	Dark Blue
Biological Environment	N/A	N/A	N/A
Socio-Economic Environment	N/A	N/A	N/A

9.10.4 ALARP Assessment and Environmental Performance Standards

Table 9-65: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Use of renewable energy (e.g. solar, wind and wave) in lieu of fossil fuels for power generation and marine vessel propulsion	No	Use of solar, wind or wave energy for a continuously running operation does not have the required reliability and will also require additional space and capital investment which are not justified. Use of renewable technology for a complete offshore LNG processing facility is not yet technologically proven and therefore not available.	N/A	N/A	N/A
Elimination	Flare Flame Outs Prevented	Yes	The flare system is a safety and loss prevention system and is required for the safe disposal of hydrocarbons in the event of process upsets or emergency situations. Flaring of hydrocarbon reduces the GHG emissions in comparison to these gases being vented. Flaring during the Prelude start-up process has been higher than originally anticipated due to unforeseen lower than expected facility reliability, availability and utilisation performance. However, Shell is striving to continually optimize and improve Prelude's flaring performance through addressing key causes of the facility's reliability, availability and utilisation performance in the immediate future. Mitigating flaring to ALARP will also result in the biggest improvements to Prelude's GHG emissions profile and emissions intensity.. Shell is inherently incentivised to maximise all three of these areas to improve economic returns from the facility so there is no EPS appropriate to include to address this issue.	8.1	No flare flame-outs occur on the Prelude flare system whilst it is intended to be in operation.	Incident reports of a flare flame out which was not auto ignited on Prelude whilst the flare is in operation.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			There have been no flare flame outs on Prelude to date. Design measures are in place to prevent this occurring. If a flare flame out where to occur, this could result in a short term spike increase in air pollutants from Prelude, however auto ignition controls are in place to mitigate this risk A flare flame out would be recorded if the auto ignition for the flare did not occur.			
Elimination	Recover the VOC emissions displaced during condensate loading and reuse in the process.	No	VOC emissions during condensate loading cannot be eliminated as this would require an additional complex installation to separate hydrocarbons from inert gas, possibly liquefy them and compress them to reuse in the process. This would lead to additional space requirements at the facility, congestion and sources of fugitive emissions for an infrequent operation (condensate loading occurs once in a fortnight). This option is considered to be disproportionate and is ALARP.	N/A	N/A	N/A
Substitution	Use of electric motor drivers or aero-derivative GTs	No	Early design considered use of variable electric motor drivers of 80MW each, with the power demand of 200MW provided by a bank of aero derivative gas turbo-alternators, which are more efficient than a steam boiler solution. Steam for process use was to be generated by Waste Heat Recovery Units (WHRU) in the GT exhaust stacks. This arrangement was not found to be sufficiently electrically stable, particularly in upset and start-up conditions. Lack of stability would result in lost production and extended flaring leading to more atmospheric pollutant and GHG emissions, thereby negating the energy efficiency benefits achieved through the application of GT.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			Direct drive aero derivative GTs were also considered to improve fuel efficiency by about 25% over the use of steam boilers, however the design was not mature enough to be adopted for the Prelude FLNG. Steam turbines were the option selected. Seven steam boilers generate sufficient steam to drive the main compressors and supply 120MW. This is less energy efficient than the other two options, resulting in an 8% fuel use increase, but is a more robust and reliable design in terms of equipment reliability. The boilers efficiency is anticipated to be greater than 90%.			
Engineering	The boilers are designed to IFC Guidelines for Thermal Power; the essential generators to IFC General EHS Guidelines; and the emergency generators to MARPOL 73/78 Annex VI.	Yes	Adoption of good industry practice available at the time Prelude FLNG was designed and constructed.	N/A	N/A - The design features were selected, installed and commissioned prior to the commencement of this EP, and are therefore not described in further detail here as an EPS.	N/A
Engineering	HP Steam boilers designed as dual fuel and will be operated on fuel gas during steady state production operations	Yes	Fuel gas, produced at Prelude, is a cleaner burning fuel in comparison to diesel and will be preferentially used during normal operations. The use of low sulphur diesel will be required only during occasional shutdown and start-up scenarios.	8.2	Limit boilers running on diesel to periods when fuel gas is not able to reasonably be used including periods such as start-up and shut down.	Daily report
Engineering	Use of end of stack technology (e.g. scrubbers or filters) to clean	No	End of stack technology is not an efficient way to minimise emissions due to additional material and	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	the exhaust gas of nitrogen oxides or particulate matter.		labour requirements to maintain scrubbers or filters in working condition. Additional safety and operability hazards and generation of solid waste could outweigh the benefits of this technology. Furthermore, modelling of a number of scenarios indicated that air quality from releases of exhaust gas will not exceed the AAQS criteria at the nearest receptors.			
Engineering	Inject steam into the flare system in order to reduce smoky appearance.	No	A flare steam injection system is designed and installed on Prelude FLNG. Steam is provided to the high pressure dry and wet flares and the low pressure wet flare to primarily cool the flare tips and prevent thermal cracking. Operational experience and vendor data indicate that at the highest flare combustion efficiency (lowest formation of VOC and particulate), the flare is still not completely smokeless. Additional steam injection can result in a smokeless but less efficient flare, thus emitting more uncombusted fuel gas as well as additional GHG emissions from the process of producing more steam. The steam injection to the flare will prioritise flare integrity and GHG optimization over air pollutant reduction. An overall improved environmental outcome is achieved following this approach due to the limited effect of air emissions on local and regional receptors and benefit from reducing GHG emissions using this approach.	N/A	N/A	N/A
Engineering	Flaring or incineration of the acid gas stream to oxidise H2S and	No	As the acid gas stream consists of more than 98% CO_2, to oxidise and render the hazardous	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	the residual hydrocarbons in the gas including methane and BTEX.		components of the stream (i.e. H_2S, BTEX, PAH and CH_4) non-hazardous, it will be required to enrich the acid gas with large volumes of hydrocarbons in order to raise the calorific value of the gas and burn it. This will lead to emissions of other pollutants (NO_x, SO_x, PM, CO) and more GHG emissions to atmosphere and the installation of a more complex system to operate on the facility in comparison to a vent stack. The atmospheric dispersion study showed that the level of pollutants near living quarters or work sites will be sufficiently low if the acid gas vent is 20m below the flare.			
Engineering	Fugitive emission design controls	Yes	Fugitive emissions in this context are those unintentional emissions that occur from equipment or component leaks, i.e.: from valves or flanges in any hydrocarbon processing areas of the plant. Fugitive emissions make up <1% of the air emissions from the facility. As outlined in the Prelude Environment Basis of Design, fugitive emissions on Prelude FLNG shall be significantly reduced by: • Use of valves with bellow or double packing seals or equally efficient equipment; • Magnetically driven or canned pumps, or pumps with double seals and a liquid barrier; • Minimisation of the number of flanges; • Closed sampling systems; • Drainage of containment effluents in closed system;	8.3	Undertake topside hydrocarbon process modules fugitive emissions / general leaks survey on at least an annual basis and repair identified in accordance with the maintenance work order system.	Records of leak detection and repair survey and associated maintenance repair records where relevant.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			• Use of relief valves instead of open vents in tank roofs; and • Use of pumps with double mechanical seals must be used for all substances, except inert liquid. This is demonstrated effective during the operation of Prelude by the results of the most recent leak detection and repair (LDAR) surveys. The last survey completed in second half of 2019 found 7 leaks up to a maximum leak rate of 34% Lower Explosive Limit @ 100mm. All topside hydrocarbon containing modules on Prelude are surveyed for fugitive emissions at least once per year whilst the facility is producing.			
Engineering	Maintenance of the flare system	Yes	During normal operations there are no practically feasible ways to conduct maintenance on the operating flare system as the pilot flare is ignited all the time. The flare system will be maintained according to the maintenance management system which allows for maintenance during certain shutdown events when the flare system is not operational. The maintenance vent is used as flare relief when the flare undergoes maintenance. Flare flow meters, upstream of the actual flare, are maintained according to the maintenance standards to ensure they are within reliability, availability and accuracy standards for this equipment. This ensures the optimization of flare performance in minimizing GHG emissions and associated VOC's occurring at the flare.	8.4	Flare system and flow meters will be maintained in accordance with the maintenance management system.	Maintenance records

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	Implement an adaptive stack emissions monitoring program (Section 9.10.5)	Yes	A stack emissions monitoring program will be implemented to validate pollutant emission rates for the boilers. The results of the program will be used to decide on the need of additional monitoring scope and frequency (adaptive management approach) and whether additional modelling studies are required.	8.5	Representative boiler stack samples carried out at least once and an assessment made on adaptive management controls.	Stack testing reports and assessment
Administrative and Procedural Controls	Implement a boiler surveillance program to ensure boilers are operating within the design operating envelope.	Yes	Operating the boiler system within the design operating envelope and at the targeted/design efficiency provides a degree of assurance that the emission levels are within the levels guaranteed by the vendor of the equipment. Parameters monitored includes: • Type of fuel used • Quantity of fuel used • Air flow (or fan speed) • Process temperature • Process oxygen content	8.6	A surveillance program is in place for the boilers and power generation units to ensure that they are operating within the design operating envelope.	Trends/data showing operation within operating envelope.
Administrative and Procedural Controls	Use low sulphur fuel oil/ diesel (< 0.5% m/m S) for boilers and marine support vessels supporting operations	Yes	This MARPOL Annex VI requirement, enforced by AMSA Marine Order 97, came into force from 1 January 2020 and applies to all marine vessels operating in the field including offtake tankers. This requirement will also be adopted for FLNG.	8.7	Use only low sulphur fuel oil/ diesel (<0.5% m/m S) for FLNG and marine support vessels.	Sulphur content of diesel, % w/w as verified in bunker receipts delivered to the FLNG on loading and bunker receipts for marine support vessels
Administrative and Procedural Controls	Prelude FLNG and specified marine vessels supporting Prelude operations comply with AMSA Marine Order 97 (Marine Pollution Prevention – Air	Yes	AMSA Marine Order 97 requires Prelude FLNG and specified marine vessels to possess the applicable pollution prevention and energy efficiency certificates. These certificates include Engine International Air Pollution Prevention Certificate	8.8	Prelude FLNG and specified vessels are required to have the following valid documentation as	Assurance records confirming SEEMP and IAPP, EIAPP, IEE certificates are in place for

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	Pollution) and the requirements of the Shell Marine Assurance Process and procedures regarding management of air pollution as required by vessel class, size and type.		(EIAPP), International Air Pollution Prevention Certificate (IAPP) and an International Energy Efficiency (IEE) Certificate. In addition, all vessels with a gross tonnage of 400 or more are required to carry a Ship Energy Efficiency Management Plan (SEEMP). These requirements are also recognised and enforced in the Shell Marine Assurance Process and procedures.		required by vessel class, size and type[31]: • EIAPP certificate; • IAPP certificate; • IEE certificate; and • SEEMP.	Prelude FLNG and specified vessels.
Administrative and Procedural Controls	The maintenance and marine vents will be vented to the flare system where anything but trace (<2%) hydrocarbons requires disposal.	Yes	An removable elbow is used to manually line up the header to vent to flare whenever there are hydrocarbons in the mixture. This is captured in OPS_PRE_009565 - Prepare LNG Storage Tank for Maintenance. It has steps to make sure that the system is lined up to flare whilst warming up the tank and whilst purging with nitrogen. It is not until the aerating stage that the gas is directed to atmosphere through the maintenance vent – to avoid oxygen ingress into the flare system. At this point there should be minimal hydrocarbons in the vessel (the procedure advises to stop nitrogen purge when the hydrocarbon content is less than 2%). The same applies for the purging of inert gases from LNG carriers, where OPS_PRE_002789 - inert tanker gas up and col down – ensures that the system is lined up to flare by swinging the same moveable elbow.	8.9	No venting of hydrocarbons will occur on Prelude. Nothing except trace hydrocarbons (<2%) will be vented to atmosphere from the marine or maintenance vents.	Incident reports of cold venting events if it occurs as an unplanned event. PI records confirm gas composition vented to atmosphere is < 2% hydrocarbons.

[31] Advice from the Recognised Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	Prelude FLNG LOPC Management Procedure (OPS_PRE_012373)	Yes	Planned venting of process hydrocarbons (methane, ethane, propane, butane, LPG or LNG) to atmosphere does not occur on Prelude. It is an important part of operating the facility to keep hydrocarbons contained within the process systems. This control does not include fugitive emissions associated with general leaks, which includes weeps and seeps from valves, flanges and other process areas which are not considered a LOPC. Definitions of LOPC's greater than weeps and seeps or minor LOPC's is outlined below: Significant LOPC. Detectable by a gas detector: • ≥100% LEL at ~ 1m • ≥20% LEL at ~ 5m	8.10	No significant loss of primary containment from process hydrocarbons to atmosphere as defined in the Prelude FLNG LOPC Management Procedure (OPS_PRE_012373).	Incident reports of LOPC events.

9.10.5 Adaptive Stack Monitoring Program

The intent of the adaptive stack monitoring program for the Prelude steam boilers is to verify that 'end of pipe' pollutant emission rates comply with the design emission rates for the boilers, specified in Table 9-52. These design emission rates have been used in the screening air quality modelling, discussed in Section 9.10.2, which provides the evidentiary support for determining the acceptability of Prelude operations impact on ambient air quality.

The two decision points that inform the planned stack monitoring program are the compliance to the design emission rates for the boilers and the compliance to the impact acceptance criterion specified in Section 9.10.6 below. Responses to these questions will inform the adaptive actions as per Figure 9-26 below.

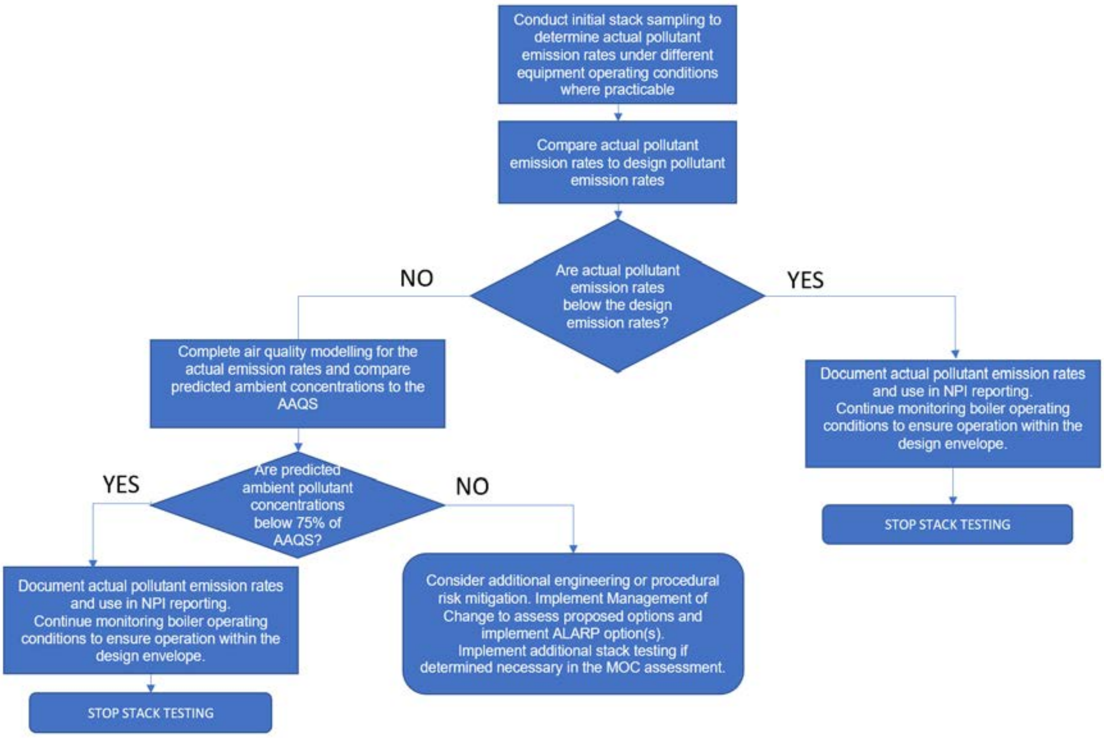


Figure 9-26: Flowchart: Adaptive Response Stack Testing Program

9.10.6 Acceptability of Impacts

Table 9-66: Acceptability of Impacts – Atmospheric Emissions

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	Air Quality	No significant impacts to air quality defined as no substantial change in air quality which may adversely impact on biodiversity, ecological	Yes	Screening air quality assessment indicates that predicted ground level concentrations of pollutants at the closest sensitive receptors for the worst-case modelling conditions are below

		integrity, social amenity or human health.		75% of the current NEPM ambient air quality standards. The worst-case wind conditions associated with highest predicted ground level ambient pollutant concentrations at the closest sensitive receptors (which are well below 75% of the current ambient air quality standards) persist only 1% of the time.
Biological Environment	N/A	N/A	N/A	N/A
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of atmospheric pollutant emissions determined the impact magnitude to be minor. Given that air quality in the area is generally expected to be very high and the lack of sensitive human receptor populations in the Prelude airshed as defined in the Air Quality NEPM (NEPC, 1998), the residual impact consequence ranking is assessed as Slight (Magnitude -1, Sensitivity – M) and therefore acceptable (Table 9-63). Impacts on air quality have also been considered in the following context.

Principles of ESD

The impacts from atmospheric pollutant and air toxics emissions are acceptable and consistent with the principles of ESD based on the following points:

- The environmental values/sensitivities within the Operational Area and the regional airshed are not expected to be significantly impacted.
- The precautionary principle has been applied to the impact modelling study and in the impact assessment.

Relevant Requirements

Management of impacts from atmospheric emissions is consistent with relevant legislative requirements, including:

- Air quality in the Prelude regional airshed complies with the current NEPM Ambient Air Quality Standards (National Environment Protection Council, 1998) as well as with the proposed draft NEPM Ambient Air Quality Standard (National Environment Protection Council, 2019).
- Marine fuel oil used by HP Steam Boilers and marine vessels supporting operations complies with 1 January 2020 MARPOL Annex VI requirement for 0.5% m/m S content in marine fuel oil and diesel.

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of atmospheric pollutant emissions from the Prelude FLNG facility and supporting marine operations indicates significant impacts and risks to threatened and migratory species will not credibly result from combustion of fuels, flaring, acid gas and VOC venting and fugitive emissions aspects of the Prelude petroleum activities.

Alignment of the Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-67.

Commonwealth Marine Environment

The impacts and risks from atmospheric pollutant emissions from the Prelude field on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 9-67.

Table 9-67: Summary of Alignment of the Impacts from the Atmospheric Pollutant Emissions Aspect of the Prelude petroleum activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	None applicable to atmospheric pollutant emissions	N/A
Wetlands of International Importance	None applicable to atmospheric pollutant emissions	N/A
Commonwealth marine area	No significant impacts on Air Quality	Criteria for significant impacts and risks to air quality over the Commonwealth Marine area where the Prelude project will operate have not been triggered by atmospheric pollutant emissions from the Prelude field.

Internal and External Context

There have been no objections or claims raised by Relevant Persons in preparation of this EP related to atmospheric pollutant and air toxics emissions aspect.

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with Shell's internal requirements.

Shell has adopted the World Bank Global Gas Flaring Reduction (GGFR) initiative (Zero Routine Flaring by 2030). This initiative is intended to avoid flaring of associated gas from oil developments and does not apply to LNG projects however Shell establishes flaring management plans for all major installations to ensure flaring is minimised to ALARP . Non-routine flaring, which nevertheless should be minimised, and flaring for safety reasons is explicitly excluded from this initiative.

Acceptability Summary

The assessment of impacts from atmospheric pollutant and air toxics emissions determined the residual impact rankings to be Slight (Table 9-4). As outlined above, the acceptability of the impacts and risks from this aspect have been considered in the context of:

- The established acceptability criteria for impacts and risks for this aspect
- ESD
- Relevant legislative requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

The residual impacts are slight which Shell considers to be inherently acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the atmospheric pollutant emissions aspect.

Based on the points discussed above, Shell considers the impacts from atmospheric pollutant emissions associated with Prelude operations to be acceptable and ALARP.

9.10.7 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
Predicted ground level concentrations of atmospheric pollutants are below 75% of the applicable ambient air quality criteria[32]	Steam boilers adaptive stack emissions monitoring (validation of vendor design emission rates). Atmospheric pollutant and air toxics emissions inventory (as part of NPI report).

9.11 Greenhouse Gas Emissions

9.11.1 Aspect Context

Operating the Prelude FLNG facility and producing LNG, LPG and condensate results in GHG emissions from various sources such as:

- Combustion of fuel (diesel and fuel gas) for power generation

[32] The 75% of AAQS acceptance criterion for level of impact for ambient air quality has been derived from the National Environment Protection Council (Ambient Air Quality) Measure, Technical Paper No. 4, Screening Procedures (National Environment Protection Council, 2007). This paper provides screening criteria against which jurisdictions can assess the monitoring needs of their regions where reduced or no direct monitoring is justified in accordance with Clause 14 (3) of the Ambient Air Quality NEPM: “Fewer performance monitoring stations may be needed where it can be demonstrated that pollutant levels are reasonably expected to be consistently lower than the standards mentioned in this Measure.” The NEPM Peer Review Committee (PRC) recommended using 75% of the AAQS criteria as the maximum acceptance limit for any ambient air pollutant screening method (e.g. inventory, modelling or monitoring), below which no air quality monitoring, or no additional air quality monitoring stations need to be established. It is further recommending lower and specific to each pollutant threshold levels when taking into account the difference in screening methods, their reliability and the exposed populations. The threshold level of 75% of the AAQS is considered appropriate for an acceptable level of impact when assessing air emissions from the Prelude field as no sensitive receptors as defined in the Ambient Air Quality NEPM are present in the Prelude airshed.

- Flaring of hydrocarbon for process safety purposes
- Venting of reservoir CO_2.
- Fugitive emissions / General Leaks
- Combustion of fuel from transportation purposes – e.g. vessels supporting Prelude operations

The above sources are further discussed in detail in Section 9.10.1.

GHG Emissions Inventory

GHG emissions forecasting for Shell forms part of the annual Operating Plan (OP) process described in section 10.1.11.

Accounting of all GHG emissions has been recorded and reported under the NGER Act since the arrival of Prelude at location in 2017.

Predicted total gross annual GHG emissions from the Prelude FLNG, over its operating life, are not expected to exceed 2.7Mt $CO_{2\text{-e}}$, on average. Over the next five years of operation (2021 – 2025 inclusive), annual GHG emissions are not expected to exceed 2.6Mt $CO_{2\text{-e}}$, on average. The maximum gross scope 1 emissions limit from the Prelude FLNG is not expected to exceed 2.95Mt $CO_{2\text{-e}}$ in any given year, on an aggregate basis.

This is based on Operating Plan forecasts and is considered a confident basis for maximum facility GHG emissions as some uncertainty is accounted for in the figures provided. The breakdown of Prelude's GHG inventory during stable operations is shown in . The chart is based on OP20 forecasts for the year of peak production. Prelude emissions inventory would be expected to vary for periods when the facility is not operating stably during process and plant operational upsets which are experienced for gas processing and/or LNG production. However, this is not expected to result in an increase in total emissions outlined above.

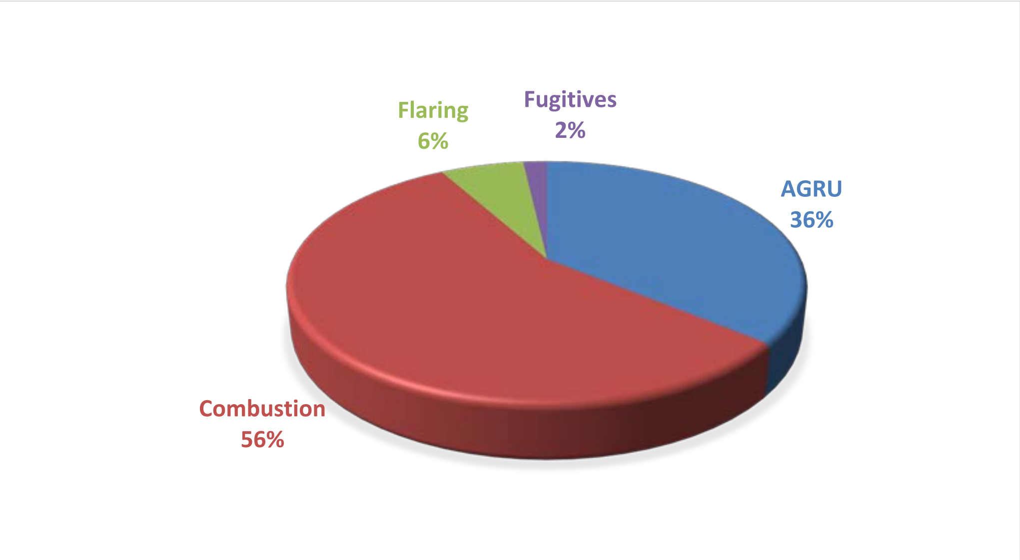


Figure 9-27: Prelude's GHG emissions inventory during stable operations.

Table 9-68: Prelude FLNG Actual Annual GHG emissions in early start-up phases

Type	Actual Emissions (CO_{2-e} kt/year)[33]		
	FY2017/2018	FY 2018/2019	FY 2019/2020
Reservoir CO_2	0	69	193
Fuel combustion	240	567	1,124
Flaring	13	1,680	789
Fugitive	0	1	3
Actual total GHG emissions	**253**	**2,317**	**2,109**
OP year emissions forecast	**398**	**2,570**	**2,787**

To put Prelude's gross scope 1 GHG emissions into context, in the financial year 18/19 Prelude contributed approximately 2.3Mtpa of the 537.5Mtpa total domestic emissions in Australia (Commonwealth of Australia 2019). There are many publications of the global GHG emissions and projected pathways of impacts under different modelled climate change scenarios. The latest figures from the Global Carbon Project, which releases annual data on GHG emissions, backed up by peer-reviewed publications, identify global fossil fuel GHG emissions in 2020 to be approximately 34,100Mtpa (Global Carbon Project 2020). The IEA World Energy Outlook (2019) predicts world energy related GHG emissions to be 35,589Mtpa in the Stated Policies Scenario (STEPS) and 15,796Mtpa in the Sustainable Development Scenario (SDS) by 2040. Table 9-69 compares the Prelude GHG emissions against these amounts.

Table 9-69- Comparisons between Prelude FLNG, Australian and Global GHG emissions

Facility	**GHG Emissions[34] (Mtpa CO_{2-e})**	**Australian Emissions**	**Percent of Global Emissions in 2020**	**STEPS Global Emissions in 2040**	**SDS Global Emissions % in 2040**
Prelude FLNG	2.7	0.5%	0.0067%	0.0076%	0.017%

9.11.2 Description and Evaluation of Impacts

This section describes how climate change, in general, may affect the Australian environment. As will be explained in the evaluation, while there is a relationship between GHG emissions and climate change, it is not possible to know the exact contribution of Prelude's emissions to these possible effects.

CSIRO (2018) is forecasting that Australia is projected to experience the following climate changes:

- increases in sea and air temperatures, with more hot days and marine heatwaves, and fewer cool extremes;

[33] Based on reported financial year NGER information.

[34] Based on expected average emissions over the life of the Prelude FLNG facility.

- sea level rise and ocean acidification; and
- decreases in rainfall across southern Australia with more time in drought, but an increase in intense heavy rainfall throughout Australia.

A summary of the predicted effects to key Australian ecosystems as a result of climate change is presented in Table 9-70. Most marine and terrestrial ecosystems are susceptible to climate change; however, the predicted impact is highly variable, both between ecosystems and within individual ecosystems.

Changes in climate, such as altering temperature, rainfall patterns and fire regimes, due to climate change are likely to result in changes in vegetation structure across all terrestrial ecosystems within Australia (Dunlop et al. 2012). Increases in fire regimes will impact Australian ecosystems by altering composition structure, habitat heterogeneity and ecosystem processes, and may assist in the spread of introduced species (which may further alter or increase the incidence of fires). Changes in climate variability, as well as averages, could also be important drivers of altered species interactions (Dunlop et al. 2012).

Table 9-70: Projected Effects of Climate Change on Key Australian Ecosystems

Selected Component of Environmental Change	**Projected Effects**
Coral Reefs	
CO_2 increases leading to increased ocean acidity	Reduction in ability of calcifying organisms, such as corals, to build and maintain skeletons.
Sea surface temperature increases, leading to coral bleaching	If the frequency of bleaching events exceeds the recovery time, reefs will be maintained in an early successional state or be replaced by communities dominated by macroalgae. Warming will increase the susceptibility of corals to diseases. Potential for new reefs to develop at higher latitudes where suitable substrates are available and until light becomes limiting; potential decrease in beta diversity of coral communities as tropical-adapted taxa expand their range to the south, amplified by differential survival of different taxa,
Increases in cyclone and storm surge	Increased physical damage to reef structure.
Oceanic Systems (including planktonic systems, fisheries, sea mounts and offshore islands)	
Ocean warming	Many marine organisms are highly sensitive to small changes in average temperature (1–2ºC), leading to effects on growth rates, survival, dispersal, reproduction and susceptibility to disease. Increasing temperatures reduce larval development time, potentially reducing dispersal distances; warm-water assemblages may replace cool-water communities.
Changed circulation patterns, including increase in temperature stratification and decrease in mixing depth, and strengthening of East Australian Current	Distribution and productivity of marine ecosystems is heavily influenced by the timing and location of ocean currents; currents transfer the reproductive phase of many organisms, therefore playing an important role in dispersal and maintenance of populations. Climate change may suppress upwelling in some areas and increase it in others, leading to shifts in location and extent of productivity zones.
Changes in ocean chemistry	Increasing CO_2 in the atmosphere is leading to increased ocean acidity and a parallel decrease in the availability of carbonate ions, which are the building blocks of calcium carbonate skeletons (such as those of many planktonic species and corals. Increased dissolved CO_2 may increase productivity.
Estuaries and Coastal Fringe (including benthic, mangrove, saltmarsh, rocky shore, and seagrass communities)	
Sea level rise	Landward movement of some species (particularly mangroves) as inundation provides suitable habitat, changes to upstream freshwater habitats will have flow-on effects to species such as wetland birds.

Selected Component of Environmental Change	Projected Effects
Increase in water temperature	Effects on phytoplankton production will affect secondary production in benthic communities.
Savannas and Grasslands	
Elevated CO_2	Shifts in competitive relationships between woody and grass species due to differential responses.
Increased rainfall in north and north-west regions	Increased plant growth will lead to higher fuel loads, in turn leading to fires that are more intense, frequent, occur over large areas and occur later in the dry season. Change to ecotonal boundaries between savanna woodlands, grasslands and monsoonal rainforest patches. Changes in rainfall seasonality are likely to be more important than changes in amount.
Tropical Rainforests	
Warming and changes in rainfall patterns	Increased probability of fires penetrating rainforest vegetation resulting in shift from fire-sensitive vegetation to communities dominated by fire-tolerant species. Cool-adapted species forced to higher elevations, altering competitive interactions.
Change in length of dry season	Altered patterns of flowering, fruiting and leaf flush will affect resources for animals.
Increased intensity of storms/tropical cyclones	Increased physical disturbance to forests, which alters gap dynamics and succession rates; shallow-rooted tall rainforest trees are particularly susceptible to uprooting, breakage and defoliation.
Rising atmospheric CO_2	Differential response of different growth forms to enhanced CO_2 may alter structure of vegetation.
Temperate Forests	
Potential increases in frequency and intensity of fires	Changes in structure and species composition of communities with obligate seeders may be disadvantaged compared with vegetative resprouters.
Warming and changes in rainfall patterns	Potential increases in productivity in areas where rainfall is not limiting; reduced forest cover associated with soil drying projected for some Australian forests.
Rising atmospheric CO_2	Overall increase in productivity and vegetation thickening.
Inland Waterways and Wetlands	
Reductions in precipitation, increased frequency and intensity of drought	Reduced river flows and changes in seasonality of flows; reduction of the area available for waterbird breeding. More intense rainfall events will increase flooding, affecting movements of nutrients, pollutants and sediments, riparian vegetation, and erosion. Groundwater dependent ecosystems may be negatively affected.
Changes in water quality, including changes in nutrient flows, sediment, oxygen and CO_2 concentration	May affect eutrophication levels, incidence of blue-green algal outbreaks; loss of cool-adapted species and increase in populations of warm-adapted species.
Sea level rise	Saltwater intrusion into low-lying floodplains, freshwater swamps and groundwater; replacement of existing riparian vegetation by mangroves.
Warming of water column; increase in depth of seasonal thermoclines in still water	Changes in abundance of temperature-sensitive species, such as algae and zooplankton; reduction in depth of lowest oxygenated zones in some instances.
Arid and Semi-arid Regions	
Increasing CO_2 coupled with drying in some regions	Interaction between CO_2 and water supply critical, as 90% of the variance in primary production can be accounted for by annual precipitation.
Shifts in seasonality or intensity of rainfall events	Any enhanced runoff redistribution will intensify vegetation patterning and erosion cell mosaic structure in degraded areas. Changes in rainfall variability and amount will also affect fire frequency. Dryland salinity could be affected by changes in the timing and intensity of rainfall.

Selected Component of Environmental Change	Projected Effects
Warming and drying, leading to increased frequency and intensity of fires	Reduction in patches of fire-sensitive mulga in spinifex grasslands potentially leading to landscape-wide dominance of spinifex.
Alpine/Montane Areas	
Reduction in snow cover depth and duration	Potential loss of species dependent on adequate snow cover for hibernation and protection from predators; increased establishment of plant species at higher elevations as snowpack is reduced.

(adapted from Steffen et al. 2009)

Emissions are primarily classed as Scope 1 (direct emission from own facilities or businesses) or Scope 2 (indirect emissions when purchasing steam or electricity for use) GHG emissions. Prelude does not have any Scope 2 emissions. The broader impacts from GHG emissions are typically considered by the international community at an ecosphere level, most frequently in terms of an increase in global temperatures. Table 9-70 identified the climate projections on the Australian environment from the increase in global temperatures.

Climate projections depend upon emission/concentration/radiative forcing scenarios, which are based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised and are therefore subject to substantial uncertainty (UNITAR 2015).

Climate projections are distinct from climate predictions. Climate predictions are estimates of future natural conditions, while climate projections are estimates of future climates under the assumptions of future human related activities such as socio-economic and technical developments. Making a prediction of GHG emission impacts at the ecosphere level is an inherently complex exercise because of the influence of variables such as surface pressure, wind, temperature, humidity and rainfall within multiple ecosystems. The listed items are all interdependent variables that contribute to a global temperature increase. For each variable, a series of generalising assumptions would be required to be able to make a sensible calculation of the impacts. Considering the complex and dynamic natural processes within the ecosphere, there is substantial uncertainty in determining a specific increase in global temperatures due to Prelude and its emissions.

It is equally speculative to suggest an isolated climate event, or series of climate events, that lead to a change to any environmental value or sensitivity within Australia (including Matters of National Environmental Significance (MNES)), are solely attributable to a specific increase in global temperature. As such, it is not possible to isolate the influence of Prelude emissions to any conclusive impact on the Australian environment. This results in a lack of full scientific certainty about the impacts of Prelude GHG emissions.

To be consistent with the precautionary principle, one of the guiding principles of ESD is that the lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation if there is also a threat of serious or irreversible environmental degradation from the action.

Considering the national and international comparisons in Table 9-69, Scope 1 emissions from the Prelude FLNG are a small portion of emission inventories, even in the SDS. This suggests a similarly small contribution to global temperature increases even though there is no calculable direct relationship.

However, the reasons previously given for being unable to quantify any increase in emissions contribution to an increase in global temperature also hold for these comparisons. Nevertheless, the numbers presented are extremely small, meaning that even if these estimates have orders of magnitude variance, it is still reasonable to conclude that, holding all other factors constant, Prelude FLNG's Scope 1 emissions' contribution to any increase in global temperatures will be small.

Whilst Scope 1 emissions from Prelude contribute a small amount to Australian and global GHG emissions, this fact alone does not make their impacts inherently acceptable. The relatively small percentage of global emissions should not be used to understate the seriousness of the threat of environmental degradation from climate change. Rather, it clarifies the source of the threat is from global emissions quantities rather than Prelude's emissions. The threat of serious environmental degradation from climate change comes from an increasing global population demanding more energy to maintain and improve global living standards. Whilst Prelude accounts for a small percentage of this demand, it does not create an isolated instance of a threat of serious or irreversible environmental degradation.

Whether climate change is irreversible is even more scientifically uncertain than predicting impacts from Scope 1 GHG emissions from Prelude for the same reasons that made that prediction speculative. The environmental influences of variables such as surface pressures, wind, temperature, humidity, and rainfall are added to the variables of human adaption measures to a lower carbon economy. This is demonstrated by the difference between the Stated Policy Scenario (STEPS) and the SDS considered by IEA.

The key features of the Prelude FLNG production technology contributing to the improvement of GHG performance include:

- Positioning the FLNG facility over the gas field has negated the need for a long pipeline to shore and has reduced compression requirements during the later life of the field as the reservoir pressure declines.
- Integrating product offloading facilities into the design of the FLNG reduces gas compression requirements for gas export to an onshore terminal.
- Shell's proprietary Double Mixed Refrigerant (DMR) process uses mixed refrigerant for the pre-cooling and liquefaction cycles which allows for a flexible process to enable full power utilisation over a wide range of ambient temperatures. The composition of the pre-cool refrigerant can be modified to balance ambient temperature changes and cut-point temperatures where traditional C3-MR processes cannot be adjusted in this way. Using another option was Nitrogen Cycle, but DMR has better liquefaction efficiency. Nitrogen Cycle can use almost double the amount of compression power to make LNG compared to DMR technology. DMR technology means there is less fuel gas demand and lower GHG emissions.
- Shell's 3-stage DMR process technology rather than a 2-stage DMR process increases the liquefaction efficiency by 8% at the expense of additional equipment required for a 3rd stage. Potentially more LNG can be produced using the same amount of power and fuel gas which translates to the same GHG emissions for 8% more production.
- Prelude FLNG was able to increase efficiency in production by reducing cooling water temperatures (i.e. taking colder seawater from a depth of 150 m rather than taking seawater from surface). At this depth, the sea water supply temperature ranges between15-23°C due to changes in tidal waves and seasons. For every degree that the temperature of the cooling medium is colder, 0.6-0.7% of production is gained for the same energy cost.

Increasing levels of GHG in the atmosphere is one contributing factor to the warming of the climate system. There is a lack of full scientific certainty about the effects of increased emissions, but they are understood to be non-linear. The evaluation considered that GHG emissions are among the causes of climate change, particularly if unmitigated.

It is considered that calculating Prelude's contribution to climate change would be speculative and would likely provide unreliable, inaccurate, and uncertain results. As evidence for this assertion, the evaluation has shown the substantial uncertainty in making an evaluation stems from two equally complex and dynamic sets of interdependent variables. The first is from predicting the contribution of Prelude GHG emissions to a specific increase in global temperatures, and the second comes from making a prediction of impacts on the Australian environment from the increase in global temperatures.

In conclusion, the environmental impacts and risks arising from Scope 1 GHG emissions from Prelude will be managed to an acceptable level because:

- GHGEM systems will be implemented in line with section 10.1.11.
- Abatement projects which improve GHG performance will be implemented on Prelude. This, in addition to other controls outlined in section 9.11.4, will ensure scope 1 emissions are always managed to ALARP. Further details on current in plan abatement projects are outlined in section 10.1.11.
- Prelude will be operated to maximise reliability, availability and utilisation which in turn delivers an optimised GHG intensity outcome along with maximising the use of already sunk direct and indirect environmental impacts associated with the footprint of constructing the Prelude FLNG.

Uncertainty in the assessment of impacts will be managed through the Greenhouse Gas and Energy Management systems outlined in section 10.1.11 and the legislative arrangements that apply to Prelude FLNG, in particular, the Safeguard Mechanism under the NGER Act. The impacts have been assessed and will be mitigated, abated, and (where legally required) offset.

9.11.3 Impact Assessment Summary

Table 9-71: Greenhouse Gas Emissions Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	-2	L	Minor
Biological Environment	-2	L	Minor
Socio-Economic Environment	-2	L	Minor

9.11.4 ALARP Assessment and Environmental Performance Standards

Much of the information collated in this ALARP assessment comes from several key documents which include the PEPCI Greenhouse Gas and Energy Efficiency Assessment (2000-110-G000-GE-G00000-HX-7180-62106, 2012), Prelude Greenhouse Gas Fuel & Flare Policy (HSE_PRE_016332, 2020), Energy Efficiency Assessment (2000-110-G000-GE00-G00000-HX-7180-62105) and Prelude FLNG GHGEMP (HSE_PRE_0130000, 2020).

Table 9-72: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Use of renewable energy (e.g. solar, wind and wave) in lieu of fossil fuels for power generation and marine vessel propulsion	No	Use of solar, wind or wave energy for a continuously running operation does not have the required reliability and will also require additional space and capital investment which are not currently justified. Use of renewable technology for a complete offshore LNG processing facility is not available or technologically proven yet. This may be further investigated in the abatement funnel assessment process outlined in section 10.1.11.	N/A	N/A	N/A
Elimination	No flaring from routine operations excluding flaring associated with pilot, process safety and non-routine events.	Yes	Once Prelude reaches stable operations flaring will make up a small percentage of GHG emissions (Figure 9-27). The flare system is a safety and loss prevention	9.1	Prelude will have no planned flaring during routine operations[35].	Measured and/or calculated flaring during routine operations balances to zero when taking account all exclusions.

[35] This excludes flaring due to pilot gas and non-routine operations such as process safety reasons, shut-downs, start-ups, well clean-up, well flow tests, pigging, failed equipment pending reinstatement (e.g. passing valves) or outstanding equipment commissioning. A baseline of 'no routine flaring' will be calculated once Prelude reaches steady state operations, but no later than the end of 2022.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			system and is required for the safe disposal of hydrocarbons in the event of process upsets or emergency situations. Flaring of hydrocarbon reduces the GHG emissions in comparison to these gases being vented. Flaring during the Prelude commissioning and start-up has been significantly higher than originally anticipated due to unforeseen lower than expected facility reliability, availability and utilization performance. Shell is inherently incentivized to maximise all three of these areas to improve economic returns from the facility so there is no EPS appropriate to include to address this.	9.2	Shell will conduct a feasibility assessment on technology for use in assessing leaking valve quantification by the end of 2021. If useful quantification is achievable and able to be implemented reasonably, this will be built into the Prelude asset management system for ongoing use once procured and commissioned.	Records of the feasibility assessment and where relevant, purchase and commissioning of equipment.
Elimination	Minimise Flaring during non-routine operations	Yes	During the life of the facility Prelude will have periods of non-routine operations that will require flaring. A significant focus as Prelude moves towards steady state is identifying activities that will reduce flaring as much as possible during these non-routine events such as trips, shutdowns (warm and cold end) and restarts (warm and cold ends). Examples of flaring reductions initiatives with a focus on non-routine events to be executed during 2020-2022 are outlined	9.14	Implementation of GHG abatement projects from 2021 onwards will result in at least 250kt $CO_{2\text{-}e}$[36] in reduced or avoided emissions by 2025 with at least 100kt $CO_{2\text{-}e}$[37] occurring by the end of 2022.	Records of measured or calculated GHG emissions abated through implementation of GHG abatement projects.

[36] On a cumulative basis between 2021-2025 inclusive.

[37] On a cumulative basis between 2021-2022 inclusive.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			in section 10.1.11. One of the most significant example initiatives is challenging the design minimum turndown limits of the wells during start-ups. Prelude has demonstrated successfully that the minimum turndown of the facility can handle is 15-22 mmscfd which is significantly lower than the design basis which was a minimum turndown of 50 mmscfd. Although this initiative is still being tested, during a restart in August 2020, this control prevented approximately 10,800 tonnes of gas to be flared.			
Elimination	Reinject the acid gas into an appropriate geological formation	No	Based on a comprehensive assessment, no technical and/or economically viable solution was identified for re-injection due to: • Lack of a contained and confined geological formation to effectively contain and seal the injected acid gas stream. Recirculation of the CO_2 through leakage back into production fluids leading to material compatibility issues was found to be a possible outcome of reinjection in the available geological strata. • Re-injection would have resulted in extra equipment onboard the FLNG Facility (CO2 compression, dehydration, extra steam boiler), leading to additional sources of	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			safety risk, emissions, congestion and maintenance requirements. CO_2 re-injection would also have required a considerable monitoring (including 4D seismic) and reporting effort to comply with Government legislation on carbon capture and storage, which could have introduced a new range of environmental, safety and operability hazards. Subsequent to Prelude's construction, there are no other feasible ways to reduce GHG emissions or improve efficiency associated with the AGRU unit on Prelude apart from already implemented design controls which include: • Using higher efficiency solvent to reduce hydrocarbon co-absorption • Cold solvent pre-heated by lean solvent leaving the regenerator.			
Substitution	Use of electric motor drivers or aero-derivative GTs	No	Early design considered use of variable electric motor drivers of 80MW each, with the power demand of 200MW provided by a bank of aero derivative gas turbo-alternators, which are more efficient than a steam boiler solution. Steam for process use was to be generated by WHRU in the GT exhaust stacks. This arrangement was not found to be sufficiently electrically stable, particularly in upset and start-up conditions. Lack of	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			stability would result in lost production and extended flaring leading to more atmospheric pollutant and GHG emissions, thereby negating the energy efficiency benefits achieved through the application of GTs. Direct drive aero derivative GTs were also considered to improve fuel efficiency by about 25% over the use of steam boilers, however the design was not mature enough to be adopted for the Prelude FLNG. Steam turbines were the option selected. Seven steam boilers generate sufficient steam to drive the main compressors and supply 120MW. This is less energy efficient than the other two options, resulting in an increase in fuel use, however is a more robust design in terms of equipment reliability. A more reliable Prelude implies less flaring due to lower frequencies of unplanned shutdowns.			
Engineering	Use of Shell's proprietary DMR process in three stages	Yes	Shell's proprietary DMR process uses mixed refrigerant for pre-cooling and liquefaction cycles which allows for a flexible process to enable full power utilisation over a wide range of ambient temperatures. Shell's 3-stage DMR process technology increases the liquefaction efficiency by 8% whilst using the same amount of power and fuel gas.	N/A	N/A – The design features of the DMR process were selected, installed and commissioned at the time this EP commences, and are therefore not described in further detail here as an EPS.	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Engineering	Supply of colder seawater from 150m water and use as a cooling medium for main process	Yes	At a depth of 150 m, the sea water supply is at a temperature of 15-23°C, depending on tidal waves and season. For every degree that the temperature of the cooling medium is colder, 0.6-0.7% of production is gained for the same energy cost. Taking this quantity of seawater 150m below surface rather than at surface is novel for FLNG from a design, construction and installation perspective. Prelude cannot produce without the operation of this seawater system; therefore, no EPS is set for its operation.	N/A	N/A – The design features of the CW system were selected, installed and commissioned at the time this EP commences, and are therefore not described in further detail here as an EPS.	N/A
Engineering	Maintenance of the flare system	Yes	Flare flow meters, upstream of the actual flare boom, are maintained according to the maintenance schedule and maintenance system to ensure they are within reliability, availability and accuracy requirements for this equipment. This enables accurate measurement of flare GHG emissions and associated VOC's. Since Prelude is now in continuous operation, there is no practical way to maintain the operating flare tip as at a minimum the pilot flare is ignited at all times. The flare system has been designed to operate in this manner.	9.5	Flare flow meters will be maintained in accordance with the maintenance management system to ensure they meet required reporting accuracy needed for NGER.	Flare meter maintenance and calibration records.
Engineering	Design of flare and AGRU vent system optimized to minimise the risk of flare flame-out to a tolerable level.	Yes	The flare boom design has been optimized to minimise the risk of a flare flame out. Avoiding flare flame outs minimises both air emissions and GHG emissions as flare combustion avoids the	9.6	No recorded flare flame outs which is not immediately auto-ignited.	Incident records of flare flame out events where auto ignition has not occurred.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			release of potentially harmful GHGs like methane and air pollutants like VOC's. There have been no flare flame out since Prelude commenced operations. Prelude's flare is fitted with ignition control to spark the flame as soon as flame out is detected.			
Engineering	Minimise use of diesel during start up and shutdowns by using boil off gas or vaporised LNG where possible	Yes	This reduces GHG emissions associated with re-start of the Prelude FLNG.	8.2	Limit boilers running on diesel to periods when fuel gas is not able to reasonably be used including periods such as start-up and shut down.	Daily report
Engineering	Maximise efficiency of pumps (U00000)	Yes	This control has been implemented on Prelude to inherently reduce GHG emissions and increase energy efficiency.	N/A	N/A - This design feature is not appropriate to have a performance standard set against it.	N/A
Engineering	All control valves to be specified 'low emission' type (U00000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	Minimise heat loss through insulation. Insulation used is the same as on onshore plant however due to the compact nature of Prelude, the piping run length and consequently heat loss is much less (U00000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	Use of LNG expanders to produce an isentropic	Yes	This control has been implemented on Prelude and is accurate as of the time	N/A	N/A - This design feature is not appropriate to have a	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	pressure drop for the LNG and refrigerant fluids (U14000)		the facility was in detailed design. It improves the efficiency of the production process, therefore reducing GHG emissions.		performance standard set-up against it.	
Engineering	NGL Recompressor and expander turbo expander (U14000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design. It improves the efficiency of the production process, therefore reducing GHG emissions.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	Heat Exchangers printed circuit and coil wound heat exchangers to increase efficiency (U14000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	Make the steam condensate line downstream of the MR and PMR Steam turbines negative pressure to increase the efficiency of the turbines (U14000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	End Flash Compressor and Motor Driver - Make motor driver variable speed (U14000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design. It improves the efficiency of the production process, therefore reducing GHG emissions.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	End Flash unit - Prior to use of end flash gas as fuel, use the low temperatures in the end flash gas to liquefy natural gas (U14000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design. It improves the efficiency of the production	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			process, therefore reducing GHG emissions.			
Engineering	HP Steam Boiler Steam Force Draught Fan (U40000) - select a high efficiency technology for fans (U14000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	Flare headers - Nitrogen purging rather than fuel gas purging (U63000)	Yes	This control has been implemented on Prelude and is accurate as of the time the facility was in detailed design. This reduces the amount of gas combusted on the facility, therefore reducing GHG emissions.	N/A	N/A - This design feature is not appropriate to have a performance standard set-up against it.	N/A
Engineering	Increasing the steam system pipe class above 900 pounds (U63000)	No	Increasing the temperature and pipe class above 900 pounds in the steam system would significantly reduce the amount of energy input required for the system. However, increasing the pipe class above 900 pounds would mean much higher CAPEX, weight of piping and HSE risks. The sum of these costs was considered greater than the possible benefits in energy efficiency that can be achieved.	N/A	N/A	N/A
Engineering	Decrease the condensing pressure of steam to below 200mbar (U63000)	No	Although the condensing pressure of the condensing steam turbines is at the lowest that can be achieved with the designed cooling system, further efficiencies could be achieved by increasing the size of the cooling system. However, this would be a significant change in the cooling system and was rejected because further study costs	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			were considered too high at the time of design.			
Engineering	Increase thermal efficiency of the boilers	No	An opportunity was raised during design to consider maximising the Thermal Efficiency of Boilers. On investigation, it was found that the boilers' thermal efficiency could be increased from 90% to 93% by increasing the size of the economisers. Increasing the thermal efficiency above 93% would require additional equipment meaning a significant increase in size, weight and cost and hence increasing the efficiency above 93% was rejected early in the investigation. A financial assessment was then carried out, which demonstrated a net benefit to increasing the efficiency from 90 to 93%. However, to obtain this increase in efficiency it is necessary to reclaim a greater amount of energy from the exhaust gas. This was found to lead to an increase in the risk of acid corrosion of components occurring during commissioning (from sulphuric acid in diesel exhaust). This risk was considered significant enough to reject the opportunity and maintain the design efficiency at 90%.	N/A	N/A	N/A
Engineering	Change all electrical motors >1 MW to VSD.	No	An opportunity was identified to consider changing all large motors (over 1MW) to Variable Speed Drivers (VSD) in order to increase their efficiency in reacting to low flows. Although, it has been registered as 'rejected' on the basis that not all large	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			motors are fitted with Variable Speed Drivers, it could be considered as partly implemented as those large motors where a significant benefit in applying variable speed exists have been changed to steam turbines. The MEG Recycle Pumps, Overhead Compressor Driver and Endflash Compressor Driver are all Steam Turbines in the design. Other pumps over 1MW have minimal variation in flow, so there is little benefit in making them variable speed.			
Engineering	Replace boilers with cogeneration combined cycle.	No	The Prelude FLNG heat and power system is based on boilers and steam turbines as opposed to a Co-Generation or Combined Heat and Power plant. This decision has the biggest individual impact on GHG output with Combined Heat and Power Plants up to 1/3 more efficient than boiler based systems. However, at the time of design, Co-Generation and Combined Heat and Power were relatively new technologies and were considered to carry significant technology risks. Given the level of technical novelty already incorporated into the FLNG design, and the costs in terms of risks were considered greater than the benefits in energy efficiency that could be achieved at the time of design.	N/A	N/A	N/A
Administrative and	Prelude Operations Playbook provides fuel model guidance to minimise GHG emissions	Yes	Prelude's Operations Playbook provides a guide and aims to achieve an optimised process shutdown and start up sequence to minimise process upsets and reduce	9.7	The Prelude Operations Playbook is available and provides panel operators the recommended optimum	Prelude Operations Playbook

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Procedural Controls	during planned plant shutdowns and start-ups.		loss of hydrocarbon inventory to flare and acid gas venting. This playbook has been updated regularly during the start-up phase to optimise the start-up process and address issues which have resulted in increased flaring. It is continually updated through learning from the early phase operations and as new opportunities are identified to improve efficiency or minimise flaring.		fuel mode during planned plant shutdowns and start-ups to achieve GHG reduction.	
Administrative and Procedural Controls	Report annually the calculated GHG Emissions and Energy to the Clean Energy Regulator.	Yes	This is a regulatory requirement under the NGER Act 2007. Because NGER reporting is a regulatory requirement, no EPS has been developed for this requirement. The Safeguard Mechanism baseline is a requirement that needs to be met. The Safeguard Mechanism sets a GHG baseline for the Prelude FLNG. Any exceedance is required to be offset through the purchase of ACCUs..	N/A	N/A	N/A
Administrative and Procedural Controls	Fugitive emission design controls	Yes	Fugitive emissions are those emissions that occur from leaks from valves, flanges from any hydrocarbon processing areas of the plant. Fugitive emissions make up <1% of the GHG emissions from the facility. As outlined in the Prelude Environment Basis of Design, fugitive emissions on Prelude FLNG shall be significantly reduced by the following adopted controls:	9.8	Undertake targeted topside fugitive emissions / general leaks survey on an annual basis, when operating, and repair identified leaks in line with the maintenance management system where it is ALARP to do so.	Records of leak detection and repair survey and associated maintenance repair records where relevant.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			• Use of valves with bellow or double packing seals or equally efficient equipment; • Magnetically driven or canned pumps, or pumps with double seals and a liquid barrier; • Minimisation of the number of flanges; • Closed sampling systems; • Drainage of containment effluents in closed system; • Use of relief valves instead of open vents in tank roofs; and • Use of pumps with double mechanical seals must be used for all substances, except inert liquid. This is demonstrated effective during the operation of Prelude by the results of the most recent LDAR surveys. The last survey completed in second half of 2019 found 7 leaks up to a maximum leak rate of 34% Lower Explosive Limit @ 100mm. This is a low amount of detected leak sources given the amount of potential leak sources on Prelude FLNG. This result also suggests that actual fugitive emissions are currently lower than predicted during design. All topside hydrocarbon containing modules on Prelude are surveyed for fugitive			

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			emissions at least once per year whilst in production. Shell Group has a target to maintain methane emissions intensity below 0.2% by 2025[38]. This target covers all oil and gas assets for which Shell is the operator and therefore includes Prelude. The objective of the Prelude Methane Improvement Plan (MIP) is to improve methane emissions reporting, focusing on reducing uncertainty associated with methane emissions quantification. This will facilitate prioritisation of methane emission sources for targeted abatement projects. Fugitive (general leaks) methane sources are being addressed via comprehensive LDAR program. Specific actions aimed at reducing methane emissions for Prelude include: 1) annual abatement project identification and assessment process (first workshop occurred in November 2020). 2) GHGEMP with emissions intensity and abatement targets linked to asset performance scorecard, required annual deliverable. MIP to be included in an			

[38] For more information see: https://www.shell.com/energy-and-innovation/natural-gas/methane-emissions/_jcr_content/par/textimage_438437728.stream/1587995196996/53beef2f8ba2e90560c074f56552e2acfe30582b/shell-methane-case-study.pdf

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			Annex of the GHGEMP. 3) Asset Quarterly Performance Appraisal (QPA) conducted and assessment of progress of MIP deliverables and abatement projects are tracked quarterly.			
Administrative and Procedural Controls	Carbon and Energy Management Information Systems (CEMIS)	Yes	A CEMIS, which is a three tier (plant, unit and equipment level) operational performance system available to the panel operator which provides them with a “live” monitoring of plant, unit and equipment performance. This system compares actual performance against a set of value drivers at equipment or unit level to optimise the plant operational and GHG emissions performance. Specified plant includes: - AGRU - NGL Extraction and Liquefaction - Steam and Power - Flaring and Venting	9.9	Commence monitoring plant energy performance within 18 months of completion of all relevant performance tests for specified plant equipment but no later than the end of 2024.	Records demonstrating CEMIS has been implemented
Engineering, Administrative and Procedural Controls	Greenhouse Gas and Energy Management (GHGEM) System including Greenhouse Gas and Energy Management Plan (GHGEMP), Abatement Workshop and Assessment Process, OP Process and Fuel and Flare Forum	Yes	Prelude has a GHGEM System which includes a GHGEMP, which receives and incorporates key inputs from the abatement assessment and OP processes (Refer section 10.1.11). The annual abatement workshop and assessment process will ensure that further detailed assessment of additional	9.10	Abatement opportunities in and out of plan are identified and summarised within GHGEMP from 2021 revision onwards.	Greenhouse Gas and Energy Management Plan

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			emission reduction opportunities is undertaken and will ensure impacts from GHG emissions are reduced to ALARP on an ongoing basis. The GHGEMP is reviewed annually to incorporate the regular review and optimisation processes that occur, namely the abatement workshop and assessment process and subsequent OP process, which sets out integrated GHG targets for the Prelude FLNG. The full GHGEM system is further described in section 10.1.11.	9.8	Undertake targeted topside fugitive emissions / general leaks survey on an annual basis and repair identified leaks in line with the maintenance management system where it is ALARP to do so.	Records of leak detection and repair survey and associated maintenance repair records where relevant.
				9.11	Conduct annual abatement assessment process as outlined in section 10.1.11.	Records of the GHG abatement assessment process.
				9.12	GHG (total emissions, intensity and abatement) targets will be set and tracked on a monthly basis (quarterly for abatement) to ensure GHG emissions are ALARP on an ongoing basis.	GHGEMP and records of monthly GHG target tracking with the Prelude asset leadership team.
				9.13	Implementation of GHG abatement projects from 2021 onwards will result in	Records of measured or calculated GHG emissions abated through implementation of GHG abatement projects.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
					at least 250kt CO_{2-e}[39] in reduced or avoided emissions by 2025 with at least 100kt CO_{2-e}[40] occurring by the end of 2022.	
				9.14	In the event trending of GHG emissions is reliably forecast to risk exceeding 2.95 Mt CO_{2-e}, proactive action will be taken in order to ensure GHG emissions are reduced to ALARP, thus providing the highest likelihood of not exceeding 2.95Mt CO_{2-e} in a year.	Records demonstrating proactive action is taken in order to reduce GHG emissions to ALARP.
				9.15	Asset surveillance engineering will carry out trending of GHG emissions and implemented abatement projects on at least a quarterly basis in order to track progress towards meeting set targets and GHG EPOs.	Records demonstrating trending of GHG emissions and implemented abatement projects occurs at least a quarterly basis.

[39] On a cumulative basis between 2021-2025 inclusive.

[40] On a cumulative basis between 2021-2022 inclusive.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
				9.16	In the event emissions in any year exceed 2.95Mt $CO_{2\text{-}e}$, review the risk assessed GHG ALARP items on the fuel and flare register to expedite activities to limit further emissions to ALARP.	Records demonstrating a review of ALARP assessment was carried out and that records demonstrate emissions are still be managed to ALARP.

9.11.5 Acceptability of Impacts

The assessment of risks from GHG emissions associated with the Prelude project has been considered in the following context.

- Defined acceptable level of GHG emissions set for Prelude
- Principles of ESD
- Relevant requirements
- Significant impacts to MNES
- Internal and external context.

Prelude's Defined Acceptable Level of GHG Emissions

Gross scope 1 GHG emissions are an inherent feature of Prelude operations. Gross scope 1 emissions from Prelude will not exceed 2.95 Mt of $CO_{2\text{-}e}$ in a calendar year, on an aggregate basis. Over the next five years, between 2021 and 2025, Prelude's average GHG emissions will not exceed 2.6 Mt of $CO_{2\text{-}e}$ and this represents a defined acceptable level of emissions. Acceptability is considered in light of:

- the development concept for Prelude that was constructed was assessed to be ALARP at the time of completing detailed design. In addition, Shell recognises that Prelude scope 1 emissions must be reduced to ALARP on an ongoing basis in order to be acceptable. An ALARP assessment of Prelude's GHG emissions is outlined in section 9.11.4 and abatement projects that improve GHG performance will be implemented on Prelude. Shell will demonstrate emissions will be reduced to ALARP on an ongoing basis through implementation of key GHGEM processes outlined in section 10.1.11. Implementation of GHG abatement projects from 2020 onwards will result in at least 250kt CO2-e in reduced or avoided emissions by 2025 with at least 100kt CO2-e occurring by the end of 2022;
- the level of GHG emissions for Prelude is consistent with design GHG emission predictions for the facility from 2011/12;
- Prelude will be operated to maximise reliability, availability and utilisation which in turn delivers an optimised GHG intensity outcome along with maximising the use of already sunk direct and indirect environmental impacts associated with the footprint of constructing the Prelude FLNG;
- the forecast GHG emissions represent a reasonable basis as outlined in section 10.1.11; and
- the level accounts for about 100kt CO2-e uncertainty of Prelude FLNG emissions throughout its operating life, which is inherent in forecasts and future investment decisions.

Principles of ESD

The Prelude FLNG GHG emissions are consistent with the principles of ESD. Of particular note is the principle of inter-generational equity – that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. Prelude demonstrates it meets this principle through ensuring GHG emissions do not exceed the defined acceptable level and by ensuring significant GHG abatement targets are achieved. In addition, the risks and impacts from GHG emissions from Prelude are consistent with the Paris Agreement and principles of ESD based on:

- meeting existing end-user demand for energy;
- facilitating the distribution of lower carbon energy to meet the UN Sustainable Development goals, in particular;
  - affordable and clean energy;
  - climate action;
  - no poverty; and
  - decent work and economic growth.
- the precautionary principle has been applied, and mitigation measures have been adopted in the absence of full scientific certainty;
- global policies and actions related to GHG emissions have been considered and Australian legislation supports these policies and will be complied with, as noted further below;
- the Prelude EIS has been subject to public comment and regulatory scrutiny which ensures the broadest community of people have been involved in management of issues that affect them. In addition, relevant persons have been consulted in the preparation of this EP. No objections or claims relevant to GHG emissions were raised by relevant persons during consultation; and
- the decision making process on production technology has effectively integrated both long-term and short-term economic, environmental, social and equitable considerations

This will be sustained throughout the life of the Prelude FLNG through inclusion of GHG minimisation and energy efficiency as selection criteria along with other technical and monetary considerations in implementing the GHGEM processes outlined in section 10.1.11 to ensure GHG emissions are reduced to ALARP and acceptable levels on an ongoing basis.

Significant Impacts to MNES

There is no clear and convincing evidence that GHG emissions from the Scope 1 GHG emissions from Prelude will result in significant impacts to threatened or migratory species (refer section 9.11.2). The impacts and risks from the GHG emissions aspect of the Prelude FLNG on the Commonwealth marine environment do not exceed any of the significant impact criteria for any MNES. However, given the lack of full scientific certainty, GHG emissions will be managed to ALARP and acceptable levels on an ongoing basis.

Relevant Requirements

The legislative frameworks for managing impacts from Prelude FLNG's GHG emissions are well-developed and comprehensive because they cover prevention, abatement, and offset of emissions in a structured and predictable way. In the operation of Prelude, Shell complies with and commits to continued compliance with the mechanisms implemented in Australia to achieve the goals of the Paris Agreement.

Australia has committed to a NDC under the Paris Agreement to reduce emissions by 26-28% below 2005 levels by 2030. The Commonwealth government's plans to achieve this commitment have included recognition of emissions associated with new LNG projects in Australia, including Prelude.

Australia's commitments under the Paris Agreement are delivered through a range of policies and initiatives, with the primary legislation for emissions management being the NGER Act. The NGER Act provides a single, national framework for the reporting and distribution of information related to GHG emissions, GHG projects, energy production and energy consumption to meet the following objectives:

- inform government policy;
- inform the Australian public;
- help meet Australia's international reporting obligations;
- assist Commonwealth, state and territory government programmes and activities, and
- avoid duplication of similar reporting requirements in the states and territories.

Under the NGER Act facility operators are required to report on direct GHG emissions, energy production and energy consumption, enabling the capture of data on energy flows and transformations occurring throughout the economy. The NGER Act is aligned with the GHG Protocol in defining Scope 1 and 2 emissions.

The safeguard mechanism provides a framework for Australia's largest emitters to measure, report and manage their emissions. It was established to ensure that emissions reductions delivered through the Emissions Reduction Fund are not displaced significantly by GHG emissions over and above business-as-usual- levels elsewhere in the economy[41]. It does this by requiring large facilities, whose net emissions exceed the safeguard threshold of 100,000 tonnes of CO_{2-e} per annum, to keep their net emissions at or below emissions baselines set by the Clean Energy Regulator. Key elements of the mechanism include:

- safeguard facilities must meet the reporting and record keeping requirements of the NGER Act, including the Clean Energy Regulator's requirements for audits prior to baseline setting or to check compliance management;
- if a safeguard facility is likely to exceed its baseline, the responsible emitter must act, including by purchasing and surrendering Australian Carbon Credit Units (ACCUs) to offset excess emissions; and
- penalties for non-compliance.

Under the Commonwealth government's framework for management of Scope 1 and 2 emissions in Australia Shell reports as a corporate group under the NGER Act and as the entity with "operational control" of the Prelude FLNG facility, this includes emissions from Prelude.

Shell has complied with and will continue to comply with the contemporary requirements as defined under the NGER Act and associated Safeguard Mechanism

[41] Explanatory Statement, NGER (Safeguard Mechanism) Rule 2015

(including any future amendments or changes in law). In summary this will require Shell to:

- complete and submit annual NGER reports for the Kyoto Protocol listed (or applicable post-Kyoto agreement at the time of operations) GHG emissions on a CO_2 equivalency basis (as defined in Section 9 of the NGER Act and NGER Regulations 2008) by fuel type, and the relevant requirements of the NGER (Safeguard Mechanism) Rule 2015;
- comply with the Safeguard Mechanism baseline set for the Prelude FLNG which is currently 2,725,687 tCO_{2-e}; and
- if the Safeguard Mechanism baseline for Prelude is exceeded, follow requirements outlined under the Safeguard Mechanism. This may require Shell to purchase and surrender ACCUs.

Regarding the NGER Act, the Safeguard Mechanism baseline could be used as a proxy for what the Australian Government has deemed to be an acceptable level of emissions from a given project. Oversight is provided by the Clean Energy Regulator audit processes, and there are reasonable penalties associated with exceedances. This creates an incentive for Shell to keep emissions within the established baseline. However, Shell recognises that the Safeguard Mechanism is a regulatory reporting requirement that may be interpreted as an accounting approach rather than remaining focussed on environmental acceptability criteria, and therefore does not by itself deliver a reduction in emissions.

Internal and external context

Shell Australia, as part of the wider Shell Group, is playing a role in working towards larger, group-level ambitions to be a net zero emissions energy business[42] by 2050, and sooner if that is possible, in step with society and our customers.

The context for the Shell Group ambition was the recognition that for society to achieve a 1.5 degrees Celsius future in line with the Paris Agreement, the world is likely to need to stop adding to the stock of GHG in the atmosphere – a state known as net-zero emissions – by around 2060. But those who can move faster, must move faster – advanced parts of the world are likely to need to reach that point by 2050.

Shell Group currently proposes to work towards this ambition in three ways, in step with society:

- an ambition to be net zero on all the emissions from the manufacture of all its products (scope one and two) by 2050 at the latest;
- accelerating Shell Group's Net Carbon Footprint ambition to be in step with society's aim to limit the average temperature rise to 1.5 degrees Celsius in line with the goals of the Paris Agreement on Climate Change;

[42]As of the date of this document Shell Group's operating plans and budgets do not reflect Shell Group's Net-Zero Emissions ambition. Shell Group's aim is that, in the future, its operating plans and budgets will change to reflect this movement towards its new Net-Zero Emissions ambition.

- aiming to help its customers decarbonise. That means working with customers to address the emissions which are produced when they use the fuels they buy from Shell Group. That effort includes working with broad coalitions of businesses, governments and other parties, sector by sector, to identify and enable decarbonisation pathways for each sector.

Shell Group's aim is that, in the future, its operating plans will change to reflect this net zero ambition.

Examples of current Shell Group-level initiatives aimed at addressing uncertainty and contributing to society achieving the goals of the Paris Agreement targets are:

- unconditional three-year target (to 2022) to reduce its Net Carbon Footprint[43] against the 2016 baseline by 3-4%, linked to remuneration for more than 16,500 staff. It is intended that this target setting will be done annually, with each year's target covering a three-year period;
- continued growth of the New Energies business, having already invested in a range of low-carbon technologies, from biofuels, hydrogen and wind power, to electric vehicle charging and smart energy storage solutions;
- monitoring and reporting on Shell Group performance. Every five years, the Shell Group proposes to assess collective progress toward meeting the Paris Agreement's long-term goal informed by the agreement's five-yearly "global stocktake". Shell Group will review its ambition based on this assessment of progress, revised scenarios, and nationally determined contributions. Inherent in this review will be an appraisal of developments in technology and policy. The first five-year review is currently anticipated to take place after 2021;
- developing scenarios. Shell Group has been developing possible visions of the future since the 1970s. Shell Scenarios[44] ask, "what if?" questions encouraging leaders to consider events that may only be remote possibilities and stretch their thinking. These scenarios also help governments, academia and business in understanding possibilities and uncertainties ahead. For example, Shell has built a scenario looking at what the EU might do to decarbonise energy in the next 30 years. It explores a possible, but highly demanding pathway to help achieve a climate-neutral EU by 2050 – including deployment of clean technologies and shifting choices to support a green economy.

Shell Group's business plans will change over time in step with society's progress towards meeting the Paris Agreement. Further information and examples of how the Shell Group is playing a role in the energy transition is available on the website (www.shell.com).

[43] Shell Group's "Net Carbon Footprint", includes Shell Group's carbon emissions from the production of its energy products, its suppliers' carbon emissions in supplying energy for that production and its customers' carbon emissions associated with their use of the energy products it sells. Shell Group only controls its own emissions. The use of the term "Net Carbon Footprint" is for convenience only and not intended to suggest these emissions are those of Shell Group or its subsidiaries.

[44] These scenarios are a part of an ongoing process used in Shell Group for over 40 years to challenge executives' perspectives on the future business environment. They are designed to stretch management to consider even events that may only be remotely possible. Scenarios, therefore, are not intended to be predictions of likely future events or outcomes.

Shell Australia, as operator of Prelude is playing a role in working towards the larger group-level ambitions, for example by:

- setting performance outcomes which result in significant GHG abatement between 2021 and 2025 (see section 9.11.6); and
- providing natural gas to customers to help them lower their own emissions by displacing other higher carbon intensity energy sources.

Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking the assessment of impacts and risks. Shell has also considered the internal context, including Shell's environmental policy and corporate requirements (as further outlined in section 10.1.11). The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

As outlined above, the acceptability of the impacts and risks from GHG emissions from Prelude operation have been considered and found to be acceptable in the context of:

- Defined acceptable level of GHG emissions set for Prelude
- The principles of ESD
- Relevant requirements
- Significant impacts to MNES
- Internal and external context

9.11.6 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
The maximum gross scope 1 emissions limit from the Prelude FLNG will not exceed 2.95 Mt $CO_{2\text{-}e}$ in any given year, on an aggregate basis.	Calculated GHG emissions reported on calendar year basis (aggregate).
Over the next five years of operation (namely 2021 – 2025), GHG emissions will not exceed 2.6 Mt $CO_{2\text{-}e}$, on average.	Calculated GHG emissions reported on calendar year basis.
Implementation of GHG abatement projects from 2021 onwards will result in at least 250kt $CO_{2\text{-}e}$[45] in reduced or avoided emissions by 2025 with at least 100kt $CO_{2\text{-}e}$[46] occurring by the end of 2022.	Calculated GHG emissions abated on a calendar year basis through implementation of GHG abatement projects.

45 On a cumulative basis between 2021-2025 inclusive.

46 On a cumulative basis between 2021-2022 inclusive.

9.12 Waste Management

9.12.1 Aspect Context

Many activities on the FLNG and supporting vessels results in the generation of a variety of hazardous and non-hazardous waste streams. Non-hazardous wastes include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard and scrap steel. Hazardous wastes include oil contaminated materials (e.g. sorbents, filters and rags), amine waste, spent chemical containers, paint solvents and containers, light tubes and batteries. Sand and sludges may also be generated during well clean-up operations and process vessel maintenance. All wastes generated (other than permitted waste discharge streams addressed elsewhere within this EP) are transported to shore for reuse, recycling, treatment or disposal by a licensed waste contractor. Note that any waste management and disposal within international jurisdictions is out of scope of this EP.

The management of wastes will not result in any planned impacts to the offshore marine environment given there is no planned release; however, improper storage and handling of wastes may result in accidental losses to the marine environment. These unplanned events may result in impacts to the marine environment. Shell's extensive operational experience indicates most accidental releases of wastes to the marine environment are typically relatively small scale and infrequent events.

Low level Naturally Occurring Radioactive Materials (NORMs) may also occur in sludges, scale and sands typically associated with the inlet/separator facilities, filters and low points within the hydrocarbon processing system. The NORM nuclides of primary concern in oil and gas production are Radium-226 and Radium-228. These decay into various radioactive progeny, before becoming stable. Radium-226 and Radium-228 belong to the two principal radioactive decay series associated with NORMs in the oil and gas industry (Uranium-238 and Thorium-228 respectively) (APPEA 2002 and IOGP 2008). Such waste streams are removed from the facility for appropriate treatment/disposal onshore.

During process related maintenance activities and opening of vessels, potentially mercury-contaminated guard beds, materials, filters, sludges and sands may also be recovered. As with other hazardous wastes, these will be assessed, handled and stored appropriately and sent to shore for proper disposal.

Waste segregation is established and maintained through the provision of labelled bins, skips or other appropriate receptacles used to comingle similar waste streams in accordance with their classification to realise efficiencies in storage, transport, treatment, recycling and/or disposal.

There are a number of dedicated and secondary/contingency waste storage areas on the FLNG facility to ensure there is sufficient capacity for all anticipated activities and phases of the activity. Waste storage on the FLNG facility has a capacity to accommodate approximately 14 days of waste accumulation during normal operations. Waste storage areas are described further in the Prelude FLNG Waste Management Procedure (HSE_PRE_010753). Additional temporary laydown areas for waste storage may be established during specific campaigns as required, e.g. during major maintenance. Waste receptacles are back loaded onto supply vessels via crane for transportation to onshore facilities.

9.12.2 Description and Evaluation of Impacts and Risks

Physical Environment

Improper management of hazardous or non-hazardous wastes and/or accidental release may result in pollution of and contamination in the marine environment via reduction in water and sediment quality. This may result in toxic effects, however given the dynamic nature of the offshore receiving environment and the small nature and scale of most potential waste spills/releases, any such effects will be of short duration and highly localised. The implications to potentially sensitive receptors due to a reduction in water and sediment quality are discussed further in the Biological Environment assessment below and are not assessed further in the context of the physical environment.

Biological Environment

There is the potential for impacts on marine fauna that may interact with wastes, such as packaging and binding, should these enter the ocean as marine fauna can become entangled and waste plastics can be ingested when mistaken as prey (Ryan et al. 1988). Marine debris has been identified as a threat for a range of vertebrate fauna species, including marine turtles, birds, marine mammals and sharks and rays. Marine debris is listed as a key threatening process under the EPBC Act. Persistent wastes such as plastics are of particular concern, as the threat to fauna may remain long after the waste is released. Potential impacts of marine debris on key fauna species include (DEWHA 2009c):

- Entanglement, potentially resulting in restricted mobility, drowning, starvation, smothering and wounding
- Ingestion (particularly of plastics) leading to physical blockage of digestive systems, leading to starvation
- Acute or chronic toxic effects.

Plastic debris can also act as a concentrator of Persistent Organic Pollutants (POPs) that occur universally in seawater at very low concentrations as they get picked up by meso/microplastics via partitioning. The hydrophobicity of POPs can facilitate concentration in the meso/microplastic litter at a level that is several orders of magnitude higher than that in seawater. When ingested by marine species, contaminated plastics present a credible route by which the POPs can enter the marine food web.

NORMs are comprised of radioactive elements such as uranium, radium and radon, and are often present at very low concentrations during normal reactions between water and rock. The associated environmental risk is incorrect disposal of waste containing NORMs, leading to pollution of the ocean and potentially chronic and acute toxicity impacts on marine flora and fauna. Inappropriate storage, handling or disposal may also impact on human health (depending on the composition of the NORMs) if the workforce are exposed to the material, however this aspect is managed via the Safety Case regime. To be classified as hazardous radioactive material from a waste management perspective, the applicable Threshold Activity Concentration Limits (TACL) must be exceeded as defined by the relevant state and/or federal regulations. The TACL is the upper level of radioactivity prescribed by the Statutory Authority below which material may be classified as Radiological Non-Hazardous. Disposal of materials that do not exceed the defined TACL may be carried out as per general non-hazardous waste.

Habitats within the Operational Area are not considered to be particularly sensitive or of high conservation value and are well represented in the region. Given the typically small volumes of wastes that may be released during any given event, potential impacts to sensitive species are expected to be restricted to individual animals. Many of the vertebrate species considered vulnerable to waste impacts occur seasonally or are expected to occur in low densities (e.g. transiting the area).

Apart from waste streams that are permitted for discharge in accordance other sections of this EP, there are no other planned waste discharges from the FLNG facility or support vessels. Given that any direct impacts from unplanned events to receptors in the offshore environment are likely to be localised and short-term, the residual risk of waste release is assessed to be Dark Blue as per Table 9-73.

9.12.3 Risk Assessment Summary

Table 9-73: Waste Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Physical Environment	N/A	N/A	N/A
Biological Environment	Slight	C	Dark Blue
Socio-Economic Environment	N/A	N/A	N/A

9.12.4 ALARP Assessment and Environmental Performance Standards

Table 9-74: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	Waste generation cannot be eliminated from the offshore facilities.	N/A	N/A	N/A
Substitution	N/A	N/A	The use of alternative materials which will produce less wastes is part of the Product Stewardship Standards of Shell. If materials that generate less wastes are identified in the future, these will undergo appropriate assessment.	N/A	N/A	N/A
Engineering	Designated Waste Storage Areas available on Prelude.	Yes	Wastes are properly stored, secured, adequately contained and transported to avoid the risks of accidental overboard discharge or release, especially during adverse weather. The Prelude FLNG Waste Management Procedure ensures the cradle-to-grave management of wastes as required by the Shell HSSE Control Framework Manual on Waste Management.	10.1	Designated waste storage facilities on Prelude is available to enable waste to be secured and stored on facilities.	Assurance against waste management facilities, equipment and practices demonstrates that appropriate waste storage facilities have been provided and maintained.
Administrative and Procedural Controls	Prelude FLNG and required marine support vessels will maintain a Garbage Management Plan (or equivalent) as relevant to vessel class, type and size.	Yes	Prelude FLNG and each required marine support vessel has its own Garbage Management Plan/Procedure (or equivalent) to manage wastes generated and stored onboard. All wastes that are not permitted for discharge are sent ashore for reuse,	10.2	Prelude FLNG and marine support vessels (to which MARPOL Annex V / Marine Order 95 applies) have a	Garbage Management Plan (or equivalent) is sighted onboard Prelude FLNG and marine support vessels and are maintained up to date.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			treatment, recycling and/or disposal as appropriate. This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and AMSA Marine Order 95.		current Garbage Management Plan (or equivalent) [47].	
				10.3	Prelude FLNG and marine support vessels to comply with AMSA marine order 94 & 95 (marine pollution prevention – packaged harmful substances/garbage), specifically: • No planned disposal of domestic waste, solid wastes or maintenance wastes overboard from vessels (other than planned discharges permitted by this EP).	Garbage record book maintained for Prelude FLNG and marine support vessels as per Marine Order 95 demonstrates that there were no unpermitted discharges of solid waste as part of the petroleum activities[48].
Administrative and Procedural Controls	Environmental awareness training for personnel	Yes	All employees and contractors working on or in connection with Prelude with defined responsibilities to fulfil as part of the EP are required to attend EP training that is formally tracked. The EP training covers waste management (Section 10.3.2).	10.4	FLNG and vessel-based personnel are aware of waste management requirements to avoid accidental losses of waste to the marine environment through the EP training.	EP training records

[47] Advice from the Recognised Organisation will be followed where there is any variation to the this EPS for the Prelude FLNG.

[48] Advice from the Recognised Organisation will be followed where there is any variation to the this measurement criteria for the Prelude FLNG.

9.12.5 Acceptability of Impacts

Table 9-75: Acceptability of Impacts – Waste Management

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations	Yes	Shell implements MARPOL standards and internal controls in relation to managing wastes, which reduces the likelihood of wastes being accidentally released to the marine environment. Given the remote location and distance from important habitats of the Operational Area, any accidental release of wastes to the environment would not be expected to interact with a large number of threatened or migratory MNES species.
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of risks from waste determined the residual risk rating of Dark Blue (Table 9-73). As outlined above, the acceptability of the risks from waste associated with the Prelude project has been considered in the following context.

Principles of ESD

The risks from waste are consistent with the principles of ESD based on the following points:

- The environmental values/sensitivities within the Operational Area are not expected to be significantly impacted, and
- The precautionary principle has been applied to the risk assessment.

Relevant Requirements

Management of the risks from waste are consistent with relevant legislative requirements, including:

- MARPOL Annex V as ratified by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
- *Navigation Act 2012 (Cth)* and *Protection of the Sea (Prevention of Pollution) Act 1983 (Cth)*:
  - Marine Order 94 – Marine pollution prevention – packaged harmful substances
  - AMSA Marine Order 95 (marine pollution prevention – garbage).
- Radiation Safety Act 1975 (WA)
- Code of Practice for the Safe Transport of Radioactive Material (Australian Radiation Protection and Nuclear Safety Agency 2019)

- Management of impacts and risks are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (Table 9-76).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of waste risks indicates significant risks to threatened and migratory species will not credibly result from the waste aspect of the Prelude petroleum activities given the limited number of animals that could potentially be impacted in the unlikely event of an unplanned release.

Alignment of the Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-76.

Commonwealth Marine Environment

The impacts and risks from the waste aspect of the Prelude field on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 8-1.

Table 9-76: Summary of Alignment of the Risks from the Waste Aspect of the Prelude Petroleum Activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Threats Relevant to the Project	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	Conservation advice on sei whale (Balaenoptera borealis) (DoE 2015c)	Pollution (persistent toxic pollutants)	Waste generated during the petroleum activities described in this EP will be managed in accordance with standard maritime requirements, international conventions (MARPOL), relevant Marine Orders and Shell's internal management system requirements. This management reduces the likelihood of the accidental release of hazardous and non-hazardous wastes into the marine environment. The frequency, quantities and nature of wastes that may be accidentally released into the environment are unlikely (C) to result in significant impacts to threatened/migratory species or the Commonwealth Marine Environment (Table 8-1).
	Conservation advice on fin whale (Balaenoptera physalus) (DoE 2015d)	Pollution (persistent toxic pollutants)	
	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015–2025 (Commonwealth of Australia 2015a)	Habitat modification including presence of oil and gas platforms/rigs, marine debris infrastructure and acute/chronic chemical discharge	
	Conservation advice on humpback whale (Megaptera novaeangliae) (DoE 2015b)	Entanglement – marine debris	
	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	Marine debris	
	Recovery Plan for Marine Turtles in Australia 2017–	Marine debris	

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Threats Relevant to the Project	Demonstration of Alignment as Relevant to the Project
	2027 (Commonwealth of Australia 2017)		
	Conservation advice on leatherback turtle (Dermochelys coriacea) (DEWHA 2008)	Marine debris	
	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	Marine debris	
	Conservation advice on whale shark (Rhincodon typus) (DoE 2015e)	Marine debris	
	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	Marine debris	
Commonwealth Marine Area	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	Marine debris	
	Threat abatement plan for the impacts of marine debris on vertebrate marine life (DEWHA 2009c)	Marine debris	
Wetlands of International Importance	N/A	N/A	N/A

External Context

There have been no objections or claims raised by Relevant Persons to date around the waste aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking future assessment of risks.

Internal Context

Shell has also considered the internal context, including Shell's Waste Strategy and Guidelines, environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of and risks from waste determined the residual risk rating to be Dark Blue (Table 9-6). As outlined above, the acceptability of the impacts and risks from waste have been considered in the context of:

- The established acceptability criteria for the waste aspect
- ESD

- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual risks of Dark Blue or lower to be inherently acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the waste aspect.

Based on the points discussed above, Shell considered the risks from waste associated with the petroleum activities described in this EP to be acceptable.

9.12.6 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
No injury or mortality of listed Threatened or Migratory MNES species as a result of unplanned waste discharge to sea.	Fauna observations and incident reports demonstrate no mortality of listed Threatened or Migratory species as a result of unplanned waste discharged from the petroleum activities within the Operational Area.

9.13 Emergency Events

9.13.1 Scenario Context

Several unplanned events (i.e. incidents or emergencies) resulting in the potential for large-scale releases of hydrocarbons or chemicals were identified for Prelude FLNG Operations, including:

- Loss of containment (LOC) of well fluids from subsea infrastructure (e.g. production wells, manifolds, flowlines or risers)
- LOC during FLNG product storage and offloading (LNG, LPG or condensate)
- LOC of heavy fuel oil to sea from marine vessels or product offtake tankers
- LOC of diesel during refuelling or following a collision between any marine vessels operating in the field
- accidental discharge of hazardous liquids or hazardous liquid wastes (e.g. MEG, amine, helifuel, etc) during bulk liquid transfers or lifting operations.

A worst-case scenario resulting from each of these events has been considered in this environmental risk assessment. Each of these scenarios is discussed further in this section. Each of these scenarios can result in smaller spills than the worst-case credible spills discussed below. The smaller spills have not been discussed specifically as their consequences will be lesser in both magnitude and impact.

LOC from Subsea Infrastructure

Prelude subsea infrastructure includes seven production wells, two production manifolds and one drill centre, four production flowlines, a riser manifold and risers as well as the well control umbilical. LOC could occur from any of these facilities due to e.g. a dropped object, corrosion, erosion, human error and/ or reservoir or external environmental events that could exceed the design tolerance of any of the components of this system.

Of these events, loss of well control incidents are known to be associated with the largest potential for environmental harm due to the large volumes of hydrocarbons contained in the reservoir and the considerable amount of time it requires to drill an offset relief well and stop the flow of reservoir fluids to the environment. Loss of well control incidents are most likely to occur during well drilling or workover when there is an open path for well fluids from the reservoir to surface, and reliance is on control systems and operators to detect an abnormal situation in its incipient stages to prevent it from escalation.

Drilling or workovers are not considered in scope of this EP, and any future requirements will be addressed in standalone campaign specific EPs and associated documentation. Now in the production phase, the source control responses will be different from drilling and completion operations. During the drilling phase, prior to Xmas tree installation, a capping stack can form a major component of a source control response plan, this is no longer the case. The current configuration of the Prelude production wells, with subsea Xmas trees installed and connected to subsea flowlines, negate the use of a capping strategy. Only for well activities where the Xmas tree is removed is this a viable consideration. As described in Section 6.4.4, there are no planned drilling or well workover activities during the life of this EP. Furthermore, in the event of the complete removal due to major damage of the production tree, debris clearance and capping activities are not considered viable as there would not be any infrastructure to land the cap on and secure it for well control operations.

Production well LOC events, although rare, are still a possibility and range from minor breaches in containment (pinhole leaks from corroded/ eroded piping or valves) through to large release events.

Drilling of a relief well would be the primary method of source control due to the presence of the subsea Xmas tree that would preventing access for the installation of a capping stack.

The modelled well fluids flow rate and therefore the worst credible discharge, in the second scenario is estimated at 20,000 bbl (3,180 m^3) per day, yielding a total released volume of 1,600,000 bbl (254,400 m^3). This rate is based on the maximum rate of gas flow expected from the most productive of the seven Prelude wells during production drilling, and without the completion in the well, and the number of days (80 days) to drill a relief well in the case of loss of well control. This volume has been used for oil spill predictive modelling (Section 9.13.2) and the risk assessment presented in this section of the EP. This volume has also been used as the basis for oil spill planning described in the OPEP.

The worst case discharge, defined as the maximum rate a well will flow, depends on the design configuration. The modelled well fluids flow rate is considered to be highly conservative because it is based on using the flow rates from the Upper Limit rather than the Base Case or High Case for a blowout through 9 $^5/_8$" casing, and does not allow for the additional frictional pressure drop from having a completion in the well.

The actual worst credible discharge during operations (blowout through the 7" production tubing) is predicted to be 10,138 bbl (~1,611 m^3) per day, yielding a total release volume of 811,040 bbl (128,944 m^3) over 80 days.

The likelihood of such incidents in Australia has been very low. A report on world-wide well control incidents commissioned by the US Department of the Interior (Bercha

International Inc. 2014) indicates the frequency of production well control incidents in Australia, derived from Gulf of Mexico incident data (1980 – 2014), to be 0.104 incidents per 1000 well years, or 1.04E-04 per well year. For the 7 production wells in the Prelude field, this translates into a frequency of 7.3E-04 well control events per annum, or remote likelihood of a well incident. Note that the higher the well fluids loss flowrate, the lower the frequency of well blowout in accordance with the formula derived by DNV based on historical data i.e. 6.9 x 10-5 Q-0.3 per well year, where Q is the mass of spilled hydrocarbons in tonnes (Det Norske Veritas, 2011).

All other releases from subsea infrastructure will be orders of magnitude smaller in volumes lost to sea compared to the uncontrolled production well release scenario with SCSSV failure. These smaller release scenarios have not been discussed or modelled further.

LOC from Product Storage and Offloading

The liquid product streams on Prelude are LNG, LPG (propane and butane) and condensate. During production these are rundown to their respective cargo storage tanks within the substructure and stored at atmospheric pressure. The substructure is double hulled on each side extending over the full length of the storage tanks. LNG, LPG and condensate storage tanks are located inboard of segregated ballast tanks covering the full length of the storage area and are separated from each other by either a void space or a ballast tank. In addition, the tanks are protected from the topsides hazards by a main deck designed to withstand explosion overpressure, jet fire and cryogenic spills. A heating system is installed to heat the transverse cofferdams and the upper portion of the centreline water ballast tanks surrounding the cargo tanks to maintain the temperature of the structure and prevent brittle failure.

LNG or LPG leaks from the topsides process modules or any hydrocarbon release from the cryogenic areas of the plant are directed to sea to protect the facility from damage due to cryogenic spills and prevent process safety incidents and escalation. Topsides condensate spills on the FLNG, however, are designed to be captured and contained in the drainage system (Appendix 13.0) and reclaimed back into the process where possible or disposed of appropriately.

Only a single product stream is offloaded at any one time.

LOC from LNG and LPG Storage and Loading

The FLNG Ship Collision Study and Collision Analysis for Substructure indicate a remote to extremely remote likelihood of ship collision as detailed in the Prelude FLNG Safety Case (Shell Australia 2017). The overall collision frequencies are dominated by the contribution of the low energy on approach supply and product offtake vessels, which would cause no breach of the outer hull but localised damage only.

For a loss of containment of LNG, LPG or condensate product from a single cargo tank to occur, collision energy levels between 193 and 500 MJ should be imparted to the FLNG hull. Energy levels greater than 500 MJ could cause extensive hull damage with release of large volumes of products. These high-energy impacts could only be associated with large passing vessels travelling at cruise speed.

Based on known shipping routes and annual traffic through the Prelude area, the annual frequency of collisions resulting in single storage tank failure and loss of containment is estimated at 4.7E-05/year and the catastrophic FLNG vessel failure frequency is 3.8E-05/year (Shell Australia 2017).

Smaller volume LNG and LPG spills could occur during LNG or LPG loading. LNG loading occurs each week at the dedicated Prelude LNG loading platform, typically over the course of 24 hrs, at a maximum combined loading rate of 10,000 m^3/h. LPG loading occurs once a month at a rate of 3000 m^3/h.

An LNG or LPG spill could result from e.g. inadvertent move of the FLNG or LNG/ LPG tanker beyond the design tolerance of the loading arms, causing arm disconnection, parting or failure; material failure due to corrosion, erosion; temperature embrittlement; overpressure or dynamic loading from product fluids, adverse weather, etc.

At the end of an LNG/ LPG carrier loading the loading arms are emptied forward to the carrier. Then the LNG/ LPG offloading header and offloading arm manifolds are drained to the LNG/ LPG storage tanks assisted by nitrogen purge. In the event of an emergency during loading, the loading header is emptied to the tanks by gravity.

LNG and LPG are gases at ambient temperatures, hence any LOC from the cargo tanks or during loading will ultimately result in loss to atmosphere and therefore cause no damage to the marine environment. The main concern with such events is the potential for fires or explosions presenting risks to personnel and property and these are addressed in the Prelude FLNG Safety Case. Environmental risks related to such releases are therefore considered non-credible and have not been discussed further.

LOC from Condensate Storage and Loading

Six atmospheric pressure condensate storage tanks are located in the aft section of the FLNG hull. Each tank has a capacity of 21,054 m^3 at 95% full and is supplied with two offloading pumps. During offloading mode all twelve offloading pumps are expected to be in operation, delivering condensate at a rate of 5,000m^3/hr to the condensate tanker. This allows offloading of up to 120,000 m^3 of condensate (net total pumpable condensate tanks storage capacity) in 24 hours. Condensate loading occurs approximately once every two weeks.

A stern tandem offloading arrangement for the discharge of condensate is provided at the aft end of Prelude. Condensate tankers are designed to be moored in the conventional manner for Single Point Mooring (SPM) bow mooring terminals with a standard OCIMF single braided (DN 400/DN 500) floating hose string deployed to the standard mid-ship manifold. Berthing utilises a hawser and hold-back support vessel rather than dynamic positioning. The condensate floating hose is stowed on an aft hose reel for controlled deployment and recovery. After offloading the remaining condensate in the hose is transferred back to the condensate tank by N_2 purge. A washing system is provided to allow washing of the hose back to the slops tanks to minimise build-up of waxy deposits within the hose.

Condensate is a liquid at ambient temperature and pressure. It is comprised of low molecular weight hydrocarbons and has similar characteristics as light diesel fuel. It is typically volatile and evaporates readily. However, Prelude condensate has a significant waxy component which may persist after the volatile portion evaporates.

Condensate containment losses from FLNG operations have been estimated as follows:

- Up to 10 m^3 from inadvertent disconnection of a coupling or flange at the topsides process modules and failure to contain by spill trays and the drain system;
- Up to 1000 m^3 for condensate offloading operation by floating hose. At a loading rate of 5,000 m^3 per hour, these quantities reflect a major loss of containment from rupture of loading hose and failure to respond within 15 minutes; or

- Release of cargo due to a high impact vessel collision and breach of hull and storage tank containment. A 42,000 m^3 release of condensate released over a period of 2 hours has been considered.

The last scenario is considered as the worst-case credible scenario and has been modelled for impact assessment purposes.

LOC of Heavy Fuel Oil / Intermediate Fuel Oil

The product offtake tankers could potentially carry heavy fuel oil (HFO)/ Intermediate Fuel Oil (IFO) as fuel. Any HFO/ IFO spill will result from a tanker collision with other vessels such as other tankers or an attendant vessel during berthing or unberthing operations as a result of e.g. human error, adverse sea/ weather conditions, loss of navigation aid systems, mechanical breakdown, miscommunication or tug failure.

Given the average volume of HFO/IFO stored in LNG carriers (up to 5,000 m^3) and the low energy collision credible during berthing/ unberthing, a 1,000 m^3 HFO spill was modelled. This is considered highly conservative given impact energy is highly unlikely to result in a HFO/ IFO tank breach.

LOC of Diesel

A diesel spill to the Operational Area could occur as outcome from:

- LOC during diesel transfer from the supply vessel to the FLNG facility; or during refuelling of the pilot tugs; or
- following a collision between any marine vessels, including the FLNG facility, operating in the field.

Diesel will be loaded onto the FLNG facility from support vessels approximately once per month. This refuelling operation takes at least 4 hours per to complete. A spill could occur as a result of any of engineering controls failure (e.g. hose rupture, coupling failures, tank overflow) or human error. However, historically the volume lost to sea in similar incidents is typically less than 160 litres or 1 bbl. (Det Norske Veritas, 2011) and potential further losses are reduced by visual observations, shutdown of pumps and automatic closure of safety valves.

The risk of a spill from vessel to vessel collision depends on the severity of impact, i.e. the speed and orientation of the vessels during the event. The worst-case scenario is where one of the vessels is ‘hit’ from the broadside by another vessel moving at near full speed resulting in a puncture of the diesel tanks below the waterline.

Prelude marine support vessels have diesel storage capacities of around 1,000 m^3, spread in multiple tanks. Pilot tugs carry similar or smaller diesel inventories onboard. The likelihood of collision between supply and support vessels and any other vessels in the field is considered remote given the low frequency of vessel collisions in ports resulting in fuel loss of containment (Det Norske Veritas, 2011) further reduced by the fact that the Operational Area is far less busy than any other Australian or international port.

The largest diesel volume spill scenario is considered to be from a supply vessel collision with the FLNG facility of magnitude such that a breach of the hull and damage to its biggest diesel storage tank would occur. The tank is located in the FLNG facility substructure and has a capacity of 750 m^3. It has been conservatively assumed for the purposes of spill modelling that in the remote chance of this happening, the whole inventory of this tank would be lost to sea. The likelihood of this event happening is estimated as remote given no such events have occurred in Shell or are known of in the industry.

LOC of Hazardous Liquids

Accidental loss to sea of hazardous liquids other than hydrocarbons (e.g. amine, MEG, hydraulic/ lube oil etc.) could occur at the Prelude location due to any of the following events:

- accidental opening of an isolation valve during normal operations
- hose failure or failure to isolate inventory during bulk liquid transfers
- lifting operations between marine vessels, including the FLNG
- adverse weather conditions resulting in dislodgement/ failure of storage vessel(s).

The worst-case spill scenarios for amine and MEG are summarised as follows:

- a 1-hour release of 1,000 m^3 of amine (methyl-diethanolamine (MDEA) containing 10-30% Piperazine) at sea surface following a complete rupture of the FLNG amine storage tank.
- a 1-hr 6,000 m^3 release of MEG (80% pure MEG and 20% seawater) at sea surface following a complete rupture of the FLNG MEG storage tank.

The likelihood of such events are expected to be low.

9.13.2 Overview of Unplanned Spill Modelling

Numerical modelling studies were commissioned for the worst-case credible spill scenarios outlined above.

Table 9-77 Summary of Modelled Hydrocarbon and Hazardous Liquids Scenarios

Scenario	Location Name	Latitude	Longitude	Depth (m)	Hazardous Liquid	Duration	Total Volume (m^3)
Loss of well control	Prelude Production Well	13°50"22" S	123°19"35.8" E	237	Well fluid	80 days	254,400
Loss of containment during product offloading (collision)	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	Condensate	2 hours	42,000
Loss of containment of heavy fuel oil	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	HFO	1 hour	1,000
Loss of containment of diesel	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	Diesel	1 hour	750

Loss of containment of amine	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	Amine	1 hour	1,000
Loss of containment of MEG	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	MEG	1 hour	6,000

The following models were used to predict impacts from these scenarios:

- Loss of well control was modelled using the Integrated Oil Spill Impact Model System (SIMAP) model with each simulation run for 108 days.
- Condensate and HFO spills were modelled using SIMAP, whereby 100 replicates over 4 seasons were run for 56 days each.
- The diesel spill scenario was modelled using the OILMAP-Deep model for nearfield modelling and the SIMAP model for the far field effects. 200 replicates over four seasons were run.
- Amine and MEG spill modelling were carried out using the three-dimensional chemical spill trajectory and weathering model, CHEMMAP (Chemical Mapping and Analysis Program). Amine and MEG modelling used 100 replicates per two seasons (summer and winter). In the case of amine, each simulation was run for 5 days, whilst for MEG, it was run for 4 days.

SIMAP and CHEMMAP represent 3D stochastic models, with physical fates component for oils and chemicals, biological effects and exposure component, GIS component, and environmental features, oil/ chemical and biological databases. OILMAP-Deep is a 2D/3D deterministic model, simulating the fate of oil in the environment (surface, water column and air distribution), interactions with the ecological component of the environment and has a stochastic component which determines the probability and time contours of oiling of the various environmental components and the most likely spill paths on a monthly, seasonal, or annual basis. The metocean conditions used as input to each model were derived from a 39-year data set of current speed and direction at half-hourly intervals.

A stochastic modelling scheme was followed for each modelled scenario, whereby the respective model was applied to repeatedly simulate the defined spill scenario using different samples of current and wind data. Starting dates for each simulation were distributed between the seasons (e.g. summer and winter) to capture the influence of the temporal and spatial variations in the current patterns that would affect the trajectory of any hydrocarbon or chemical spills that commenced in these periods. The results of the replicate simulations were then statistically analysed and mapped to define contours of risk around the release point.

For hydrocarbons, the timeseries contour compilations include floating, entrained, dissolved and accumulated hydrocarbons.

Hydrocarbon Impact Thresholds

Spilled hydrocarbons can exist as floating, entrained, dissolved and accumulated (i.e. stranded onshore) hydrocarbons. Each of these fractions/ phases can interact with the environment in diverse ways due to different pathways to receptors and cause/effect mechanisms. Guideline impact thresholds (NOPSEMA 2019b) for floating, entrained, dissolved and accumulated hydrocarbons were applied to the hydrocarbon spill modelling studies and used to inform the assessment of potential impacts and risks. Three thresholds were applied to each phase i.e. low exposure, moderate exposure and high exposure. These are described in Table 9-78 and are used to delineate the extent (outer edge) of the low, moderate or high exposure zones for each hydrocarbon type. The low, moderate and high exposure zones represent bands/ ranges of hydrocarbon concentrations, grouped on the basis of scientific knowledge of potential impacts of the various hydrocarbon phases on environmental receptors.

Table 9-78: Hydrocarbon Exposure Zones and Thresholds

Exposure Zone	Threshold	Justification
Floating Oil		
Exposure Zone Low (1 g/m^2 – 10 g/m^2)	1 g/m^2	The 1 g/m^2 threshold represents the practical limit of observing hydrocarbon sheens in the marine environment and therefore has been used to define the outer boundary of the low exposure zone. This threshold is considered below levels which would cause environmental harm and is more indicative of the areas perceived to be affected due to its visibility on the sea-surface. This exposure zone represents the area contacted by the spill and defines the conservative outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone Moderate (10 g/m^2 – 25 g/m^2)	10 g/m^2	Ecological impact has been estimated to occur at 10 g/m^2 as this level of oiling has been observed to mortally impact birds and other wildlife associated with the water surface (French et al. 1996; French 2000). Contact within this exposure zone may result in impacts to the marine environment.
Adverse exposure zone High (> 25 g/m^2)	25 g/m^2	The 25 g/m^2 threshold is above the minimum threshold observed to cause ecological impact. Studies have indicated that a concentration of surface oil 25 g/m^2 or greater would be harmful for the majority of birds that contact the hydrocarbon at this concentration (Koops et al. 2004; Scholten et al. 1996). Exposure above this threshold is used to define the high exposure zone.
Accumulated (Shoreline) Oil		
Exposure zone Low (10 g/m^2 – 100 g/m^2)	10 g/m^2	A threshold of 10 g/m^2 has been defined as the zone of potential 'low' exposure. This exposure zone represents the area visibly contacted by the spill and defines the outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone Moderate (100 g/m^2 – 1,000 g/m^2)	100 g/m^2	French et al. (1996) and French-McCay (2009) have defined an oil exposure threshold of 100 g/m^2 for shorebirds and wildlife (furbearing aquatic mammals and marine reptiles) on or along the shore, which is based on studies for sub-lethal and lethal impacts. The 100 g/m^2 threshold has been used in previous environmental risk assessment studies (French et al. 2011; French-McCay 2004; French-McCay 2003; French McCay et al. 2012; National Oceanic and Atmospheric Administration 2013). This threshold is also recommended in AMSA's foreshore assessment guide as the acceptable minimum thickness that does not inhibit the potential for recovery and below which is best remediated by natural coastal processes alone (AMSA 2015). Thresholds of 100 g/m^2 and 1,000 g/m^2 will define the zones of potential 'moderate' and 'high' exposure on shorelines, respectively. Contact within these exposure zones may result in impacts to the marine environment and coastal areas.
Adverse exposure zone High (> 1,000 g/m^2)	1,000 g/m^2	

Exposure Zone	Threshold	Justification
Entrained Hydrocarbons		
Exposure zone Low exposure (10 parts per billion (ppb)–100 ppb)	10 ppb	The 10 ppb threshold represents the lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the ANZECC & ARMCANZ (2000) water quality guidelines. Due to the requirement for relatively long exposure times (> 24 hours) for these concentrations to have an observable impact, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained oil plumes, or when entrained hydrocarbons adhere to organisms or entrained oil is trapped against a shoreline for periods of several days or more. This exposure zone is not considered to be of significant biological impact. This exposure zone represents the area contacted by the spill and conservatively defines the outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone Moderate (100 ppb–500 ppb)	100 ppb	The 100 ppb threshold is considered conservative in terms of potential for toxic effects leading to mortality for sensitive mature individuals and early life stages of species. This threshold has been defined to indicate a potential zone of acute exposure, which is more meaningful over shorter exposure durations. The 100 ppb threshold has been selected to define the moderate exposure zone. Contact within this exposure zone may result in impacts to the marine environment.
Adverse exposure zone High (> 500 ppb)	500 ppb	The 500 ppb threshold is considered a conservative high exposure level in terms of potential for toxic effects leading to mortality for more tolerant species or habitats. This threshold has been defined to indicate a potential zone of acute exposure, which is more meaningful over shorter exposure durations. The 500 ppb threshold has been selected to define the high exposure zone.
Dissolved Aromatic Hydrocarbons		
Exposure zone Low (6 ppb–50 ppb)	6 ppb	The threshold value for species toxicity in the water column is based on global data from French et al. (1999) and French-McCay (2003, 2002), which show that species sensitivity (fish and invertebrates) to dissolved aromatics exposure > 4 days (96-hour LC50) under different environmental conditions varied from 6 ppb–400 ppb, with an average of 50 ppb. This range covered 95% of aquatic organisms tested, which included species during sensitive life stages (eggs and larvae). Based on scientific literature, a minimum threshold of 6 ppb is used to define the low exposure zones (Clark 1984; Engelhardt 1983; Geraci and St Aubin 1988; Jenssen 1994; Tsvetnenko 1998). This exposure zone is not considered to be of significant biological impact and conservatively defines the outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone Moderate (50 ppb–400 ppb)	50 ppb	A conservative threshold of 50 ppb was chosen as it is more likely to be indicative of potentially harmful exposure to fixed habitats over short exposure durations (French-McCay 2002). French-McCay (2002) indicates that an average 96-hour LC50 of 50 ppb could serve as an acute lethal threshold to 5% of biota. The 50 ppb threshold has been selected to define the moderate

Exposure Zone	Threshold	Justification
		exposure zone. Contact within this exposure zone may result in impacts to the marine environment.
Adverse exposure zone High (> 400 ppb)	400 ppb	A conservative threshold of 400 ppb was chosen as it is more likely to be indicative of potentially harmful exposure to fixed habitats over short exposure durations (French-McCay 2002). French-McCay (2002) indicates that an average 96-hour LC50 of 400 ppb could serve as an acute lethal threshold to 50% of biota. The 400 ppb threshold has been selected to define the high exposure zone.

The dissolved aromatic hydrocarbon impact thresholds presented in Table 9-78 are considered conservative and appropriate for the assessment of impacts on marine receptors given evidence on impacts from additional ecotoxicity studies. For example, the Browse Joint Venture (JV) ecotoxicity testing of Calliance condensate (ESA, cited in Woodside Energy Limited, 2013) on a broad range of taxa of ecological relevance indicated no observed effect concentrations were achieved at concentrations orders of magnitude greater than the 400 ppb threshold for the High Exposure Zone. Calliance condensate is considered to be broadly similar to Prelude condensate given a similar location, geology, formation, and depth.

Calliance ecotox testing (Woodside Energy Limited, 2013) showed results for no observed effect concentrations per Table 9-79.

Table 9-79: Browse JV Ecotox testing on Calliance Condensate

Biota and life stage	Exposure duration	NOEC – dissolved aromatic concentration of unweathered Calliance condensate showing no direct biological affect (ppb)
Sea urchin fertilisation	1 hour	13,360
Sea urchin larval development	72 hours	32,360
Macroalgal germination	72 hours	44,950
Microalgal growth test	72 hours	24,270
Rock oyster spat survival test	48 hours	32,360
Tiger prawn acute toxicity test	72 hours	1280
Larval fish imbalance test	96 hours	1280

**Source: Table 5-5 from Woodside's Outer Canning Exploration Drilling Program Environment Plan (Woodside 2013).*

The dissolved and entrained thresholds are instantaneous measures and based on the results of testing presented in table above are highly conservative. These thresholds are also considered appropriate for diesel and HFO/ IFO given the similarity in cause effect pathways.

Chemical (Amine and MEG) Impact Thresholds

Environmental threshold values for amine were developed from literature, following the ANZECC Guidelines (2000; 2018). An ecotoxicity value was derived for amine's main component, MDEA, by identifying previous studies with ecotoxicity results for marine organisms and using the ANZECC Guidelines to derive a threshold. Five ecotoxicity thresholds were identified from different sources, which were used to determine a moderate reliability threshold of 1.8 mg/L, which is the lowest LC50 value in Table 9-80 divided by 100.

Table 9-80: The acute or chronic toxicity of different aquatic organisms and the time period of exposure

Organism (species)	Source	Type of Acute or Chronic Toxicity	Exposure Time Period (hour)	Toxicity Value (mg/L)
Fish (unknown)	MSDS	LC50	Not specified in study	1,466
Algae (skeletonema costatum)	Hansen et al	EC50	48	141.4
Zooplankton (Calanus finmarchicus)	Hansen et al	LC50	Not specified in study	183.4
Algae/bacteria (Vibrio fischeri)	Brooks, 2008	EC10	0.25	36
Carp (Cyprinidae)	Brooks, 2008	LOEC	Not specified in study	0.5

For MEG, which is classified as "practically non-toxic" to aquatic organisms by the U.S. Environmental Protection Agency (USEPA) and PLONOR under the OSPAR Commission, the Predicted No Effect Concentration (PNEC) of 859 mg/L, recommended by the World Health Organisation (WHO 2000), was used in assessing modelling outcomes. The MEG PNEC was derived from the No Observed Effect Concentration (NOEC) of 8590 mg/L for chronic exposure of daphnids (reproductive end point assessment) divided by a safety factor of 10 (WHO 2000). This concentration is two orders of magnitude lower than MEG's LC_{50} values for other aquatic organisms (e.g. aquatic invertebrates, fish and tadpoles, in WHO 2000) and is therefore considered appropriate. The chemical is also considered as non-persistent in the environment and does not bioaccumulate (Staples et al. 2001).

9.13.3 Summary of Loss of Containment Modelling Results

Loss of Well Control

A loss of containment due to loss of well control will involve the turbulent discharge of gas and condensate at the seabed through a restriction (the well head). The condensate will be discharged as a jet of small droplets into the water column (237 m below sea level) which would be carried forth and upwards to the sea surface by the buoyancy of the gas cloud, which will be counteracted by the viscous resistance imparted by the surrounding seawater. Where the release occurs at water depths exceeding 100-200 m, the gas plume would lose its momentum prior to breaking through to the surface and the entrained oil droplets may become trapped by the density layers in the water column (Chen & Yapa, 2002).

Thus, for deeper releases (>200 m), the gas and oil will tend to separate before the oil surfaces because the gas either goes into solution or accelerates away from the oil droplets. The height at which the gas lift ceases is referred to as the trapping height. The rate at which oil rises from the trapping height will be determined by a number of factors, including the relative buoyancy of the oil versus local water density, the size of the droplets (increased viscous resistance for smaller sizes), the presence of density barriers in the water column and the action of shear currents that might be present in that location.

The Prelude OILMAP-Deep model included specification of the discharge rate, hole size, gas-to-oil ratio, the temperature of the oil on exiting and before subsequent cooling by the ambient water. The temperature and salinity profiles of the water column were also specified to describe the vertical density profile.

The plume trapping height (where the gas lift ceases) was estimated at approximately 213 m above seabed, hence approximately 24 m below sea level. The diameter of the water and condensate plume at this level was estimated at approximately 27.1 m. Based on the small oil droplet sizes forecast by OILMAP-Deep (15.1-90.0 µm), the droplets will then rise slowly at a net rate determined by their buoyancy relative to the surrounding water density and the viscous resistance imposed by the water. The results essentially suggest that the majority of the oil will be entrained into the upper mixed layer of the ocean, with some surfacing potential based on the proportion of larger droplets.

Key results from the SIMAP stochastic modelling studies for a worst-case loss of well control LOC showed:

- **Floating hydrocarbons** will predominantly surface in the immediate vicinity of the release site with concentrations above the low exposure threshold most frequently occurring in waters to the northwest and southeast, with the furthest travelled distance from the release site being to the north-northeast and the west-southwest. Concentrations of floating oil ≥1 g/m2 could potentially be found up to 875 km to the west-northwest of the release site. The 10 g/m2 threshold is contained within 10 km from the release site, whilst the high exposure threshold is never exceeded. The annualised probability of floating oil at concentrations of 1 g/m^2 or greater reaching nearshore waters is predicted to be 6% at Browse Island, 5% at Heywood Shoals, 4% at Echuca Shoals and ≤3% for all other assessed sensitive receptors. Probability of contact <0.5% is predicted for nearshore waters to all sensitive receptors by floating oil concentrations of 10 g/m^2 or greater.

- The highest maximum local **accumulated shoreline concentration** from the single worst case modelling run is predicted at the Indonesian Boundary receptor at 3 kg/m^2, and the highest maximum local accumulated shoreline volume is also predicted for this receptor at 51 m^3, ~0.02% of spilled volume. The probability of contact of floating oil film with this receptor from all replica runs is predicted to be less than 0.5%.

- For Australian receptors, the highest maximum local **accumulated shoreline concentration** from the single worst case modelling run is predicted at the Buccaneer Archipelago at 123 g/m^2, and the highest maximum local accumulated shoreline volume is also predicted for this receptor at 1.1 m^3. The probability of contact of floating oil film with this receptor from all replica runs is predicted to be less than 0.5%. For all receptors, the highest maximum local accumulated shoreline concentration is predicted at the Indonesian Boundary receptor at 3,034 g/m^2, and the highest maximum local accumulated shoreline volume is also predicted for this receptor at 51 m^3 (less than 0.5% probability).

- **Entrained hydrocarbon** concentrations above 10 ppb were predicted to potentially reach waters 2,200 km to the west of the release site and to waters south of Shark Bay (1,800 km southwest) The forecast maximum potential extent for entrained concentrations above the 100 ppb moderate exposure threshold is also around 2,200 km to the west of the release site and as far southwest as waters off Bernier and Dorre Islands (~1,500 km southwest). At the highest threshold of 500 ppb, the forecast maximum potential extent is also up to around 2,000 km west of the release site and as far southwest as North West Cape (1,200 km southwest). The highest annualised probabilities for entrained concentrations ≥10 ppb contacting the nearshore waters of receptors are predicted for Heywood Shoals (96%), Browse Island (94%) and Echuca Shoals (94%). Probabilities for contact of >80% are also indicated for the nearshore waters of Ashmore Reef (89%), Cartier Island (87%), Barracouta Shoals (87%), Vulcan Shoals (86%), Seringapatam Reef (84%), Hibernia Reef (84%) and Fantome Shoals (83%). Highest probabilities for contact at 100 ppb or greater are predicted for Browse Island (90%) and for contact above 500 ppb, a highest probability of 83% is indicated, also for Browse Island.

- **Dissolved aromatic hydrocarbons** follow similar directions to those outlined for the entrained condensate. The annualised outer contours of probability indicate the potential for concentrations at or above 6 ppb to occur in waters up to 2,000 km to the west-northwest of the release site. The forecast maximum potential extent for dissolved aromatic hydrocarbons ≥50 ppb could also stretch in isolated patches up to 2,000 km west of the site. At a threshold of 400 ppb, the predicted maximum extent reduces to around 1,500 km west-northwest of the release site in isolated transient patches. The highest annualised probability for concentrations of at least 6 ppb in the nearshore waters of receptors is forecast for Ashmore Reef at 94%. Risks for contact of 90% or above are also indicated for nearshore waters of Echuca Shoals (92%), Heywood Shoals (92%), Cartier Island (92%), Browse Island (90%) and Barracouta Shoals (90%). For contact by plumes with concentrations of at least 50 ppb and 400 ppb, the highest probabilities are predicted at 79% and 30%, respectively, for the nearshore waters of Browse Island. The maximum dissolved aromatic hydrocarbon concentration, at any depth, is also forecast for the Browse Island receptor at 7,815 ppb (~7.8 ppm).

Figure 9-28: Extent of the ZPI (low exposure threshold) and the moderate exposure thresholds (floating, dissolved and entrained) based on the stochastic results of all worst case credible spill scenarios combined

Condensate Spill

Key results from the SIMAP stochastic modelling study (APASA 2014) for the worst-case condensate LOC event during offloading operations showed:

- **Floating oil** at or above 1 g/m^2 is forecast to extend up to 820 km to the west of the release site and up to 650 km to the north or southwest of the release site. The 10 g/m^2 contour is forecast to extend up to 460 km west / southwest and north / northwest and distances of up to 330 km west / southwest and 370 km north of the release site for the 25 g/m^2 contour. The probability of contact for low, moderate and high exposure thresholds for the nearest sensitive receptors at Browse Island is 6.25%, 2.75% and 1.75% respectively.
- The **maximum accumulated shoreline concentration** from the single worst case run is forecast at the Indonesian Boundary at 3.1 kg/m^2 with the maximum accumulated shoreline volume being 1,393 m^3 at this receptor. The probability of floating oil contact with the Indonesian Boundary (cumulative from all runs) is predicted at 0.5%.
- The **maximum accumulated shoreline concentration** from the single worst case run for the Australian shoreline is predicted at the Buccaneer Archipelago at 0.7 kg/m^2 along with a maximum accumulated shoreline volume of 14m^3. The probability of floating oil contact with this sensitive receptor (cumulative from all runs) is predicted to be less than 0.25%.
- **Entrained oil** at or above 10 ppb is forecast to extend up to 1,850 km to the northwest, 850 km to the northeast and 1,150 km to the southwest of the release site. At the 100 ppb threshold, the potential extent is comparable to the lower threshold but the probabilities of occurrence decrease. Entrained oil at or above 500 ppb is generally forecast to extend up to 900 km from the release site, with the potential of extending up to 1,700 km to the west-northwest.
- **Dissolved aromatic hydrocarbon concentrations** at or above 6 ppb are forecast to extend up to 1,300 km to the west-northwest and 800 km to the southwest of the release site. At the 50 ppb threshold, dissolved aromatic hydrocarbons are forecast to extend up to 700 km, with the potential occurrence of isolated patches at further distances. Concentrations at or above 400 ppb are generally forecast to extend up to 300 km from the release site, with the potential of extending up to 600 km to the southwest.

Heavy Fuel Oil Spill

The CHEMMAP stochastic modelling study (APASA, 2014b) for the 1 hr surface 1,000 m^3 HFO/ IFO spill event due to ship collision at the Prelude location, modelled over the summer and winter seasons resulted in the following findings:

- The potential **floating oil** exposure zones were shown up to 1700 km west / northwest, 500 km east/northeast and 300 km east/northeast of the release location at the low, moderate and high thresholds respectively.
- The **maximum accumulated shoreline concentration** within Australian territory is forecast at the Archipelago (Buccaneer) at 13.3 kg/m^2. The maximum accumulated shoreline volume is also forecast at this receptor at 475 m^3. At the Indonesian Boundary, the maximum accumulated shoreline concentration (averaged over all replicate runs) is forecast at 23 g/m^2, with maximum accumulated shoreline volume (worst case replicate simulation) at 575 m^3(<0.25% probability).
- **Entrained oil** at or above 10 ppb is forecast to extend up to 20 km from the release site with probabilities of threshold exceedance less than 5% at this distance. At the 100 ppb threshold, the potential extent is reduced to within 5 km of the release site. Entrained oil is not forecast at or above 500 ppb within the model domain.

- Plumes of **dissolved aromatic hydrocarbons** with concentrations of 6 ppb or greater were not forecast to occur within the model domain or within any of the assessed sensitive receptors.

Diesel Spill

The worst-case diesel spill modelling scenario included 1 hr surface 750m^3 release of Marine Diesel Oil (MDO), nearfield modelling with OILMAP-Deep and SIMAP model which included 200 replicates per four seasons (APASA, 2014c). The key modelling results include:

- The potential **floating oil** exposure zones were shown up to 500 km in the south-southwest direction and 60 km and 10 km from the release location at the low, moderate and high thresholds respectively. The probability of floating oil film contact with Browse Island is 2%, Echuca Shoals 2.5%, Heywood Shoal 1% and less than 0.5% at all other sensitive receptor locations.
- The **maximum accumulated volume** in the worst case replicate simulation is 61.1 m^3, 6.7 m^3, 9.1 m^3 and 0.07 m^3 at Browse Island, Ashmore Reef, Cartier Island and Buccaneer Archipelago respectively. The maximum local accumulation averaged among replicate spills is 25 g/m^2 at Browse Island, 7.2g/m^2 at Cartier Island and 5.5 g/m^2 at Scott Reef, with less than 1 g/m^2 at all other emergent features.
- The 100 ppb **entrained oil** annualised probability at the closest sensitive receptors is 3% for Browse Island, 4% for Heywood Shoal and 2% for Echuca Shoals with 1% or less for all other receptors. The probability of contact with entrained oil at the high exposure level of 500 ppb is less than 0.5% at all sensitivities.
- The annualised probability of exposure to **dissolved aromatic hydrocarbons** at the low exposure threshold of 6 ppb is 2% at Browse Island and 1% at Heywood and Echuca shoals. For all other sensitive locations, this exposure probability is less than 0.5%. Annualised probabilities for the moderate and high exposure thresholds of 50 ppb and 400 ppb are less than 0.5% at all sensitivities.

MEG Spill

The CHEMMAP stochastic modelling study (APASA, 2019a) for the 1 hour 6,000 m^3 MEG spill event during chemical loading operations shows dissolved MEG at or above 859 mg/L (PNEC) is forecast to potentially occur at distances up to 8 km to the east and 7 km to the west of the release site over both seasons. Easterly trajectories are forecast to be more dominant in summer months, with concentrations at or above threshold predicted up to 7 km from the release site to the west. During winter months, westerly trajectories are forecast to be more dominant, with concentrations at or above threshold predicted up to 6 km from the release site to the northeast. Dissolved MEG is not forecast to contact any of the sensitive receptors at or above 50 mg/L in any season.

Amine Spill

The CHEMMAP stochastic modelling study (APASA, 2014a) for the 1 hr surface 1,000 m^3 amine spill event predicts the 1.8 mg/L dissolved amine concentration to extend over 78 km to the northeast and over 70 km to the southwest of the release site over both seasons. The probability of contact of the amine plume with Browse Island was highest during the winter season at 2% and falls down to 1% over the entire year. The single event worst case contact concentration was predicted to be 13.9 mg/L and occurred in the winter period. Similar concentrations and probabilities of contact are likely for the Heywood Shoals; however, the contact is likely to be of lower likelihood and short duration. A spill of amine may drift over the closest two KEFs (Continental

Slope Demersal Fish Communities and Ancient Coastline at 125 m depth contour), however given these two receptors are located sub-surface in considerable water depth, this is unlikely to lead to any environmental effects or damage given the expected positive buoyancy of the plume.

9.13.4 Description and Evaluation of Impacts and Risks

Table 9-81: Summary of Combined Hydrocarbon Spill Modelling Results for Sensitive Receptors with Contact above Moderate Exposure Thresholds and Chemical Spill Modelling Results

Geographical Receptor Location	Distance from Operational Area [km]	EP Section Ref.	HC Concentration Above Moderate Exposure Thresholds			Potential Exposure to Amine > 1.8 mg/L	Potential Exposure to MEG > 859 mg/L
			Floating	Accumulated (Shoreline)	Entrained/ Dissolved		
Key Benthic Communities							
Browse Island	39	Section 7.2.1	Yes	Yes	Yes	Yes	No
Echuca Shoal	61		Yes	-	Yes	Yes	No
Heywood Shoal	81		Yes	-	Yes	No	No
Cartier Islet	136		Yes	No	Yes	No	No
Seringapatam Reef	136		Yes	-	Yes	No	No
Goeree Shoal	144		Yes	-	Yes	No	No
Vulcan Shoal	146		Yes	-	Yes	No	No
Scott Reef	159		Yes	No	Yes	No	No
Ashmore Reef	169		Yes	No	Yes	No	No
Hibernia Reef	194		Yes	-	Yes	No	No
KEFs							
Continental Slope Demersal Fish Communities	14	Section 7.2.3	Yes	-	Yes	Yes	No
Ancient coastline at 125 m depth contour	41		Yes	-	Yes	Yes	No
Seringapatam Reef and Cmlth waters in the Scott Reef Complex	131		Yes	-	Yes	No	No
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	134		Yes	No	Yes	No	No
Carbonate bank and terrace system of the Sahul Shelf	206		Yes	-	Yes	No	No
Canyons linking the Argo Abyssal Plain with the Scott Plateau	384		No	-	Yes	No	No
Pinnacles of the Bonaparte Basin	457		No	-	Yes	No	No
Mermaid Reef and Cmlth waters surrounding Rowley Shoals	523		No	-	Yes	No	No
Glomar Shoals	941		No	-	Yes	No	No
Exmouth Plateau	1,127		No	-	Yes	No	No
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	1,256		No	-	Yes	No	No
Commonwealth waters adjacent to Ningaloo Reef	1,304		No	-	Yes	No	No

Demersal slope and associated fish communities of the Central Western Province	1,747		No	-	No	No	No
Western rock lobster	1,862		No	-	No	No	No
RAMSAR Wetlands							
Ashmore reef national nature reserve	162	Section 7.2.5	Yes	No	Yes	No	No
Roebuck bay	474		No	No	Yes	No	No
Eighty-mile beach	610		No	No	Yes	No	No
Commonwealth Marine Area							
Commonwealth Marine Environment - Kimberley multiple use zone - Ashmore Reef recreational use zone & Sanctuary zone - Cartier Island Sanctuary zone - Oceanic shoals multiple use zone	0	Section 7.2.6	Yes	-	Yes	Yes	Yes
WA Mainland Coastline							
WA mainland coastline - Camden Sound	<200km	Section 7.2.7	Yes	Yes	Yes	No	No
BIAs and Habitat Critical for the Survival of a Species							
Blue and pygmy blue whales	Migration - 78	Section 7.2.8.2	Yes	-	Yes	Yes	No
	Foraging - 132		Yes	-	Yes	No	No
Humpback whale	Migration - 145		Yes	-	Yes	No	No
	Calving - 145		Yes	-	Yes	No	No
	Resting - 145		Yes	-	Yes	No	No
	Nursing - 145		Yes	-	Yes	No	No
	Migration (north and south) - 327		No	-	Yes	No	No
Dugong	Foraging (high density seagrass beds) - 168		Yes	-	Yes	No	No
	Foraging - 176		Yes	-	Yes	No	No
	Calving - 176		Yes	-	Yes	No	No
	Breeding - 176		Yes	-	Yes	No	No
	Nursing - 176		Yes	-	Yes	No	No
Australian snubfin dolphin	Foraging - 187		No	-	Yes	No	No
	Breeding - 190		No	-	Yes	No	No

	Foraging (high density prey) - 190		No	-	Yes	No	No
	Calving - 190		No	-	Yes	No	No
	Resting - 190		No	-	Yes	No	No
Indo-Pacific humpback dolphin	Foraging - 190		No	-	Yes	No	No
	Calving - 190		No	-	Yes	No	No
	Breeding - 190		No	-	Yes	No	No
	Foraging (high density prey) - 190		No	-	Yes	No	No
	Significant habitat - unknown behaviour - 247		No	-	Yes	No	No
Indo-Pacific/spotted bottlenose dolphin	Calving - 190		No	-	Yes	No	No
	Foraging - 190		No	-	Yes	No	No
	Breeding - 239		No	-	Yes	No	No
Flatback turtle	Inter-nesting buffer - 268		No	-	Yes	No	No
	Foraging - 344		Yes	-	Yes	No	No
	Nesting - 302		No	No	Yes	No	No
	Inter-nesting - 356		No	-	Yes	No	No
	Mating – 1,005		No	-	Yes	No	No
	Migration corridor – 1,005		No	-	Yes	No	No
	Aggregation – 1,114		No	-	Yes	No	No
Green turtle	Nesting - 23		Yes	No	Yes	Yes	No
	Foraging - 43		Yes	-	Yes	Yes	No
	Inter-nesting buffer - 121		Yes	-	Yes	No	No
	Inter-nesting - 169		Yes	-	Yes	No	No
	Mating - 174		Yes	-	Yes	No	No
	Migration corridor - 1,005		No	-	Yes	No	No

	Aggregation – 1,114		No	-	Yes	No	No
	Basking – 1,130		No	-	Yes	No	No
Hawksbill turtle	Foraging - 141		Yes	-	Yes	No	No
	Inter-nesting buffer - 150		Yes	-	Yes	No	No
	Nesting - 169		Yes	No	Yes	No	No
	Nesting - 971		Yes	No	Yes	No	No
	Mating – 1,005		No	-	Yes	No	No
	Migration corridor – 1,005		No	-	Yes	No	No
	Inter-nesting – 1,005		No	-	Yes	No	No
Loggerhead turtle	Foraging - 344		Yes	-	Yes	No	No
	Inter-nesting buffer - 986		Yes	-	Yes	No	No
	Nesting – 1,008		Yes	No	Yes	No	No
	Nesting – 1,285		Yes	No	Yes	No	No
	Inter-nesting – 1,688		Yes	-	Yes	No	No
Olive ridley turtle	Nesting – critical habitat - 177		No	No	No	No	No
	Foraging - 344		Yes	-	Yes	No	No
Whale shark	Foraging - 33		Yes	-	Yes	No	No
	Foraging (high prey density) – 1,329		No	-	Yes	No	No
Dwarf sawfish	Foraging - 203		No	-	Yes	No	No
	Nursing - 416		No	-	Yes	No	No
Freshwater sawfish	Pupping - 416		No	-	Yes	No	No
	Foraging - 416		No	-	Yes	No	No
	Nursing - 433		No	-	Yes	No	No
Green sawfish	Foraging - 203		No	-	Yes	No	No
	Pupping - 454		No	-	Yes	No	No
	Nursing - 769		No	-	Yes	No	No
Red-footed booby	Breeding - 59		Yes	No	Yes	Yes	No

Greater frigatebird	Breeding - 59		Yes	No	Yes	Yes	No
Lesser frigatebird	Breeding - 60		Yes	No	Yes	Yes	No
Wedge-tailed shearwater	Breeding - 61		Yes	No	Yes	Yes	No
	Foraging (in high numbers) – 1,741		No	-	No	No	No
White-tailed tropicbird	Breeding - 68		Yes	No	Yes	Yes	No
Brown booby	Breeding - 118		Yes	No	Yes	No	No
Lesser crested tern	Breeding - 141		Yes	No	Yes	No	No
Little tern	Resting - 142		Yes	No	Yes	No	No
	Breeding - 245		No	No	Yes	No	No
Roseate tern	Breeding - 142		Yes	No	Yes	No	No
	Resting - 571		No	No	No	No	No
Fairy tern	Breeding - 991		No	No	Yes	No	No
Bridled tern	Foraging (in high numbers) – 1,747		No	-	No	No	No
Sooty tern	Foraging – 1,772		No	-	No	No	No
Little shearwater	Foraging (in high numbers) – 1,826		No	-	No	No	No
White-faced storm petrel	Foraging (in high numbers) – 1,837		No	-	No	No	No
World Heritage Properties							
Ningaloo Coast	1,283	Section 7.3.1.1	No	No	Yes	No	No
Shark Bay	1,651		No	No	No	No	No
Commonwealth Heritage Places							
Scott Reef and surrounds	155	Section 7.3.1.2	Yes	No	Yes	No	No
Ashmore Reef National Nature Reserve	162		Yes	No	Yes	No	No
Mermaid Reef – Rowley Shoals	535		No	-	Yes	No	No
Ningaloo Marine Area - Commonwealth Waters	1,304		No	-	Yes	No	No
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,877		No	-	No	No	No
National Heritage Places							
The West Kimberley	1,283	Section 7.3.1.3	Yes	No	Yes	No	No
Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves	1,651		No	No	Yes	No	No

The Ningaloo Coast	1,877		No	No	Yes	No	No
Shark Bay, Western Australia	1,283		No	No	No	No	No
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,651		No	-	No	No	No
Underwater Cultural Heritage							
TBA		Section 7.3.1.5	No	-	Yes	No	No
Marine Protected Areas							
Commonwealth							
Kimberley	111	Section 7.3.2	Yes	-	Yes	No	No
Cartier Island	134		Yes	-	Yes	No	No
Ashmore Reef	162		Yes	-	Yes	No	No
Oceanic Shoals	321		Yes	-	Yes	No	No
Argo-Rowley Terrace	323		No	-		No	No
Roebuck	480		No	-		No	No
Mermaid Reef	523		No	-		No	No
Joseph Bonaparte Gulf	604		No	-		No	No
Eighty Mile Beach	788		No	-		No	No
Dampier	950		No	-		No	No
Montebello	1,047		No	-		No	No
Gascoyne	1,277		No	-		No	No
Ningaloo	1,304		No	-		No	No
Shark Bay	1,588		No	-		No	No
Abrolhos	1,781		No	-		No	No
State							
Lalang-garram / Camden Sound	182	Section 7.3.2	No	-		No	No
North Kimberley	188		No	-		No	No
Rowley Shoals	567		No	-		No	No
Eighty Mile Beach Marine Park	612		No	-		No	No
Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area	1,097		No	-		No	No
Muiron Islands Marine Management Area and Ningaloo Marine Park	1,283		No	-		No	No
Shark Bay Marine Park	1,691		No	-		No	No
Fisheries							
Commonwealth Fisheries							
North-west slope trawl fishery	0	Section 7.3.3.3	Yes	-	Yes	Yes	Yes
Southern bluefin tuna fishery	0		Yes	-	Yes	Yes	Yes
Western tuna and billfish fishery	0		Yes	-	Yes	Yes	Yes

Skipjack fishery	0		Yes	-	Yes	Yes	Yes
Northern prawn fishery	395		Yes	-	Yes	No	No
Western deepwater trawl fishery	1,072		No	-	Yes	No	No
WA State Fisheries							
Mackerel Fishery	0	Section 7.3.4.4	Yes	-	Yes	Yes	Yes
West Coast Deep Sea Crustacean	0		Yes	-	Yes	Yes	Yes
South West Coast Salmon	0		Yes	-	Yes	Yes	Yes
Northern Demersal Scalefish	0		Yes	-	Yes	Yes	Yes
Marine Aquarium and Specimen Shell	28		Yes	-	Yes	No	No
Abalone	28		Yes	-	Yes	No	No
Broome Prawn	28		Yes	-	Yes	No	No
Kimberley Prawn	47		Yes	-	Yes	No	No
Kimberley Gillnet and Barramundi	213		No	-	Yes	No	No
Pilbara Trap	477		No	-	Yes	No	No
Pilbara Fish Trawl	560		No	-	Yes	No	No
Nickol Bay Prawn	560		No	-	Yes	No	No
Onslow Prawn	920		No	-	Yes	No	No
Exmouth Gulf Prawn	1,263		No	-	Yes	No	No
West Coast Rock Lobster	1,272		No	-	Yes	No	No
Gascoyne Demersal Scalefish	1,470		No	-	Yes	No	No
Shark Bay Scallop	1,512		No	-	No	No	No
Shark Bay Prawn	1,512		No	-	No	No	No
Shark Bay Crab	1,670		No	-	No	No	No
Shark Bay Beach Seine and Mesh Net	1,685		No	-	No	No	No
West Coast Demersal Scalefish	1,765		No	-	No	No	No
Northern Territory Fisheries							
Offshore Net and Line Fishery	537	Section 7.3.3.5	No	-	Yes	No	No
Spanish Mackerel Fishery	537		No	-	Yes	No	No
Demersal Fishery	540		No	-	Yes	No	No
Timor Reef Fishery	569		No	-	Yes	No	No
Coastal Line Fishery	618		No	-	No	No	No
Indonesian and Timor-Leste Coastlines							
Indonesia and Timor-Leste	>300	Section 7.3.7	Yes	-	Yes	No	No
Oil and Gas Industry							
INPEX Inchys FPSO	17	Section 7.3.8	Yes	-	Yes	Yes	No
Crux Platform (Future)	160		Yes	-	Yes	No	No

Montara FPSO	188		Yes	-	Yes	No	No

Physical Environment

Water Quality

Figure 9-29 presents the environmental fate of the modelled 80-day subsurface release of 254,400 m^3 of Prelude well fluids. The figure indicates approximately 10% of the hydrocarbon volume will evaporate to air, less than 2% or 5,000 m^3 forming a surface slick over a large area, more than 80% of the hydrocarbon (200,000 m^3) will decay within 100 days from the outset of the release with entrained and dissolved hydrocarbons in the water column peaking at the end of the 80-day period (approximately 40% of the total released volume) then reducing to 16% of the total hydrocarbon volume released within 20 days after spill cessation.

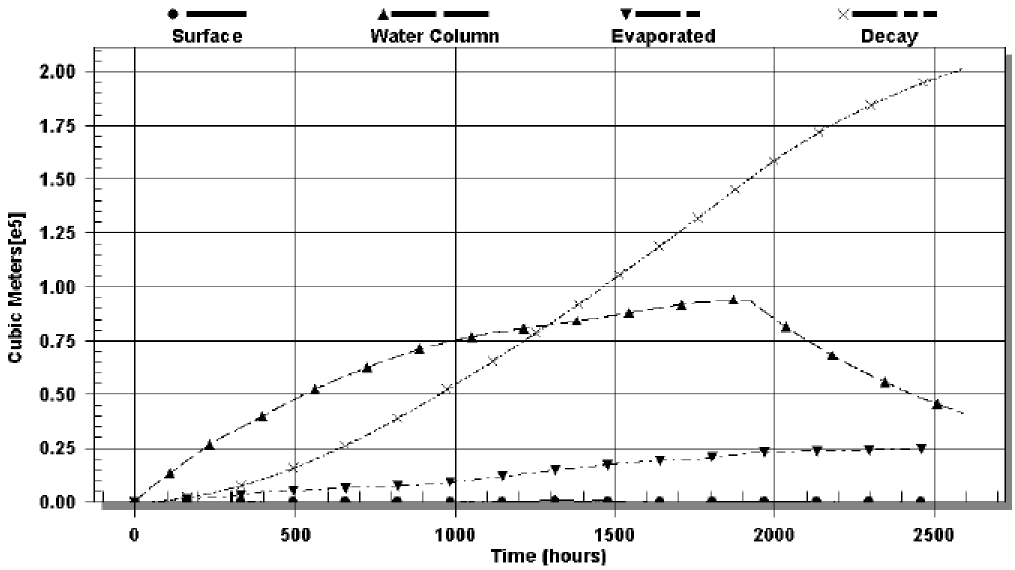


Figure 9-29: Predictions for the partitioning of oil mass over time through weathering processes for a subsea blowout of Prelude condensate for 80 days (1,600,000 bbl) (APASA, 2013)

The low residual volumes of floating oil will continue to weather, decay and diminish through further partitioning between the water column, air and shore/ sediment accumulation. The dissolved hydrocarbon fraction will have the greatest impact on water quality due to the presence of compounds such as BTEX and PAHs, which are known to be toxic to marine biota (refer to Biological Environment section below for a discussion of these effects). BTEX compounds are not expected to persist in the marine environment due to their volatility and will continually diminish due to weathering and biodegradation once released into the environment. PAHs are less volatile than BTEX due to their higher molecular weight/ more complex structures and are expected to persist for longer. The concentrations of hydrocarbons in the water column will decrease over time once the release has stopped due to processes such as dispersion, dilution, physical and biological degradation, and evaporation. For short duration release scenarios (i.e. diesel, HFO and condensate), these processes will begin to reduce the total amount of hydrocarbons in the water column shortly after the release.

MEG and amine spills may also adversely affect water quality to an extent. The MEG PNEC of 859 mg/L was modelled to be contained within an 8 km distance from the release location. MEG is readily biodegradable and its concentration will reduce significantly within days of the release. Refer to Section 9.9.2 for further impact assessment on MEG in the marine environment.

Amine will affect a larger area than a MEG spill due to its impact threshold of 1.8mg/L, which is forecast to extend over 78 km to the northeast and over 70 km to the southwest. The product exhibits readily to inherent biodegradability and is not anticipated to bioaccumulate and therefore is not persistent in the marine environment (Nalco Champion n.d).

Sediment Quality (Subsurface)

Sediment quality is not expected to be significantly affected by any of the worst-case scenarios that release hydrocarbons at the sea surface. Hydrocarbon contaminants (e.g. PAHs) from such surface releases are unlikely to reach the seabed due to the water depth and low natural sedimentation rates in the region. Hydrocarbon contaminants from the worst case subsea releases (loss of well control) may contaminate sediments by advective transport of the plume that will be formed during the release (Romero et al. 2015). This is considered likely to occur for the loss of well containment scenario due to the relatively long duration of the release. Any resulting contamination will be concentrated around, and down-current from the wellhead. Due to the low density and volatile nature of the hydrocarbon, weathered condensate is unlikely to be deposited to the seabed. The diesel and HFO releases from a loss of fuel from a vessel scenario have relatively low portions of volatiles, which are expected to evaporate quickly following the release. The remaining diesel and HFO fractions may sink to the seabed if exposed to considerable sedimentary particles, however this is considered very unlikely to occur in the open sea due to the low density of the residual hydrocarbons relative to seawater and the naturally low suspended solids and associated sedimentation rates. Residual diesel and heavy fuel oils near shorelines may be exposed to higher sediment loads and be more likely to sink. Stranding of residual/persistent oils on shorelines may lead to long-term contamination of sediments with high-molecular weight hydrocarbons. These compounds are typically much less toxic than low-molecular weight hydrocarbons.

The surface releases of amine and MEG are not considered likely to affect sediment quality due to the low inherent natural suspended solids, low sedimentation rates and the properties of the amine and MEG constituents, which are reported to have low organic carbon-water partition coefficient, KOC, indicating low adhesion/ high mobility of those chemicals in sediments (NLM Toxnet Database). Additionally, the amine plume will be buoyant due to lower density relative to sweater so it will remain in the surface layers of the water column.

Air Quality

The gas plume from the worst-case loss of well containment scenario will result in a gas cloud upon reaching the water surface. This potentially large gas cloud is expected to disperse rapidly in the open, offshore environment. The formation of gas clouds can pose a significant safety risk from the formation of explosive mixtures and asphyxiation. Given the localised extent and open environment, this risk is considered to be very low for the receiving environment.

The table below presents the risk assessment for the worst case in terms of impacts emergency event (i.e. well LOC) for the physical environment, based on the worst case outcome for any environmental receptor (i.e. water quality).

Environmental Receptor	Consequence	Likelihood	Residual Risk
Physical Environment (Water, Sediment and Air Quality)	Massive	B-Remote	**Yellow**

Biological Environment

Benthic Communities

Bare Sediments

Seabed releases of Prelude well fluids may result in impacts to water quality and sediments in the vicinity of the release location (refer to sections Water Quality and Sediment Quality above). The seabed in the Operational Area and surrounds is characterised by bare sediments which host low density infaunal and epibenthic communities of filter feeding and deposit feeding organisms. These fauna species may be subject to acute and chronic toxic effects from exposure to hydrocarbons, however the extent of the affected habitat is expected to be localised to the vicinity of the release location. This bare sediment habitat is widely represented in the Timor Sea, and the associated fauna assemblages are not considered to be particularly sensitive or of high conservation value. Filter feeding benthic communities may be vulnerable to entrained and dissolved hydrocarbons. Entrained hydrocarbons can be ingested by filter feeders, leading to increased exposure due to accumulation of ingested oil droplets (Payne & Driskell 2003). While typically less toxic than dissolved hydrocarbons, entrained oil may still cause toxic effects and may also result in physical impacts such as clogging of filter feeding organs, potentially resulting in reduced feeding efficiency. Filter feeder, and sessile organisms in general, may be exposed to concentrations of dissolved hydrocarbons that result in acute and chronic toxic effects.

The more diverse benthic communities in the ZPI are found in shallower waters (< 50 m depth) or in association with islands, shoals, reefs, banks and the shoreline of the Australian, Indonesian and Timor-Leste mainlands. This diversity is due to ambient conditions supporting a healthy presence of primary producers, such as zooxanthellate corals, macroalgae and seagrasses and mangroves.

Modelling results from the loss of well containment, condensate, diesel and HFO scenarios indicate that several offshore reefs and islands, banks and shoals, may be contacted by hydrocarbons above adverse impact thresholds. Impacts on the primary producer communities in these locations are discussed below.

Corals

Experimental studies and field observations in the aftermath of hydrocarbon spills for corals indicate contact with hydrocarbons may result in impacts from no observable injury through to complete or partial tissue death of the colony, with tissue death occurring on the coral colony's surface where oil has adhered (Johannes et al., 1972, Jackson et al., 1989). Branching corals appear to be more sensitive to contact with hydrocarbons than other species and growth forms (Johannes et al., 1972), however, these are uncommon on intertidal reef flats and generally occur only in significant abundance subtidally.

Subtidal corals avoid direct contact with surface oil slicks but can be exposed to the entrained and dissolved hydrocarbon plumes when at the same depths. These hydrocarbon fractions are most likely to cause sublethal effects, such as polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduction in growth rates and impaired reproduction (Negri and Heyward, 2000). The planktonic stages (spawned gametes and larvae) of coral are more susceptible to adverse effects from exposure to hydrocarbons because of their tendency to float or remain near the water surface thus bringing them into direct contact with surface slicks (Villanueva et al., 2008). In addition, the concentrations of water-soluble fractions that inhibit fertilisation or are lethal to coral gametes are lower than those for lethal or sublethal effects in adult colonies (Heyward et al., 1994; Negri and Heyward, 2000). Coral planktonic stages of mass spawning species are largely confined to a 1 to 3-week period after spawning which generally occurs in March/ April but may occur twice a year for the coral colonies in the Timor sea. A spill outside of these periods is of less concern for coral planktonic stages.

Compared to subtidal coral habitats, reef flat communities generally have the lowest coral cover and lowest diversity of corals due to the harsh conditions for coral growth i.e. regular tidal exposure and extensive wave action (particularly along the west coast of Australia). As hydrocarbon ultimately floats to the sea surface, the most vulnerable coral colonies to direct contact with hydrocarbon spills are intertidal corals found on a reef flat, which are periodically exposed during low tides. As such, whilst the reef flat habitat is the most vulnerable coral habitat to direct contact to spills, it is also regarded as the least sensitive of the shallow coral habitats.

The intertidal and shallow water coral reef species at Browse Island, Heywood and Echuca Shoals and other nearby reefs and shoals could potentially suffer sub-lethal stress and, depending on the exposure time and concentration, potentially high rates of mortality. The exposure time and concentration are a function of the location, including the distribution of entrained and dissolved hydrocarbons throughout the water column, the extent of the spill, the met-ocean conditions at the outset of the spill and in the days and weeks following it. The extent of sub-lethal stress and mortality on coral species is likely to be species and depth dependent with intertidal and shallow subtidal species most likely to be impacted by hydrocarbon exposure, compared to their deeper counterparts. These shallow water communities have shown that they can recover quickly from natural mass mortality events. However, depending on the severity of the spill, recovery may still take years.

<u>Macroalgae and Seagrass</u>

Although seagrass and macroalgae may be subject to lethal or sublethal toxic effects including mortality, reduced growth rates and impacts to seagrass flowering, several studies have indicated rapid recovery rates may occur even in cases of heavy oiling (Burns et al.; Dean et al., cited in WEL, 2011).

Most seagrasses within the area that may be affected by the worst-case hydrocarbon spill scenarios are subtidal, although there may be relatively small areas of intertidal seagrasses along the WA coastline. Seagrass in the subtidal and intertidal zones will have different degrees of exposure to hydrocarbon spills. Subtidal seagrass is unlikely to be exposed to surface spilled hydrocarbons, as most hydrocarbons in subtidal environments will be concentrated at the surface. Intertidal seagrasses are vulnerable to smothering by floating oil slicks, which can lead to mortality if it coats their flowers, leaves and stems (Dean et al. 1998; Taylor and Rasheed 2011). Long-term impacts to seagrass are unlikely unless hydrocarbon is retained within the seagrass meadow for a sustained duration (Wilson and Ralph 2011). Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie et al. 2010). The potential for toxic effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs.

Like seagrasses, the potential impacts to macroalgae depend on the exposure pathway; most macroalgae in the region are subtidal, although intertidal macroalgae may be present. Studies of subtidal macroalgal assemblages exposed to fuel oil spills have shown that impacts from exposure are slight (Edgar et al. 2002; Lobón et al. 2008). Effects of exposure to oil on intertidal macroalgae are more variable; some studies reported little evidence of impacts (Díez et al. 2009), while others show significant impacts (De Vogelaere and Foster 1994). Recovery of intertidal macroalgae has been shown to occur faster in areas where oil has been left to degrade naturally compared to areas subject to intensive clean-up operations (De Vogelaere and Foster 1994). The same applies to the amine spills from the facility which were predicted to reach the closest sensitive receptors in only 2% of the cases above the defined impact threshold.

Mangroves

Intertidal mangrove habitats occur throughout much of Kimberley, offshore islands, Indonesia and Timor Leste and are highly susceptible to oil pollution (NOAA 2014). Given the distance between potential release locations and the nearest mangroves, any spilled hydrocarbons reaching mangroves will be highly weathered. Mangroves are vulnerable to contact with floating hydrocarbons, which may coat prop roots and pneumatophores (aerial roots that support oxygen uptake) (Duke and Archibald 2016). Exposure can result in direct effects such as yellowed leaves, defoliation and mortality, and indirect effects such as reduced recruitment and increased sensitivity to other stressors (NOAA 2014). Like seagrasses, mangroves can also be impacted by entrained and dissolved aromatic hydrocarbons either in the water or sediment.

Mangrove communities will not be impacted by the worst case modelled chemical spills from Prelude due to the large separation distance, dilution and low toxicity and low persistence of MEG and amine's low toxicity.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events (i.e. well LOC, diesel or HFO) for benthic communities, based on the worst-case outcome for any of the environmental receptors in this group.

Environmental Receptor	**Consequence**	**Likelihood**	**Residual Risk**
Benthic Communities (Bare Sediments, Corals, Macroalgae and Seagrass and Mangroves)	Major	B-Remote	**Yellow**

Pelagic Communities (Plankton, Pelagic Fish and Invertebrates)

Plankton

Potential impacts to phytoplankton and zooplankton from the worst-case hydrocarbon or chemical spills are expected to consist of short-term acute toxic effects. Planktonic communities are characterised by relatively rapid turnover rates of short-lived biota. The high turnover rate will lead to rapid recovery as the spilled hydrocarbons decay in the environment. Within plankton communities, there is evidence from laboratory studies that some taxonomic groups, particularly zooplankton (e.g. copepods) may be more sensitive to hydrocarbon pollution (Almeda et al. 2013; Jiang et al. 2010). Few reliable studies have shown any impacts of hydrocarbon spills on planktonic communities, with most studies concluding that impacts from hydrocarbon pollution cannot be distinguished from natural variability (Abbriano et al. 2011; Davenport et al. 1982; Varela et al. 2006). Many marine species have planktonic larval phases (e.g. corals, many species of fish). Organisms with planktonic larval phases typically produce very high numbers of larvae. A worst-case credible spill may result in increased mortality of planktonic larvae (which are subject to high natural mortality); however, this is not expected to result in population, habitat or species scale impacts.

Pelagic Fish

Fish respire through gills, which may make them more vulnerable to dissolved hydrocarbons than fauna with less permeable skins, such as cetaceans, marine reptiles and birds. Despite this apparent vulnerability, fish mortalities are rarely observed to occur due to hydrocarbon spills (Fodrie and Heck 2011; International Tanker Owners Pollution Federation 2011), although recorded instances of fish mortality from spills in confined areas (e.g. bays) exist. These observations are consistent with fish moving away from hydrocarbons in the water (Hjermann et al. 2007). Stochastic modelling results for all surface spills indicated that hydrocarbons are likely to be concentrated in surface layers. As a result, demersal fish are unlikely to be directly affected unless near a subsea release, as they are typically concentrated around seabed features e.g. shoals, banks and subsea KEFs. Pelagic fish are more likely to encounter dissolved and entrained hydrocarbons above adverse exposure thresholds but may move away from affected areas following detection.

Exposure of fish to hydrocarbons may results in acute and chronic effects and may vary depending on a range of factors such as exposure duration and concentration, life history stage, inter-species differences and other environmental stressors (Westera and Babcock 2016). Early life history stages of fish (planktonic eggs and larvae) may be more vulnerable to hydrocarbon pollution than juvenile and adults, as these early life history phases cannot actively avoid water with high concentrations of hydrocarbons. Fish embryos and larvae may exhibit genetic and developmental abnormalities from long-term exposure to low concentrations of hydrocarbons (Fodrie and Heck 2011), although such long exposures may not be representative of real-world conditions. Exposures to PAHs have also been linked to increased mortality and stunted growth rates of early life history (pre-settlement) of reef fishes, as well as behavioural impacts that may increase predation of post-settlement larvae (Johansen et al. 2017). Given the temporal and spatial scale of the worst-case credible spill scenarios (as shown by a single deterministic run), and the typically high supply of eggs and larvae, it is unlikely that any of the worst-case credible spill scenarios will result in significantly reduced recruitment of fish due to impacts during early life history phases.

Environmental monitoring of pelagic and demersal fishes immediately following the Montara oil spill indicated that despite the exposure to hydrocarbons, no adverse effects were detected in fish (Gagnon and Rawson 2012, 2011). Further sampling and testing over time indicated that fish captured in close proximity to the Montara wellhead were comparable to those collected from reference sites (Gagnon and Rawson 2012, 2011). This conclusion is supported by studies of fish stocks following large-scale hydrocarbon spills, which have shown relatively little evidence of reduced recruitment at the scale of fish stocks/populations (Fodrie and Heck 2011).

MEG or amine spills will also have transient effects on water quality and as such are not expected to adversely affect local fish communities at the population level.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for pelagic communities, based on the worst-case outcome for any of the environmental receptors in this group.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Pelagic Communities (Plankton, Pelagic Fish and Invertebrates)	Moderate	B - Remote	Dark Blue

Key Ecological Features (KEFs)

Modelling study results indicated no KEFs will be exposed to adverse impact thresholds for floating hydrocarbons, but several KEFs may be exposed to entrained and dissolved hydrocarbons above adverse impact thresholds. KEFs with the closest proximity to the credible spill sources that may experience contact above moderate impact thresholds include (see Table 9-81):

- continental slope demersal fish communities
- ancient coastline at 125 m depth contour
- Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex
- Ashmore Reef and Cartier Islands and surrounding Commonwealth waters.

The continental slope demersal fish communities and the ancient coastline at 125 m depth contour are entirely sub-tidal. The relatively diverse benthic communities associated with these habitats, such as filter feeding communities and demersal fish assemblages may be impacted by dissolved and entrained hydrocarbon above moderate exposure thresholds, which may result in acute or chronic toxic effects. KEFs are most likely to be contacted by the subsea loss of well control scenario, due to the large entrained hydrocarbon fraction. Modelling results indicated that no single deterministic run affected the entirety of a sub-tidal KEF; most runs typically affected a minor portion of any given KEF. Given the nature of the KEFs and the scale of potential impacts, recovery of impacted parts of a KEF are expected to be facilitated by movement and recruitment of biota from the unaffected areas.

Several offshore reefs and islands within KEFs were identified by the modelling study results as potentially being contacted by hydrocarbons above adverse exposure thresholds. These include Ashmore Reef and Cartier Island and Seringapatam Reef and Commonwealth waters in the Scott Reef complex. Offshore reefs and islands typically host light-dependent ecosystems characterised by benthic primary producers and biological communities that are distinct from coastal islands and the mainland. Potential impacts will be limited to submerged receptors only as floating oils were predicted to contact any of these KEFs at concentrations well below the lower adverse impact threshold at very low annual probabilities between 0.5% and 3%. Environmental effects will be similar to those described for sub-tidal KEFs.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for pelagic communities, based on the worst-case outcome for any of the environmental receptors in this group.

Environmental Receptor	Consequence	Likelihood	Residual Risk
KEFs	Major	B-Remote	**Yellow**

Threatened and Migratory Species

Cetaceans and Dugongs

Marine mammals potentially present, their conservation status and any associated BIAs within the ZPI are detailed in Section 7.2.8.

Cetaceans exposed to surface, entrained or dissolved aromatic hydrocarbons above adverse exposure thresholds may suffer external oiling, ingestion of oil and inhalation of toxic vapours (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Cetaceans in coastal waters (e.g. coastal dolphin species and humpback whales at the northern limit of their migration) are at lower risk of impacts than cetaceans in offshore water due to the oil weathering before reaching coastal waters.

Skin contact with floating hydrocarbons could result in irritation and absorption and potential for impact to eyes and airways. Inhalation of vapours or the ingestion of hydrocarbons can potentially have lethal effects due to damage to the whale's respiratory and nervous systems. Baleen whales, such as blue whales and humpback whales, are the most likely to be susceptible to hydrocarbon ingestion due to their feeding through baleen plates including from near water surface. Toothed whales and dolphins are less susceptible due to their 'gulp' feeding approach, often targeting individual specific prey away from the sea surface (Woodside Energy Limited 2011).

However, cetaceans and dugongs are highly mobile, capable of long migrations, and typically in low numbers/densities in the moderate exposure zone. Experimental and field observations indicate that whales and dolphins may be able to detect and actively avoid hydrocarbon slicks, but this may not always be possible and exposure to floating oil may still occur (Smith et al. 1983, Geraci and St. Aubin 1990).

Vessel-based surveys of the Browse Basin area by the Centre for Whale Research (Western Australia) Inc. between June and November 2008 recorded low numbers of cetaceans in a broad survey area, with average densities of 0.00013 large cetaceans (whales) per square kilometre (1 whale per 7,700 km^2) and 0.026 small cetaceans (dolphins) per square kilometre, or 1 cetacean in 39 km^2 (Jenner, Jenner & Pirzl 2009, cited in INPEX 2010). Given such sparse distributions, it is not anticipated that impacts to a significant portion of the cetacean and other mammal populations would result if a spill was to occur.

Dugongs are known to occur in coastal waters and around offshore islands within the moderate exposure zones identified by the stochastic spill modelling. There is a paucity of studies examining the effects of hydrocarbon spills on dugongs, although the direct impacts of exposure to hydrocarbons may be similar to cetaceans. Like cetaceans, dugongs are expected to be resilient to direct impacts due to their thick skin and blubber. Suitable dugong habitat is associated with seagrass meadows, which are typically restricted to shallow waters around the mainland coast and islands. The distance of dugong habitat from the worst-case credible spill release locations means that oil reaching dugong habitat will be highly weathered.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for cetaceans and dugongs.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Cetaceans and Dugongs	Moderate	B-Remote	Dark Blue

Reptiles

Stochastic modelling results indicated moderate exposure zones overlap the known distribution of several species of marine turtles and sea snakes. Saltwater crocodiles were also identified as potentially occurring within the adverse exposure zone; given the preferred habitat for saltwater crocodiles are freshwater rivers and estuaries, impacts to this species from the worst-case hydrocarbon spills are not considered credible. Marine turtles may be exposed to floating hydrocarbons when at the sea surface (e.g. breathing, basking etc.), and are not expected to actively avoid floating hydrocarbon slicks (NOAA 2010). Exposure to floating or entrained hydrocarbons may result in external oiling, which could result in impacts such as inflammation or infection (Gagnon and Rawson 2010, Lutcavage et al. 1995; NOAA 2010). Given the large portion of non-persistent hydrocarbons in Prelude condensate and well fluids, the loss of diesel or heavy fuel oil scenarios are considered to pose the greatest risk of external oiling. Dissolved hydrocarbons may result in toxic effects on marine turtles, however their relatively impermeable skin reduces the potential for these impacts.

Stochastic modelling identified island and mainland shoreline habitats (sandy beaches and inter-nesting habitat) that may be exposed to hydrocarbons above moderate exposure thresholds. Some of these are classified as habitat critical for the survival of marine turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a) and BIAs as listed in Table 7-7. Of these, the critical nesting and inter-nesting habitats for green turtles at Browse island have the highest probability to be affected above moderate impact thresholds.

Several shoals and banks occur in the ZPI, which may be used as foraging areas by marine turtles. Impacts to benthic habitats and biota at these shoals and banks may result in a reduction of prey for marine turtles. A spill reaching critical nesting habitats during peak periods to turtle nesting could result in impacts. With respect to floating oil, given the distance of these locations from Prelude, worst-case credible spills of Prelude well fluids, condensate, HFO or diesel reaching these areas will be highly weathered and unlikely to result in impacts from an acute toxicity perspective, except for Browse Island.

Sea snakes have similar exposure pathways to spilled hydrocarbons as marine turtles (although sea snakes will not be exposed to shoreline hydrocarbon accumulation). Potential impacts are expected to be comparable and may include irritation of eyes and mucous membranes. Sea snake mortality has been linked to exposure to hydrocarbon spills, with dead sea snakes recovered from the region of the Montara oil spill showing high levels of petroleum hydrocarbons (including PAHs) in the trachea, lungs and stomach (Gagnon 2009). These results are consistent with exposure through ingestion and respiration of hydrocarbons. Ashmore Reef and Hibernia Reef are noted as being one of the few sites where the critically endangered leaf-scaled sea snake and short-nosed sea snake have been recorded, along with other species of sea snake. Both the leaf-scaled and short-nosed sea snakes have not been detected at Ashmore Reef since 2001, despite increased biological survey effort. Both locations were identified by the stochastic modelling as potentially being exposed to hydrocarbon above moderate adverse exposure limits.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for reptiles.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Reptiles	Major	B-Remote	**Yellow**

<u>Seabirds and shorebirds</u>

Seabirds and shorebirds are present in the ZPI (see Section 7.0 for details). Seabirds are particularly vulnerable to hydrocarbon spills owing to high potential for contact with the sea surface where they feed, rest or moult. Feeding by seabirds recorded in the region involves snatching prey items from or below the water surface by paddling or aerial diving, and these birds also rest on the ocean surface. Migrating and residential shorebirds by contrast are less susceptible to severe oiling and associated physical effects as they confine feeding to shorelines (Sholz et al. 1992; cited in Woodside Energy Limited 2011) and they do not land on the water surface. In cases where the hydrocarbon spill comes ashore large number of shorebirds may be impacted.

In the event of a spill, seabirds and shorebirds are likely to make contact with spilled hydrocarbons due to the amount of time they spend on or near the surface of the sea and on affected foreshores. Contact with hydrocarbon may impact a bird's ability to fly due to external and/ or internal exposure potentially leading to death by drowning, starvation or predation. Hydrocarbon contamination affects the feathers insulation, buoyancy and waterproofing properties and ultimately the bird's survival. The overriding behaviour of a bird with oiled feathers is preening to the exclusion of all other normal activities. As an affected bird preens, it ingests and inhales hydrocarbons, which can cause damage to internal organs such as the lungs, intestines and liver. Suppression of the immune system can also occur and other effects include impacts to reproductive success through decreased fertility of eggs and reduction in egg shell thickness.

Specifically, estimates for the minimal thickness of floating oil that might result in harm to seabirds through ingestion from preening of contaminated feathers, has been estimated by different researchers at approximately 10g/m^2 (French 2000) to 25g/m^2 (Koops et al. 2004).

The main area of sensitivity for migratory birds are the Ashmore Reef and Cartier Islands, which are recognised as particularly important for feeding migratory shore birds during non–breeding periods. These islands are an important staging point during the migration between the Northern Hemisphere and Australia. During October to November and March to April large flocks of birds protected under the JAMBA, CAMBA and ROKAMBA are more likely to be present in the area and sensitive to shoreline oil contact. Browse Island, and Seringapatam and Scott Reefs are recognised as important habitat for seabirds. These locations, as indicated by modelling, will not be affected to any adverse impact levels i.e. > 10g/m^2 (French 2000).

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for seabirds and shorebirds.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Seabirds and shorebirds	Massive	B-Remote	**Yellow**

Socio-Economic and Cultural Environment

Commonwealth Heritage Places and Marine Protected Areas

Commonwealth Heritage Places and Marine Protected Areas overlap with the sensitive receptors discussed in the Physical and Biological Environment sections above.

Several offshore islands and reefs listed as Commonwealth Heritage Places were identified by the spill modelling results as potentially being contacted by hydrocarbons above moderate exposure thresholds. These include:

- Ashmore Reef National Nature Reserve Commonwealth Heritage Place
- Scott Reef and Surrounds Commonwealth Heritage Place
- Mermaid Reef – Rowley Shoals Commonwealth Heritage Place

The environmental values of these reefs are primarily their outstanding natural values. These have been discussed in the preceding sub-sections.

Modelling results of the worst-case credible spill scenarios indicated a range of Commonwealth, state and territory marine parks may be contacted above moderate exposure thresholds (Table 9-81). These parks contain a range of environmental values such as marine biota, representative marine habitats and unique sea scapes (e.g. KEFs). Environmental values for these marine parks are described in Section 7.0 and discussed above in Physical and Biological Environments. Refer to these sections for discussion of potential impacts to these environmental values within marine parks.

The table below presents the risk assessment outcome for this receptor.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Commonwealth Heritage Places and Marine Protected Areas	Massive	B-Remote	**Yellow**

Fishing Industry

A number of commercial fisheries operate within the moderate exposure zone determined from spill modelling results. The worst-case credible hydrocarbon spill scenarios may result in a range of impacts to commercial fishing activities, such as (International Tanker Owners Pollution Federation 2011):

- displacement of fishing effort from areas affected by a spill or spill response activities
- damage to fish stocks due to mortality
- closure of fisheries by management agencies
- inability to sell catch due to perceived or actual fish tainting or contamination
- oiling of fishing gear, particularly by floating oil.

A significant hydrocarbon spill would likely result in the temporary closure of areas of fisheries within the area of moderate exposure. The spatial extent and duration of the closure would depend on the nature and scale of the pollution resulting from the hydrocarbon spill. Given the large spatial extent of managed fisheries relative to the area potentially contacted above moderate exposure thresholds for any single event, a spill is unlikely to result in the complete closure of a fishery. Rather, the closure of areas to fishing is more likely to result in the displacement of fishing effort during the response and recovery phases. Displacement from productive fishing areas may result in impacts to fishers such as increased costs and reduced catch per unit effort and reduced income. Exposure of fish to hydrocarbons may result in tainting, which may render landings unsuitable for human consumption. Tainting may occur even at low levels of hydrocarbon exposure. Monitoring of fish for taint immediately following capping of the Montara well detected differences between fish likely to have been exposed to hydrocarbons, however these differences were not conclusively linked to oil contamination and fell within the range of “normal” fish odours (Rawson et al. 2011). Samples collected at the same monitoring locations two and four months after were not distinguishable (Rawson et al. 2011). These results are consistent with other studies of fisheries resources exposed to hydrocarbon pollution, which acknowledge the potential for impacts to fisheries resources and have shown little potential risk for consumers if suitable fisheries management actions are undertaken (Law and Hellou 1999; Law and Kelly 2004). Fish caught in areas affected by a significant hydrocarbon spill may be perceived as being of poorer quality, even if no decrease in quality is evident. This may result in lower prices at the time of sale and subsequently lead to reduced income for commercial fishers.

The table below presents the risk assessment outcome for this receptor.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Fishing Industry	Moderate	B-Remote	Dark Blue

Tourism and Recreation

There are currently no known tourism activities in the Operational Area, or immediate surrounding areas, due to the remoteness and water depth of the area. Some tourism activities may occur at the remote offshore islands and reefs within the ZPI. These activities are expected to be exclusively nature-based tourism and impacts to the environmental values associated with these islands and reefs may impact upon tourism activities. Mainland coastline and islands will typically host more nature-based tourist activities than offshore islands. This activity is expected to be seasonal, with increased visitation during the winter dry season months. Impacts to tourism activities are expected to be minor based on the likelihood and nature of contact to environmental values that support tourism activities. Impacts to these values may result in displacement of tourism activity, introduction of temporary exclusion zones or avoidance of areas with visible oil sheens, and a corresponding loss of revenue for tourist operators (e.g. charter fishing cancellations due to fishery closures).

The table below presents the risk assessment outcome for this receptor.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Tourism and Recreation	Minor	B-Remote	Dark Blue

Defence

Defence activities within the offshore North Australian Exercise Area (NAXA) are unlikely to be affected by the worst-case credible hydrocarbon spills. Activities may be temporary displaced from areas where spill response operations are underway. This would be highly localised and temporary in nature.

Shipping

Potential impacts to commercial shipping from the worst-case credible spill scenarios are expected to be slight and consist of temporary displacement of other users from areas where spill response activities are underway. These are expected to be concentrated around the release location.

The table below presents the risk assessment outcome for defence and shipping.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Defence and Shipping	Minor	B-Remote	Dark Blue

Oil and Gas Industry

Petroleum activities in the region include drilling and pre-installation activities for the future Shell-operated Crux facility, the INPEX-operated Ichthys facility and the Montara development. Other exploration activities are expected to occur in the Timor Sea throughout the life of the Prelude operations. Reduction in water quality as a result of a worst-case credible spill may affect the operation of these facilities if seawater at the facility is no longer suitable for intake (e.g. for use as cooling water or feed water for RO water generation). This may result in impacts to routine operations such as decreased production. A worst-case hydrocarbon spill response may result in competition for vessels and potentially drilling rigs (if well intervention or a relief well is required).

The table below presents the risk assessment outcome for the oil and gas industry.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Oil and Gas Industry	Minor	B-Remote	Dark Blue

Indonesian and Timor Leste Coastlines

The spill modelling results indicate there is the potential for the well loss of containment spill scenario resulting in contact with the Indonesian coastline. The probability of floating film contact with the Indonesian Coastline was estimated at < 0.5% and minimum arrival time of 64 days for those rare contact scenarios, with maximum local accumulation of 3 kg/m^2 for the worst replicate spill. Contact for entrained oil was also predicted at 33% for the moderate exposure threshold. The probability of dissolved hydrocarbon contact was predicted to be approx. 5% for the moderate exposure threshold.

Given the relatively long time to contact, soluble aromatic hydrocarbon fractions are unlikely to be present, leaving relatively low toxicity residual hydrocarbons such as paraffins. Potential impacts may include smothering of coastal infrastructure (e.g. aquaculture, fishing equipment), which may result in localised economic impacts.

The table below presents the risk assessment for the worst case in terms of impacts emergency events for seabirds and shorebirds.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Indonesian and Timor Leste Coastlines	Major	B-Remote	Yellow

9.13.5 Risk Assessment Summary

The risk assessment summary in Table 9-82 is based on the worst case in terms of consequences spill event, i.e. the loss of well control LOC.

Table 9-82: Emergency Events Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Physical Environment	Massive	B-Remote	Yellow
Biological Environment	Major	B-Remote	Yellow
Socio-economic Environment	Massive	B-Remote	Yellow

9.13.6 ALARP Assessment and Environmental Performance Standards

Table 9-83: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	None identified	N/A	N/A	N/A	N/A	N/A
Substitution	Substitute MEG, Amine or HFO/IFO within MDO or LNG with less hazardous chemicals	No	MEG and amine (MDEA) have been selected based on their performance and non-hazardous HES properties. MEG is classified as PLONOR and is also considered as non-persistent in the environment and does not bioaccumulate. Amine (MDEA) is biodegradable and exhibits low toxicity. Additionally amine is used in closed systems and is not intended to be disposed to the marine environment. It is not practical for Shell to mandate vessel specifications or requirements regarding fuel types onboard offtake tankers visiting the Prelude FLNG facility.	N/A	N/A	N/A
Engineering	FLNG is double hulled	Yes	Prelude FLNG is double-hulled except for the area around the hull thrusters as purposefully designed. In addition, the condensate storage tanks are surrounded by ballast water tanks which provide additional protection in case of a hull breach.	N/A	N/A- Prelude FLNG is permanently installed (moored) and commissioned at the time this EP commenced, and is therefore not described in further detail here as an EPS	N/A
Engineering	Condensate offloading hoses have Marine Breakaway Coupling (MBC)	Yes	The MBC is designed to prevent oil spills and protect the transfer system from damage in the event of a tanker breakout or an excessive pressure surge.	11.1	Condensate offloading hose is equipped with a MBC	Records demonstrating presence of an MBC on the condensate offloading hose.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Engineering	Use of radars/ Automatic Identification System (AIS)/ Automatic Radar Plotting Aid (ARPA) and associated alarms on FLNG, infield support vessels and supply vessels	Yes	Use of radars/ Automatic Identification System (AIS)/ Automatic Radar Plotting Aid (ARPA) and associated alarms on FLNG, infield support vessels and supply vessels. This technology allows early identification and notification of approaching vessels and is crucial in minimising the risk of vessel-to-vessel collision. All product off-loading activities are done in accordance to the Prelude Terminal Information Book (OPS_GEN_004647) which includes specific collision prevention procedures and measures including: • Controlled speed for all marine vessels in the PSZ • Ability for three way communication between FLNG, infield support vessels and offtake vessel • The PSZ is patrolled by support vessels • FLNG radar/ ARPA and associated alarms monitored for approaching vessels • Vessels follow pre-determined access routes to the FLNG and assess environmental conditions (wind, current and sea state) • Contractual requirement for vessels to be manned by competent crew • All contracted vessels employed are subjected to a stringent assurance process, and • Product offtake tankers are assisted by Prelude infield support vessels and piloted by Prelude FLNG marine pilots to ensure safe berthing/ offloading/bunkering/ de-berthing.	11.2	Product offtake tankers are assisted by Prelude infield support vessels.	AIS information shows offtake tankers being assisted by Prelude infield support vessels.
				11.3	Product offtake tankers are piloted by competent marine pilots to ensure safe berthing/ offloading/ de-berthing.	Pilot Competency Assurance
				11.4	The FLNG supporting vessels are equipped with suitable and operational navigation and collision avoidance equipment, specifically: • ARPA • AIS • Radar, and/or • Equivalent system.	Marine Assurance records

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	Exclusion zone around drill centre and FLNG	Yes	As per section 616 of the OPGGS Act, a PSZ is established for the Prelude FLNG, moorings and drill centre. The gazetted PSZ prohibits all vessels other than vessels under the control of Shell and those operated by authorised persons from entering or being present in the area of the PSZ without the consent in writing of NOPSEMA. This small area of this established zone in the open ocean environment is considered to be inconsequential to other marine users.	1.3	Compliance with PSZ as per Section 616 of the OPGGS Act.	Gazette notice of PSZ Incident report form used to record breaches of PSZ requirements.
Administrative and Procedural Controls	Lifting procedures and maintenance & inspection of lifting equipment.	Yes	The Shell Australia Lifting and Hoisting Standard (OPS_PRE_010176) and Manual (OPS_GEN_010724) are mandatory for all lifting operations on the FLNG. The standard which specifies lifting requirements, performance standards and roles and responsibilities will be implemented to reduce the risk of dropped objects impacting subsea infrastructure potentially resulting in damage or at a worst case, a loss of well control event.	11.5	All lifts are approved in line with the Prelude Lifting and Hoisting Standard including the required use of PTW/risk assessment where applicable	Records of PTW, lift plans, training records and lifting equipment register
Administrative and Procedural Controls	FLNG and Vessel Bunkering Procedures for Hydrocarbons and Chemicals	Yes	The purpose of these procedures is to ensure that good practice and industry standards are applied during bunkering operations. Implementation of these procedures will minimise the risk of a spill incident through e.g. both facilities prepared for bunkering, drains plugged, approved bunker plan for specified volumes, designated receiving tanks and agreed pumping rates, direct communication between all involved and supervision at both ends and availability of spill kits onboard each vessel/facility.	11.6	The FLNG and contracted marine support vessels will have dry-break couplings, inspected and certified bunkering hoses, and this equipment will be maintained.	Assurance and maintenance records.
				11.7	No spills to water as a result of bunkering activities.	Incident records

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	SOPEP for vessels[49]	Yes	SOPEP shall be in place for all marine support vessels as required by class in accordance with as per AMSA Marine Order 91.	11.8	Vessels shall have a current SOPEP onboard to respond to small spills	A valid SOPEP for relevant vessels is in place
Administrative and Procedural Controls	Vessel anchoring and mooring plan	Yes	No support vessel anchoring in the Operational Area except in emergency situations or under issuance of a specific permit by Shell.	11.9	No support vessel anchoring in the Operational Area except in emergency situations or under issuance of a specific permit by Shell.	Records verify no breaches of anchoring procedures in the Operational Area.
Administrative and Procedural Controls	Subsea control operators are competent	Yes	Subsea control operators are trained and competent in the operation and monitoring of the hydrocarbon system.	11.10	Subsea control operators are competent in the operation and monitoring of the hydrocarbon system	Competency assurance records
Administrative and Procedural Controls	NOPSEMA accepted WOMP	Yes	Maintenance of well integrity is a key requirement to avoid loss of well control. The wells at Prelude are covered by NOPSEMA accepted Well Operations Management Plan (WOMP) that details key controls in place for the duration of the well lifecycle.	11.11	Accepted WOMP in place for Prelude wells to manage risks associated with well operations	WOMP acceptance letter
Administrative and Procedural Controls	NOPSEMA accepted safety case	Yes	In accordance with the OPGGS (Safety) Regulations 2009, all key activities will be undertaken in accordance with the accepted Prelude safety case.	11.12	Accepted safety case in place for Prelude to manage risks associated with operations	Safety case acceptance letter

[49] Advice from the Recognised Organisation will be followed and updates made where required, where there is any variation to the this control measure which may be applicable to the Prelude FLNG.

9.13.7 Acceptability of Risks

Table 9-84: Acceptability of Risks – Emergency Events

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	Water quality	Limited environmental impact to water quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Yes	Weathering data indicates low residual volumes of floating oil will continue to weather, decay and diminish through partitioning between the water column, air and shore/ sediment accumulation. The dissolved hydrocarbon fraction will have the greatest impact on water quality due to the presence of compounds such as BTEX and PAHs. BTEX compounds are not expected to persist in the marine environment due to their volatility and will continually diminish due to weathering and biodegradation once released into the environment. PAHs are less volatile than BTEX due to their higher molecular weight/ more complex structures and are expected to persist for longer. The concentrations of hydrocarbons in the water column will decrease over time once the release has stopped due to processes such as dispersion, dilution, physical and biological degradation, and evaporation.
	Sediment quality	Limited environmental impact to sediment quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Yes	Sediment quality is not expected to be significantly affected by any of the worst-case scenarios that release hydrocarbons at the sea surface. Hydrocarbon contaminants (e.g. PAHs) from such surface releases are unlikely to reach the seabed due to the water depth and low natural sedimentation rates in the region. Residual diesel and heavy fuel oils near shorelines may be exposed to higher sediment loads and be more likely to sink. Stranding of residual/persistent oils on shorelines may lead to long-term contamination of sediments with high-molecular weight hydrocarbons. These compounds are typically much less toxic than low-molecular weight hydrocarbons.
Biological Environment	Benthic communities	Limited environmental impact which directly impacts bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities which adversely effects biological diversity or ecological integrity.	Yes	Modelling results from the loss of well containment, condensate, diesel and HFO scenarios indicate that several offshore reefs and islands, banks and shoals, may be contacted by hydrocarbons above adverse impact thresholds. Shallow water corals communities have shown that they can recover quickly from natural mass mortality events. However, depending on the severity of the spill, recovery may still take years. Although seagrass and macroalgae may be subject to lethal or sublethal toxic effects

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
		Limited environmental impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.		including mortality, reduced growth rates and impacts to seagrass flowering, several studies have indicated rapid recovery rates may occur even in cases of heavy oiling Mangrove communities will not be impacted by the worst case modelled spills due to the large separation distances between Prelude and the intertidal mangrove habitats found along the Kimberley coastline, offshore islands, Indonesia and Timor Leste.
	Pelagic communities (Non-Threatened or Migratory)	Limited environmental impact leading to adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	Yes	Potential impacts to phytoplankton and zooplankton from the worst-case hydrocarbon or chemical spills are expected to consist of short-term acute toxic effects. Planktonic communities are characterised by relatively rapid turnover rates of short-lived biota. The high turnover rate will lead to rapid recovery as the spilled hydrocarbons decay in the environment. Exposure of pelagic fish to hydrocarbons may results in acute and chronic effects and may vary depending on a range of factors such as exposure duration and concentration, life history stage, inter-species differences and other environmental stressors. Studies of fish stocks following large-scale hydrocarbon spills, which have shown relatively little evidence of reduced recruitment at the scale of fish stocks/populations.
	KEFs	Limited impact to environmental values of KEFs	Yes	The continental slope demersal fish communities and the ancient coastline at 125 m depth contour are entirely sub-tidal. The relatively diverse benthic communities associated with these habitats, such as filter feeding communities and demersal fish assemblages may be impacted by dissolved and entrained hydrocarbon above moderate exposure thresholds, which may result in acute or chronic toxic effects. Modelling results indicated that no single deterministic run affected the entirety of a sub-tidal KEF; most runs typically affected a minor portion of any given KEF. Given the nature of the KEFs and the scale of potential impacts, recovery of impacted parts of a KEF are expected to be facilitated by movement and recruitment of biota from the unaffected areas.
	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or	Yes	Shell has identified the potential for hydrocarbon pollution, and potential consequential habitats degradation for to listed threatened or migratory MNES fauna populations from a large scale hydrocarbon

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
		Migratory MNES fauna populations. Management of aspects of the project must be aligned to conservation advice, recovery plans and threat abatement plans, including for bird and marine turtle species.		release as a major environmental risk. Shell has applied a range of controls that are intended to reduce the likelihood of such a release occurring, and mitigative controls to understand and reduce the severity of impacts should such as release occur. Large-scale hydrocarbon releases pose a significant safety risk for Shell personnel, and considerable effort will be applied to reduce the inherent likelihood of large-scale hydrocarbon releases occurring.
	Ramsar Wetlands	Limited environmental impacts to ecological values of Ramsar wetlands	Yes	Shell considers large-scale releases of hydrocarbons from Prelude to be unacceptable. Such spills have a potential to result in significant environmental impacts. Consequently, Shell will apply its considerable experience and knowledge in the offshore petroleum industry to ensure such a release never occurs from Prelude. Shell has applied a conservative approach to the identification and modelling of the credible worstcase hydrocarbon spills. This information was used to inform the evaluation of the environmental impacts and risks, and is consistent with the precautionary principle. Shell will implement industry standard controls to manage the risk of unplanned hydrocarbon spills through this EP and associated OPEP commensurate to the nature and scale of the hydrocarbon pollution risks Prelude operations.
	Commonwealth Marine Area	Limited environmental impacts to the Commonwealth Marine Area (refer to Table 8-1)	Yes	
	WA mainland coastline	Limited environmental impacts to mainland coastline.	Yes	
Socio-economic Environment	Commonwealth Heritage Properties	Limited environmental impacts to defined heritage values	Yes	
	Marine Protected Areas	Limited environmental impacts to ecological values of Marine Protected Areas	Yes	
	Fisheries	No interference with fishing to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Yes	
	Tourism & recreation	No negative impacts to nature-based tourism resources resulting in demonstrated loss of income.	Yes	

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
	Defence & shipping	No interference with defence activities as directed by the Department of Defence. No interference with navigation to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Yes	
	Oil and Gas industry	No interference with other titleholders to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out the petroleum activities	Yes	
	Indonesian & Timor Leste Coastlines	No impacts to Indonesian or Timor-Leste coastlines or nearshore environments are acceptable.	Yes	

A comprehensive assessment of the risks from the worst-case credible spill scenarios arising from Prelude Operations has been undertaken. Globally, Shell is experienced in the design, installation and decommissioning of similar developments and understands the impacts and risks that may arise from these worst case credible spill scenarios. Shell has undertaken environmental studies, numerical modelling and consultation to identify the environmental receptors that may be affected and understands the nature and implications of potential hydrocarbon pollution. These studies, along with Shell's organisational experience, allows a high degree of confidence to be placed in the outcomes of the assessment of the risks.

Principles of ESD

The risks and impacts from the worst-case credible spill scenarios are inherently inconsistent with some of the principles of ESD based on the following:

- environmental resources and sensitivities may be significantly impacted in the event a worst-case credible spill, and
- a worst-case credible spill may prevent others exercising their right to access environmental resources.

Shell will apply a range of controls to ensure that a worst-case credible spill from the Prelude project never occurs. These include a range of industry best practices that have been developed through extensive industry experience, including the lessons learned from significant unplanned releases such as the Macondo and Montara well blowouts. Following successful application of these controls, Shell considers the residual risk to be consistent with the principles of ESD. This consistency is achieved by:

- developing natural resources in an environmental responsible manner, resulting in income for government, generation of Australian jobs, and developing an increased understanding of the Timor Sea environment.
- application of the precautionary principle in the assessment of hydrocarbon spill scenarios by:
  - using worst-case credible spill scenarios. Industry statistics indicate the vast majority of unplanned spills are significantly smaller than the worst-case credible spills.
  - using a stochastic modelling approach for numerical modelling of the worst-case credible spill scenarios that includes a large number (hundreds) of deterministic runs covering a range of metocean conditions.
  - using environmentally conservative adverse exposure zone thresholds.

Relevant Requirements

Management of the impacts and risks from unplanned hydrocarbon spills are consistent with legislative requirements, including:

- compliance with international maritime conventions, including:
  - STCW Convention
  - SOLAS Convention
  - COLREGS
  - MARPOL: Annex I: prevention of pollution by oil and oily water.
- compliance with Australian legislation and requirements, including:
  - Navigation Act 2012 and Protection of the Sea (Prevention of Pollution from Ships) Act 1983:
    - Marine Order 21 (Safety of Navigation and Emergency Procedures
    - Marine Order 27 (Radio Equipment)
    - Marine Order 30 (Prevention of Collisions)
    - Marine Order 71 (Masters and Deck Officers)
    - Marine Order 91 (Marine pollution prevention – oil).
  - OPGGS Act 2006 and OPGGS (E) Regulations:
    - accepted WOMPs for all well activities, including drilling, operation, suspension and abandonment
    - accepted EP and OPEP for all petroleum activities associated with the Prelude project.
  - Implementation of recognised industry best practices, such as:
    - design, construction and operation of Prelude infrastructure in accordance with recognised industry standards
    - mutual aid agreement in place with other petroleum operators to assist with drilling rig availability for relief well drilling

- agreements in place with oil spill response service providers
- development of SIMOPS plans for activities that may interact with the Prelude FLNG facility.

Matters of National Environmental Significance

Commonwealth Marine Environment

Table 9-85 provides a summary of the alignment between managing of the emergency events aspect at Prelude with the relevant MNES acceptability considerations listed in EPBC Management Plans/Recovery Plans/Conservation Advices.

Table 9-85: Summary of Alignment of the Impacts from the Emergency Events associated with the Prelude Petroleum Activities to Relevant Requirements for MNES

Matters of National Environmental Significance	**MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)**	**Demonstration of Alignment as Relevant to the Project**
Threatened and Migratory Species – Marine Mammals	Emergency events due to loss of containment are not considered to be acceptable to Shell. In the event of such an incident, the relevant EPBC Management Plans, Recovery Plans and Conservation Advice documentation will be consulted based on the nature/scale of the spill and the determination of the potentially impacted environmental sensitivities to ensure mitigation and recovery efforts are in alignment. Refer to Table 7-6 for full list of potential plans at the time of writing this EP. The relevant databases will be checked at the time to ensure currency and any relevant inclusions will be made.	Shell has identified the potential for hydrocarbon pollution, and potential consequential habitats degradation, from large-scale hydrocarbon releases as a significant environmental risk. Shell has applied a range of controls that are intended to reduce the likelihood of such a release occurring, and mitigative controls to understand and reduce the severity of impacts should such a release occur.
Threatened and Migratory species - marine reptiles		
Threatened and Migratory species - sharks and rays		
Threatened and Migratory species - birds		
Commonwealth Marine Environment		

External Context

There have been no objections or claims raised by Relevant Persons to date around the emergency events aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, controls and EPSs which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements. Shell has, and will continue to maintain, an appropriate spill response framework, which includes regular testing of the response arrangements as per Section 10.7.

Acceptability Summary

The assessment of impacts and risks from the worst-case credible unplanned hydrocarbon spills determined the residual impact and risk rating is Yellow (Table

9-82). Given the significant consequence of the risks associated with these worst-case hydrocarbon spills, Shell has undertaken an extensive, conservative risk assessment and will apply a range of controls consistent with relevant requirements and industry best practice.

As outlined above, the acceptability of the impacts and risks from unplanned spills associated with Prelude operations has been considered in the context of:

- The established acceptability criteria for the emergency events aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Based on the points discussed above, Shell considered the impacts and risks from worst case Prelude emergency events to be acceptable following the application of the controls outlined in the ALARP Demonstration above.

9.13.8 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
No unplanned release of hydrocarbons or chemicals to the marine environment as a result of loss of containment from: • subsea infrastructure, • during storage and offloading, • refuelling, • vessel collision or • bulk transfer or lifting.	Incident reports associated with spills which initiated the ERT and/or IMT.

9.14 Oil Spill Response Strategies

9.14.1 Spill Impact Mitigation Assessment

As described in the SIMA presented in the OPEP, not all response strategies are applicable for every spill scenario. It is considered that a combination of response strategies may be required to implement an effective response.

In all spill scenarios (Section 9.13.1) source control and monitor and evaluation spill response strategies will be implemented. For condensate and diesel releases the success of various response strategies is considered to be limited based on the expected spreading, dispersion and evaporation rates in the marine environment making certain strategies such as contain and recover and surface dispersant application ineffective. Whereas for HFO spills they may be implemented as primary or secondary response strategies.

The applicability of all spill response strategies are assessed in the strategic SIMA presented in the OPEP. An ALARP assessment of the oil spill response strategies described in the OPEP are presented in Table 9-86.

Capability, readiness and implementation requirements for the specific spill response strategies are addressed in the OPEP (HSE_PRE_013075), which includes control measures and EPSs around the required level of performance of each response strategy, and hence are not repeated in this EP.

Table 9-86: ALARP assessment of oil spill response capability

Oil Spill Response Strategy	Resources	Environmental gain from increasing or improving resources	Alternatives considered	ALARP assessment
Source Control				
Site survey	Documents: Browse Basin Source Control Contingency Plan Source Control Equipment Mobilisation Plan Equipment: Vessel equipped with ROV and tooling Personnel: Subsea Intervention Group/Source Control Branch	A site survey involves the use of a vessel equipped with an ROV to conduct visual observations of the well and surrounding subsea infrastructure, following the loss of containment event. The information gathered is used to enable further source control planning and establish those source control activities that could be implemented. A single vessel with a single ROV is required to conduct the site survey. Multiple vessels and/or ROV's would not result in a better environmental outcome. If the failure can be immediately isolated remotely then this is the quickest response to reduce the environmental impact.	Additional vessels equipped with ROV's would not result in increased benefit for planning source control activities.	A vessel equipped to undertake the site survey is expected to take approximately 7-10 days to mobilise. The vessel to undertake the site survey would be sourced from within Australia using Shell's established vessel contracting procedures. The cost of maintaining a vessel with full ROV spread and ROV crew at all times to undertake a site survey is considered to be grossly disproportionate given that several vessels with ROVs could be made available on short notice within the region. The following well and subsea tree valves are fail-safe closed valves (SCSSSV, PMV, PWV and PSDV). With the subsea tree still connected, if there is a leak then the initial response would be to attempt to isolate the failure by remotely functioning one or more valves from the facility. There is also some ROV intervention capability.
Deployment of SFRT/SIRT and subsea dispersant injection (SSDI)	Documents: Browse Basin Source Control Contingency Plan Source Control Equipment Mobilisation Plan Equipment: AMOSC Subsea First Response Toolkit (SFRT) including 500 m^3 of Dasic Slick gone NS, mobilised to Broome in 6 days.	Access to the SFRT/SIRT to enable intervention in the event of a loss of well control scenario will also enable SSDI capability. SSDI will increase the entrainment of hydrocarbons in the water column thereby reducing the presence of hydrocarbons at the sea surface that can present environmental impacts. The application of subsea dispersant also has benefits over surface application in that it can	Consideration was given to moving the AMOSC SFRT to Broome to from Perth to enable for faster deployment however, it is owned by industry (others may also need the equipment in other areas) and as it is not on critical path there	Based on its location in WA, the AMOSC SFRT (located in Perth) would be mobilised as the primary control with the SIRT located in Norway/Brazil as a redundancy. As described in the row above, a vessel equipped to undertake the site survey is expected to take approximately 7-10 days to mobilise therefore the timeframe for mobilisation of the SFRT is not a limiting factor and improving this timeframe would not result in an environmental benefit.

Oil Spill Response Strategy	Resources	Environmental gain from increasing or improving resources	Alternatives considered	ALARP assessment
	OSRL Subsea Incident Response Toolkit (SIRT) mobilised to Broome. Personnel: Subsea Intervention Group/Source Control Branch, Shell's Well Control Virtual Emergency Response Team (WC VERT) available in 24 hours. AMOSC (SFRT) and Oceaneering (SIRT) personnel available in 24 hours.	reduce volatile organic compounds at the sea surface making it safer for responders to access the area for further source control activities. Where surface application of dispersant can only be applied in daylight hours, SSDI can occur 24 hours a day. The volume of dispersant associated with the SFRT can be replenished from various stockpiles located within Australia and Internationally.	is little value to be gained by such.	
Relief well drilling As described in Section 9.13.1, due to the presence of the Subsea Xmas Tree, the primary method of source control is the drilling of a relief well.	Documents: Prelude Well Operations Management Plan (WOMP) Prelude Safety case Browse Basin Source Control Contingency Plan Browse Basin Exploration and Appraisal Well Control Contingency Plan including relief well locations Relief Well Manual Well Kill Modelling & Analysis APPEA MoU Equipment: MODU to drill relief well and kill the well in 80 days, kill fluid & pumping equipment, tubulars, ranging equipment. Personnel: Shell Relief Well Task Force 24-72 hours.	Improving the timeframes to drill a relief to will reduce the volume of hydrocarbons released to the marine environment.	The relief well injection spool (RWIS) is a spool piece with side outlets installed below the BOP of the relief well to enable the connection of more surface pumping resources. These additional resources can deliver greater kill fluid rates to the relief well. As all Prelude wells can be killed with the pumping capacity of standard MODU, use of the RWIS would not result in a faster well kill and	Compliance with Shell's global standards for well design integrity to assure mechanical and functional integrity for all anticipated loads throughout the life of the well. These standards meet or exceed current International and Australian standards. The APPEA MoU allows the signatories to share rigs, equipment, personnel and services to assist other operators in the event of a well blowout. This would potentially enable Shell to source a suitable relief well MODU in a quicker timeframe, and would also provide access to additional equipment, personnel and services. Access to source control specialists is not considered a limiting factor.

Oil Spill Response Strategy	Resources	Environmental gain from increasing or improving resources	Alternatives considered	ALARP assessment
	Specialist personnel from Wild Well Control and Boots and Coots Various locations internationally +72 hours.		subsequent environmental benefit.	
Monitor and Evaluate				
Modelling (oil spill trajectory, fate & weathering, met ocean data, satellite imagery)	Processes: AMOSC call-off procedure Equipment: ADIOS2 on IMT PCs In-house deterministic modelling Personnel: Shell Geomatics team	Oil spill trajectory modelling can be commenced using AMOSC call off contract with RPS group within 2 hours of IMT being notified of the spill. The data would be used to inform IAPs and confirm the selection of other response strategies in the following days. Therefore, there is no environmental gain in improving the activation timeframe.	N/A	No alternative or additional controls have been identified that could improve this response.
Surveillance - vessel	Processes: N/A Equipment: FLNG support vessels Personnel: Trained ISV crew	Several support vessels will be present in WA-44-L. Shell has a contract with marine vessel contractors to provide additional vessels for oil spill response activities if required. There is no environmental gain from providing additional vessels.	N/A	Increasing vessel surveillance capability is not considered to be warranted based on the limitations associated with visual observations made from a vessel platform. Aerial surveillance in conjunction with deployment of tracking buoys is a more effective method of obtaining situational awareness. Vessel surveillance can be undertaken through the use of existing FLNG support vessels.
Surveillance - aerial	Processes: Third party call-off contract Aerial surveillance observation log Equipment: N/A Personnel: Trained aerial observers (AMOSC/AMSA/OSRL)	Shell has third-party call off contracts for helicopters and fixed wing aircraft. These aircraft can be ready for mobilisation in 4-8 hours. Trained aerial observers are available within 24 hours.	Personnel trained in aerial observation could be on standby in order to provide higher quality data to the IMT. However, in the 1st 24 hours the spill it is likely to cover a relatively small	Untrained aerial observation opportunities exist via Shell crew change helicopters. This in conjunction with tracking buoys and other monitor and evaluate data is expected to provide sufficient information for the IMT in the 1st 24 hours, until such time as trained aerial observers are available.

Oil Spill Response Strategy	Resources	Environmental gain from increasing or improving resources	Alternatives considered	ALARP assessment
			geographical location close to the release point. Therefore, initial untrained observations are considered to be adequate given the other data available to the IMT such as spill modelling, tracker buoy data etc.	
Tracking buoys	Processes: N/A Equipment: Tracking buoys Personnel: Trained ISV/FLNG crew for tracking buoy deployment	Tracker buoys are available for immediate deployment from a variety of locations including the Prelude FLNG. No environmental benefits can be gained by increasing the number of buoys available or time to deploy.	Access to additional buoys is available from the shared stockpile located in Broome.	No alternative or additional controls have been identified that could improve this response.
Surface Chemical Dispersant				
Vessel based dispersant application	Processes: Shell Surface Dispersant Application Guide Equipment: 5 m^3 Dasic Slickgone and AFEDO spray set on each ISV (3 vessels in field or en-route) Personnel: ISV personnel trained in vessel application techniques	Based on the existing capability, Shell could commence vessel based dispersant application immediately subject to AMSA approval (where relevant). Additional supplies of dispersant can be obtained from stockpiles on the Australian mainland.	N/A	In the event of a spill that was amenable, surface application of dispersant from vessels can be implemented immediately upon approval. In the event that additional stockpiles of dispersant are required they can be accessed from stockpiles in various locations across Australia.
Fixed Wing Aerial Dispersant (FWAD) application	Processes: Shell Surface Dispersant Application Guide. AMOSC/OSRL call-off procedure.	Pre-positioning of aircraft and personnel (air attack supervisor) in particular could enable a faster response time resulting in quicker	Additional costs associated with pre-positioning aircraft and personnel are	Shell has access to AMSA fixed wing aircraft wheels up in 4 hours and first implementation within 36 hours with supporting monitoring aircraft.

Oil Spill Response Strategy	Resources	Environmental gain from increasing or improving resources	Alternatives considered	ALARP assessment
	Equipment: N/A Personnel: Air attack supervisors and pilots.	application of dispersant with more oil treated and hence an overall environmental benefit.	estimated to be in the order of 10s of thousands of dollars per day and are considered to be grossly disproportionate given the access to vessel-based dispersant application.	Surface application of dispersant using vessels can be implemented much faster and therefore the costs associated with increasing FWAD capability are considered to be grossly disproportionate given the risk.
Contain and recover				
Containment and recovery equipment (offshore boom and skimmer system)	Processes: Shell Offshore Contain and Recover Guide. Equipment: FLNG support vessels AMOSC stockpile (Broome) 400 m of offshore boom and skimmer system. Waste storage capability Personnel: AMOSC/AMSA/OSRL trained and experienced personnel.	Increasing a contain and recover response will results in the removal of more oil from the sea surface and therefore less will accumulate on shorelines resulting in less environmental impacts to shoreline receptors and less waste generation.	Additional dedicated vessels with offshore boom and skimmer systems would cost in the order of 10s of thousands of dollars per day and is not considered warranted given the availability of such equipment is not a limiting factor in the effectiveness of this strategy.	Shell has access to the AMOSC stockpile located at Broome (and other stockpiles elsewhere in Australia). The effectiveness of this response strategy is affected by sea state conditions and the thickness of oil at the sea surface; therefore it may only be applicable to the HFO spill scenario. Maintaining booms and skimmers offshore is not practicable due to space limitations. The availability of contain and recover equipment is not a limiting factor and other response strategies could be implemented in faster timeframes (vessel-based dispersant) that would be more effective on HFO spills.
Shoreline Protection and Deflection				
Shoreline and nearshore booming equipment	Processes: Browse Island Incident Management Guide Equipment: AMOSC/OSRL specialised equipment	Undertaking an improved shoreline protection and deflection response may reduce shoreline accumulation of oil resulting in less environmental impacts to shoreline	Access to additional booming equipment would cost in the order of thousands of dollars per day	Given the logistical and safety limitations with shoreline response in the Browse Basin, implementation of the response will take approximately 1 week to occur from decision being made to commence (noting that this decision may be made by WA DoT as the Control

Oil Spill Response Strategy	Resources	Environmental gain from increasing or improving resources	Alternatives considered	ALARP assessment
	Personnel: AMOSC/OSRL trained and experienced personnel.	receptors and less waste generation. However, shorelines in the Browse Basin are difficult to access due to their remoteness and safety risks and may not result in an overall environmental gain.	and is not considered warranted given the availability of such equipment is not a limiting factor in the effectiveness of this strategy.	Agency). Pre-positioning of booms may result in potential damage to sensitive locations and is not considered ALARP. Improving on this response is not considered to provide an environmental gain.
Shoreline Clean-up				
Shoreline Clean-up Assessment	Processes: Shoreline Clean-Up Assessment OMP, Browse Island Incident Management Guide Helicopter call-off contract Equipment: Staging and accommodation facility Personnel: AMOSC/OSRL trained and experienced personnel.	Shoreline assessment specialised personnel can be deployed to remote shorelines from staging/accommodation facilities within 5-6 days. Undertaking quicker shoreline assessment would be beneficial to obtain pre-impact results, however, shorelines in the Browse Basin are difficult to access due to their remoteness and safety risks. Earlier deployment may not result in an overall environmental gain.	N/A	Shoreline surveys must be conducted systematically to be a crucial component of effective decision-making. Repeated surveys are needed to monitor the effectiveness and effects of ongoing treatment methods (i.e. changes in shoreline oiling conditions, as well as natural recovery). Improving the time for specialised personnel to access remote shorelines to make assessments is not warranted and will not result in an environmental gain. Noting that the decision to commence this strategy may be made by WA DoT as the Control Agency.
Manual and mechanical removal (washing, flooding & flushing, sediment reworking & surf washing)	Processes: Shoreline Clean-Up Assessment OMP, Browse Island Incident Management Guide Equipment: AMOSC/OSRL specialised equipment Personnel: AMOSC/OSRL trained and experienced personnel.	Predictive oil spill modelling indicates the largest volumes accumulating on shorelines is 1,393 m^3 of condensate at the Indonesian Boundary and 475 m^3 of HFO at the Buccaneer Archipelago. Depending on the sensitivity of the shoreline removal of accumulated oil using heavy machinery and/or large numbers of personnel may result in additional environmental damage.	Costs for additional clean-up equipment are considered to be negligible and are not considered a limiting factor in the effectiveness of this strategy. Constraints primarily lie in mobilising equipment and	Shell has access to shoreline response kits. Given the logistical and safety limitations with shoreline response in the Browse Basin, implementation of the response will take approximately 1 week to occur from decision being made to commence (noting that this decision may be made by WA DoT as the Control Agency). Large scale operations involving large numbers of personnel and/or heavy equipment may cause adverse environmental impacts at many of these sensitive shoreline locations and would not result in an environmental gain. Manual clean-up equipment, using smaller teams for longer periods would be more effective

Oil Spill Response Strategy	Resources	Environmental gain from increasing or improving resources	Alternatives considered	ALARP assessment
		Access by heavy machinery would also be restricted at offshore islands.	personnel safely rather than sourcing additional equipment.	in most of the shoreline locations predicted to be contacted.
Oiled Wildlife Response				
Oiled wildlife response implementation	Processes: WA Oiled Wildlife Response Plan (WAOWRP) Equipment: AMOSC OWR containers (2) and box kits. NatPlan OWR containers (4), OSRL OWR equipment. Personnel: AMOSC/OSRL trained and experienced national and international OWR personnel.	Given access to local OWR equipment and personnel (AMOSC) through existing arrangements the response capability cannot be improved to result in an environmental gain unless an OWR kit is maintained offshore.	Any OWR will be undertaken in consultation with the relevant agencies e.g. WA DBCA and WA DoT. Such consultation is more likely to be a time limiting factor than accessing additional OWR resources.	Shell is a participating member of AMOSC with access to Mutual aid arrangements. AMSA MoU and OSRL contracts, enabling access to national and international oiled wildlife expertise. The closest OWR container is located in Fremantle and can be mobilised to Broome within 30 hours by vessel. Additional containers and box kits are available from other locations within Australia (including Broome for the closest box kit). Maintaining a dedicated OWR kit offshore is not considered to be reasonable given the low likelihood of needing to implement an OWR and the requirement for trained OWR personnel.
Waste Management				
Waste management	Processes: Oil Spill Waste Management Plan Template. Equipment: Assorted waste receptacles and trucks from waste contractor with additional stocks from sub-contractors located in Darwin, Broome and/or Dampier. 635 m^3 capacity of offshore storage in Darwin. Personnel: Waste contractor personnel (Rusca Brothers).	There are no limitations to obtaining the required waste storage capacity for this EP and no environmental benefit obtained by accessing additional waste storage capacity.	Costs for additional waste management resources are considered to be negligible.	Predictive oil spill modelling indicates the largest volumes accumulating on Australian shorelines is 475 m^3 of HFO at the Buccaneer Archipelago. Using a bulking factor of 10, potentially 4,750 m^3 of waste could be generated during a shoreline clean-up response. Decanting from contain and recover operations will also generate waste for disposal. Typically, this oily liquid waste would be held in the inboard storage tanks of the support vessels and disposed of at an onshore facility. Based on Shell's waste contractor capability the available resources are considered to be suitable for the worst-case spill scenario.

9.14.2 Aspect Context

This section describes any new or unique environmental impacts or risks presented by implementation of the emergency events response strategies included in the OPEP (HSE_PRE_013075) which may be enacted to respond to hydrocarbon and chemical spills as described in Section 9.13. Where impacts and risks are already adequately addressed in the preceding sections of this EP, as indicated in Table 9-87, they are not discussed further in this section.

Typically environmental aspects, impacts and risks that arise from conducting the emergency response activities are similar to those already described in Section 9.3 to 9.12. for the planned and unplanned activities, particularly for vessel-based operations. Where additional impacts or risks exist for the identified aspects, these are described in the following subsection. Table 9-87 summarises the aspects generated by implementing the spill response activities and identifies any that are new or unique aspects for further assessment.

Table 9-87: Spill response strategies and associated environmental aspects identified for each including those that are considered new or unique

		Aspects Generated											
		Physical Presence	Lighting[2]	Noise Generated	Disturbance to Seabed	Disturbance to Ground[1]	Introduced Marine Pests	Discharge of Liquid Wastes	Planned Chemical Discharge[1]	Atmospheric Emissions	Greenhouse Gas Emissions	Waste Management	Emergency Events
Response Activities	Source Control (including SSDI)[3]	✓	✓	✓	✓		✓	✓	×	✓	✓	✓	✓
	Monitor and Evaluate	✓		✓			✓	✓		✓	✓	✓	✓
	Natural Recovery												
	Chemical Dispersant (Surface)	✓		✓			✓	✓	×	✓	✓	✓	✓
	Contain and Recover	✓		✓	✓		✓	×		✓	✓	✓	✓
	Protect and Deflect	✓		✓		×	✓	✓		✓	✓	✓	✓
	Shoreline Clean-up		⊠			×		✓		✓	✓	✓	
	Oiled Wildlife Response	✓		✓			✓	✓		✓	✓	✓	✓
	Scientific/ Oil Spill Monitoring	✓		✓			✓	✓		✓	✓	✓	✓

Notes:

✓ - The aspects and associated impacts and risks are already adequately addressed in the EP Sections 9.3-9.12.

× - There is an aspect of the response activity that may produce a new or unique impact/risk not already addressed in the EP.

1. New or different aspect not previously described in the EP
2. Due to daylight operations only for typical vessel-based activities (excluding source control), lighting impacts for stationary, non-operating vessels at sea during night will not present a credible impact to sensitive receptors.
3. As described further in the OPEP, source control activities to respond to a LoWC emergency event may include drilling a relief well. All source control activities will be managed in accordance with the accepted OPEP, Safety Case and WOMP.

9.14.2.1.Subsea (Source Control) and Surface Dispersant Application

Dispersants are applied to hydrocarbon spills to enhance the breakdown of hydrocarbon droplets and enhance dispersion into the water column to:

- Break up floating oil and reduce floating oil concentrations, thereby reducing the exposure of seabirds and surfacing marine fauna to hydrocarbons
- Reduces the size of the entrapped oil droplets further aiding dispersion and enhancing biodegradation.

Additionally, source control is the primary response strategy for the well loss of containment scenario and is aimed at stopping the flow of well fluids to the environment. Subsea Dispersant Injection (SSDI) may be required as part of the overall source control strategy to ensure conditions are safe for responders (i.e. minimise gas cloud concentration and extent) to enable relief well drilling.

9.14.2.2 Contain and Recover - Decanting Operations

Application of the Contain and Recover strategy is significantly limited by weather, logistics, and requires substantial temporary waste storage for recovered hydrocarbons. Recovered hydrocarbons will inevitably contain a large proportion of water in addition to recovered oil that may need to be decanted back to the sea to optimise the recovered oil fraction. Refer to the OPEP for further details.

9.14.2.3 Shoreline Clean-up and Protect and Deflect – Disturbance to Ground

Conducting shoreline protection and clean-up involves moving personnel and equipment, which includes the environmental aspect of ground disturbance. The objective of shoreline clean-up is to apply clean-up techniques that are appropriate to the shoreline type to remove as much oil as possible where there is a net environmental benefit in doing so. Various techniques may be used alone or in combination to clean up oiled shorelines, including Shoreline Clean-up Assessment Technique (SCAT), natural recovery, absorbents, sediment reworking, manual and mechanical removal and washing, flooding, and flushing. Considerations for selecting and implementing shoreline clean-up techniques are included in the OPEP.

The deployment of booms to protect sensitive shoreline receptors, typically pre-emptively, introduces the potential for ground disturbance or damage to nearshore habitats such as intertidal reefs, mangroves, seagrasses and macroalgal communities that are present at Browse Island and other offshore islands/shorelines.

9.14.3 Description and Evaluation of Impacts

<u>Subsea and Surface Dispersant Application – Planned Chemical Discharges</u>

Physical Environment

Water Quality

Environmental effects associated with dispersant application include a temporary reduction in water quality and exposure of marine biota to dispersant chemical's inherent ecotoxicity, biodegradability and bioaccumulation properties. The level of toxicity varies amongst the different dispersant types and can result in increased in-water concentrations of the toxic components of hydrocarbons. Dispersant combined with dispersed oil can be acutely toxic in the water column at specific concentration thresholds, and is noted for its toxicity to habitats such as corals, seagrass, and macroalgae.

Biological Environment

Benthic Communities

Environmental effects associated with dispersant application include an increase in the mass of entrained hydrocarbons with smaller droplet sizes affecting larger areas and being bioavailable for ingestion by some oceanic and benthic organisms (e.g. fish, plankton, benthic invertebrates). The effects of entrained hydrocarbons on sensitive environmental receptors are discussed in Section 9.13.4.

The extent of these impacts will also depend on the chemical dispersant type and dose rates, and external conditions (time of the year, weather and sea conditions, proximity of sensitive receptors and their life stage, etc.). These impacts will provide another consideration into the decision process on strategy selection (SIMA) and timing on a case-by-case basis at the time of the incident as described in the OPEP.

Sensitive reef communities are located within the Browse Basin, with the closest being around Browse Island, Echuca and Heywood Shoals and Ashmore and Cartier Islands, while seagrass meadows are located in some of these areas also. If applied appropriately, dispersants can provide a net environmental benefit by limiting exposure of an oil spill to high environmental value sensitive receptors. Elevated concentrations of dispersant are generally localised and of short duration, with dilution and dissipation being relatively rapid after application. Therefore, residual impacts from the use of dispersants are expected to be low in nature and scale when assessed in isolation compared to the impact of the spill without dispersant application, and ranked as minor impact consequence (Magnitude -2, Sensitivity M).

Decanting Operations/Contain and Recover – Discharge of Liquid Wastes

Physical Environment

Water Quality

In order to optimise recovery of floating hydrocarbon removed from the sea surface during Contain and Recover operations, it may be required to decant some of the oily water from temporary storage back into the ocean which may result in dissolved and entrained hydrocarbons being released back into the marine environment. This is not expected to lead to additional environmental impacts compared to the pre-application state of this strategy as the decanted water will be released at the spill site within already affected boomed areas and not elsewhere. Thus, no additional adverse environmental impacts are expected for water quality and marine biota and the residual impact consequence is assessed as nil (Magnitude 0, Sensitivity – L).

Shoreline Clean-up and Protect and Deflect– Disturbance to Ground and Lighting

Biological Environment

Disturbance to Intertidal Habitats and Marine Fauna

Conducting shoreline clean-up activities, including moving personnel and equipment, has the potential to cause damage to terrestrial and intertidal habitats, with subsequent impacts to dune/beach structure, flora such as mangroves and fauna such as turtles and birds (including nests). Invasive or frequent clean-up can also involve physical removal of substrates that could adversely impact habitats, fauna and alter coastal geomorphology and hydrodynamics. The impacts associated with undertaking shoreline clean-up may be more than if the product was left in place and remediated through natural processes (Natural Recovery). Leaving the product in place is a very common response option if continual human and vessel/vehicle traffic has the potential to generate greater impacts than the product itself. The optimal suite of response strategies will be determined through the SIMA process described in the OPEP.

The deployment of booms to protect shorelines and intertidal environments could potentially cause physical damage to coral reefs/intertidal ecosystems through the movement of the booms and/or anchors. A review of shoreline and shallow water habitats, and bathymetry, and the establishment of demarcated areas for access and anchoring will reduce impacts to nearshore environments.

Shoreline clean-up and protect/deflect activities will be managed to minimise impacts on turtles (including hatchlings) and birds through minimising disturbance to nesting, and feeding sites. Responder transfer to shore would be on small boats or helicopters. Responders would be accommodated on nearby medium sized vessels or facilities such as Prelude (if available). An assessment of appropriate equipment and personnel numbers required to reduce habitat damage, along with the establishment of access routes/demarcation zones, and operational restrictions on equipment and personnel movements will limit sensitive habitat damage and damage to important fauna areas. The establishment of temporary camp areas will be done in consultation with DoT, DBCA and a Heritage Advisor if access is sought to culturally significant areas.

Given the controls in place and the short-term and localised incidental environmental effects from shoreline clean-up activities, there would only be minor residual impact consequences presented by personnel and equipment undertaking shoreline clean-up activities (Magnitude -2, Sensitivity – M).

Lighting

Shoreline response activities may require use of lighting which can cause disorientation, disruption to nesting and breeding behaviours in seabirds, shorebirds and turtles.

Shoreline clean-up and protect/deflect activities will be managed to minimise impacts on turtles (including hatchlings) and birds through minimising disturbance to nesting, and feeding sites. An assessment of the need to conduct night-time operations in sensitive areas will be made and operational restrictions established. Due to the remote location of potentially impacted shorelines, conduct of response operations with smaller teams to reduce ecological impacts (Refer to Section 12.3 of OPEP) and the safety implications associated with dangerous marine fauna (e.g. saltwater crocodiles), it is unlikely that operations will be conducted at night.

Given the controls in place and the short-term and localised incidental environmental effects from shoreline clean-up activities, there would only be minor residual impact consequences presented by personnel and equipment undertaking shoreline clean-up activities (Magnitude -2, Sensitivity – M).

9.14.4 Impact Assessment Summary

Table 9-88 lists the highest residual impact consequence rankings of the relevant environmental receptor groups.

Table 9-88: Spill Response Strategies Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Physical Environment – water quality	-2	M	Minor
Biological Environment – benthic communities, intertidal habitats and marine fauna	-2	M	Minor
Socio-economic and Cultural Environment[1]	N/A	N/A	N/A

1- Potential impacts to socio-economic and cultural environment receptors are not predicted to exceed those presented in Section 9.13 and are therefore not repeated in this section.

9.14.5 ALARP Assessment and Environmental Performance Standards

An ALARP assessment of oil spill response capability is presented in Table 9-86. A description of controls, EPSs and MC for each oil spill response strategy are presented in the OPEP.

9.14.6 Acceptability of Impacts

Table 9-89 Acceptability of Impacts – Oil Spill Response Strategies

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	Water quality	Limited environmental impact to water quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Yes	Spills from decanting and the application of dispersant may result in a temporary reduction in water quality. The level of toxicity varies amongst the different dispersant types and can result in increased in-water concentrations of the toxic components of hydrocarbons. Dispersant combined with dispersed oil can be acutely toxic in the water column. Dispersant application has a limited window of opportunity, as the ability for the dispersants to break up the hydrocarbons typically decreases as the product weathers therefore surface application would only be considered as a secondary response option for an HFO spill in conjunction with the operational SIMA, Shell Surface Dispersant Application Guide and the necessary regulatory approvals. Residual impacts from the use of dispersants are expected to be low in nature and scale when assessed in isolation compared to the impact of the spill without dispersant application.

Biological Environment	Benthic communities	Limited environmental impact which directly impacts bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities which adversely effects biological diversity or ecological integrity.	Yes	Increased in-water concentrations of toxic components of hydrocarbons due to dispersant application may potentially contact submerged receptors such as corals, seagrass and macroalgae. Damage from protect and deflection equipment such as booms and anchors has a potential to damage intertidal habitats. The optimal suite of response strategies will be determined through the operational SIMA.
	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations. Management of aspects of the project must be aligned to conservation advice, recovery plans and threat abatement plans, including for bird and marine turtle species.	Yes	Moving personnel and equipment associated with shoreline clean-up activities has the potential to cause ground disturbance or lighting impacts which may affect listed Threatened or Migratory MNES fauna populations fauna such as nesting turtles and birds (including nests). The impacts associated with undertaking shoreline clean-up may be more than if the product was left in place and remediated through natural processes (Natural Recovery). Leaving the product in place is a very common response option if continual human and vessel/vehicle traffic has the potential to generate greater impacts than the product itself. The optimal suite of response strategies will be determined through the operational SIMA and in consultation with relevant agencies such as WA DBCA and WA DoT.
	WA mainland coastline	Limited environmental impacts to mainland coastline.	Yes	Damage from protect and deflection equipment such as booms and anchors has a potential to damage nearshore habitats along the WA coastline. The optimal suite of response strategies will be determined through the operational SIMA and in consultation with the relevant agencies such as WA DoT.
Socio-economic Environment	Fisheries	No interference with fishing to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Yes	Shell will implement industry standard controls to manage impacts from the implementation of oil spill response strategies required due to unplanned hydrocarbon spills. An operational SIMA will be developed by the IMT using real-time monitoring and evaluation data to select the optimal suite of response strategies.
	Tourism & recreation	No negative impacts to nature-based tourism resources	Yes	

		resulting in demonstrated loss of income.		

New and/or unique environmental impacts associated with implementation of the possible spill response strategies are considered to be acceptable where they present a net environmental benefit compared to the 'do nothing' option as determined and documented through the SIMA process as described in the OPEP.

Assessment of these impacts from the spill response strategies discussed above determined the residual ranking of minor or lower (Table 9-88). The acceptability of these impacts has been considered in the context of:

Principles of ESD

The response option impacts described above are consistent with the principles of ESD based on the following points:

- The health, diversity and productivity of the marine environment will be optimised for future generations through minimising the impact of any large scale spills through implementation of the accepted OPEP and associated response strategies;
- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental impacts
- With the prevention and mitigation controls in place, the conservation of biological diversity and ecological integrity shall be optimised following a large scale spill.

Relevant Requirements

Management of the impacts associated with spill response strategy implementation are consistent with relevant legislative requirements, including:

- The NOPSEMA accepted OPEP (HSE_PRE_013075).

Matters of National Environmental Significance

Threatened and Migratory Species

Alignment with the relevant management plans, recovery plans and conservation advice for threatened and migratory fauna will be addressed on a case-by-case basis through the SIMA process when selecting appropriate spill response strategies (Reference is made to Table 7-6 for the list of potentially applicable plans and advisory documents). These plans and advisory documents will assist with determining protection priorities once the nature, scale and trajectory of the spill is understood post event.

Commonwealth Marine Environment

The new and/or unique environmental impacts presented by dispersant application, decanting and/or shoreline clean-up on the Commonwealth marine environment when assessed in isolation from the spill event itself will not credibly exceed any of the significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date around the dispersant application, decanting or shoreline clean-up aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of the risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

As outlined above, the acceptability of the associated impacts have been considered in the context of:

- The established acceptability criteria
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

The residual impacts have been assessed as minor which Shell considers to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the new and/or unique impacts associated with implementation of the identified spill response strategies. Based on the points discussed above, Shell considers the residual impacts to be ALARP and acceptable.

9.14.7 Environment Performance Outcome

Environment Performance Outcome	Measurement Criteria
Spill response strategies shall be selected and implemented to minimise the overall environmental impacts from a spill and the associated implementation of the response strategies themselves.	OPEP implementation records and SIMA records

10.0 Environmental Plan Implementation Strategy

The OPGGS (E) Regulations require an Implementation Strategy to be incorporated into the EP that includes:

- Measures, systems and practices to ensure that environmental risks continue to be identified and reduced to a level that is ALARP, mitigating measures are effective, and EPOs and standards are met
- Chain of Command
- Measures to ensure workers are aware of their responsibilities
- Monitoring and management
- Records and reporting
- OPEP provided as a separate document together with this EP submission
- Consultation.

10.1 Management Systems

The Shell HSSE & SP-MS provides a structured and documented framework for the effective management of HSSE & SP risks and demonstrates how the requirements of the Shell Group HSSE & SP Control Framework are implemented throughout Shell. The Shell HSSE & SP-MS Manual consists of the following sections:

- Leadership & Commitment
- Policy & Objectives
- Organisation, Responsibility & Resources, Standard & Documents
- Risk Management
- Planning & Procedures
- Implementation, Monitoring & Reporting
- Assurance
- Management Review

The HSSE & SP-MS is subject to a continuous improvement ‘plan, do, check, review’ loop, with eight components as outlined in Table 10-1. There are numerous, specific ongoing (typically annual) assurance activities against each of the eight components in this HSSE & SP-MS Manual as detailed below. The audit and review function of the HSSE-MS seeks to ensure that the system is being implemented, is effective and to identify areas for improvement. Examples of elements that demonstrate continuous improvement are highlighted under each section.

Table 10-1: HSSE & SP-MS Elements Implementation and Improvement

Management System Element	Implementation and Improvement
Leadership and Commitment *Creating and sustaining a culture that drives Shell's commitment of no harm to people or the environment*	Seek ongoing feedback on how others perceive HSSE & SP leadership (performance reviews, HSE Culture Survey (Shell People Survey), 360 feedback)
Policy and Objectives *Supporting the implementation of Shell HSSE & SP Commitment and policy*	Set annual HSSE & SP targets to drive continuous performance Annually Review and approve HSSE & SP objectives
Organization, Responsibilities and Resources *Establishing and maintaining an organization that enables the compliance with the HSSE & SP Control Framework*	When there are changes in the Business or organization, identify the positions that require Competence assurance. HSSE & SP Critical Position Register, Shell People Competency Profiles
Risk Management *Identifying the HSSE & SP hazards and establishing the controls to reduce the risks to ALARP*	Ongoing review of Hazards and Risks. Regular review of Risk Registers
Planning and Procedures *To integrate the requirements of the HSSE & SP Control Framework into business plan and procedures: Emergency & Crisis Response, Spill Preparedness and Response, MOC, PTW*	Establish and maintain a programme of testing of Emergency Response plans and procedures at least once a year or more frequently based on the level of risk. Shell Australia ERP, Records of ER drills, exercises and AARs.
Implementation, Monitoring and Reporting *Implement the HSSE & SP requirements embedded in plans and procedures and take corrective action when necessary*	Report all Incidents, including Near Misses, to the Supervisor of the work activity. Learn from Significant Incidents and High Potential Incidents through communication and implementation of required actions.
Assurance *Providing assurance that the HSSE &SP Control Framework requirements are implemented and effective*	Establish, maintain and execute HSSE & SP Self-Assessments in support of the Business HSSE & SP Assurance Plan, self-assessment, CF Gap Analysis, HSSE & SP Management Review. • Management Review (documents demonstrating how Shell Australia reviews the effectiveness, adequacy and fitness for purpose of the HSSE & SP Management System and take action to improve) • Review the HSSE & SP Management System and its individual elements at least once a year and document the results.
Management Review *Reviewing the effectiveness, adequacy and fitness for purpose of the HSSE & SP MS and taking actions for improvement*	Assess the Effectiveness and Adequacy of the management system in delivering the policy and Objectives and in driving continual improvement.

Shell's HSSE & SP-MS covers all operations within its business, including that of the Prelude FLNG Facility and all assets/operations (e.g. to Prelude and future operations).

Management of HSSE on the Prelude FLNG facility is through the implementation of the Shell HSSE MS, supplemented by facility/asset specific HSSE systems/procedures (e.g. Prelude Permit to Work system and associated procedures such as Confined Space Entry, Isolations, etc.).

Shell implements specific pre- and post-contract award processes and activities aimed at ensuring that contracts consistently and effectively cover the management of HSSE & SP risks and deliver effective management of HSSE & SP risks for contracted activities.

Contractor HSSE & SP Management is governed by the Shell HSSE & SP Control Framework. As a minimum, all relevant field active contractors' HSSE & SP-MS will be assessed to ensure they meet materially equivalent outcomes to Shell's HSSE & SP-MS.

For the activities that occur offshore but not onboard of the Prelude FLNG facility (e.g. vessel activities within the PSZ), Vessel Contractor predominantly use their own vessel/facility HSSE-MSs to manage work scope onboard their vessel.

10.1.1 Environment Critical Element Management

Environmentally Critical Element (ECE) is an item of equipment or structure whose failure could lead to:

1. the release of a major environmental hazard or whose purpose is to prevent or limit the consequences of a major environmental hazard (RAM Red or Yellow 5A/5B Environmental risks); or
2. environmental regulatory non-compliance as part of implementing the controls to manage environmental hazards to ALARP and Acceptable levels.

Environmentally Critical Elements are mostly equipment and are frequently referred to as Hardware Barriers.

Identification of ECEs, and assurance of their implementation effectiveness is an important element of ensuring that barriers will function as required. Figure 10-1 illustrates the overall process of identification of ECEs and integration with Safety Critical Elements (SCEs), the Business Management System (BMS) and the competency system. Figure 2 illustrates the relationship between ECEs and SCEs.

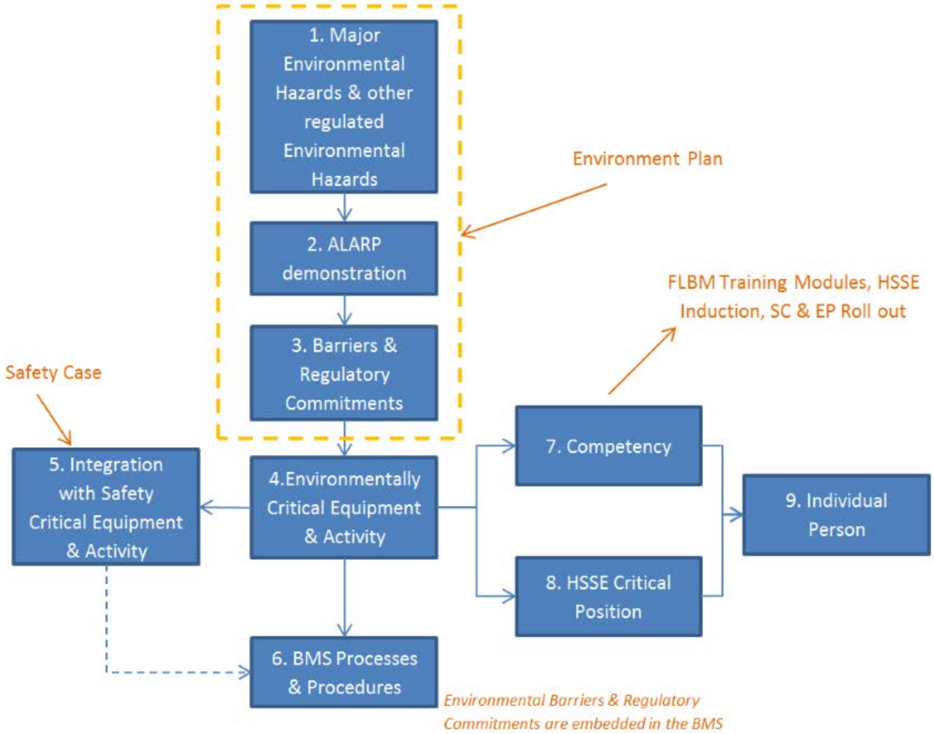


Figure 10-1: ECE Identification Process

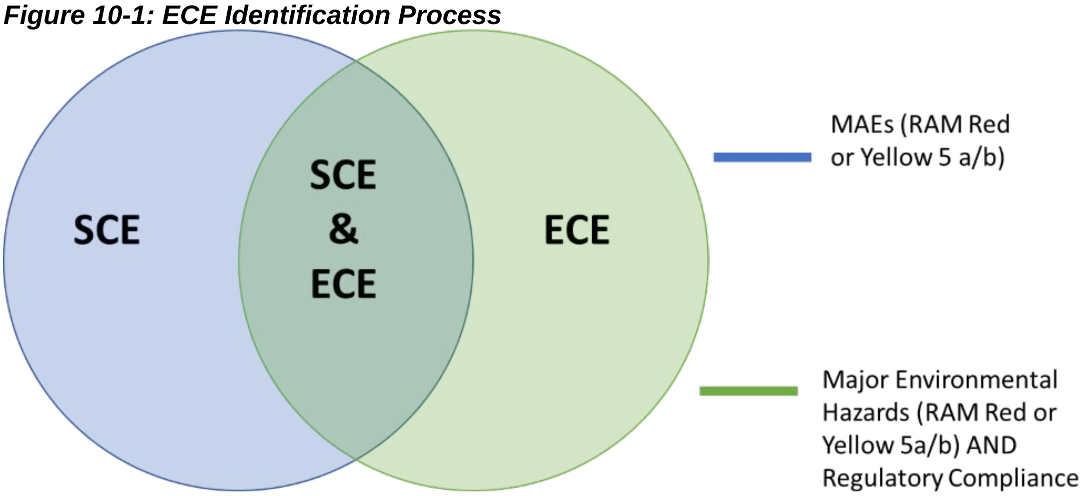


Figure 10-2: Illustration of the relationship between SCEs and ECEs

For Prelude FLNG, Major Environmental Hazards (RAM Red or Yellow 5a/b) are also associated with some Major Accident Events (MAE) in the Safety Case. Some Bowties within the Safety Case are also appropriate for managing the Major Environmental Hazards. Those Bowties were developed to illustrate the threats that can lead to the realisation of an MAE (incl. those associated with Major Environmental Hazards) and the barriers that can prevent this occurring or mitigate the consequences. Some ECEs are also SCEs.

Deviation

Deviations are able to occur through following the ECE management guidance (OPS_PRE_15791). This is an approved non-compliance of the mandatory requirements of a procedure, standard or specification. This is applied to assurance and environmentally critical corrective and preventative maintenance that will not be or has not been carried out by the due date.

Overrides are able to occur following the ECE management guidance. An override is an interruption to the normal operation of an environmentally critical element that prevents it from performing the desired action.

10.1.2 Contractor Management

Contractors and their sub-contractors carry out a number of activities on behalf of Shell. Effective management of environment, integrity, health and safety risks in contracts involves setting clear expectations and managing these risks throughout the contract lifecycle.

Shell implements specific processes and activities aimed at ensuring that contracts consistently and effectively cover the management of HSSE & SP risks for the contracted activities. These processes are detailed in the Prelude HSSE & SP Contractor Management Strategy Manual. The contractor management processes implemented for Prelude FLNG are consistent with the requirements of the Shell HSSE & SP Control Framework Contractor HSSE Management Manual.

Key aspects of the Contractor HSSE Management are:

<u>Pre-contract Award Activities</u>

- Appointing a competent contract owner and contract holder for each contract.
- Determine the Contract HSSE & SP risk, by assessing the risk associated with the contracted activities.
- Determine the contract mode.
- For a high contract HSSE Risk, the contractor is to develop and provide a Contract HSSE Plan.
- Assess whether the Contractor has the capability and resources to manage the risks associated with the contracted activities.
- Before contract award, confirming that the Contractor meets requirements. Focus on closing gaps in draft contract HSSE & SP Plan submitted by Contractor.
- Define the level of Company monitoring based on the capability of the Contractor, the contract HSSE & SP risk and the contract mode.

<u>Post-contract Award Activities</u>

- Require the Contractor to demonstrate that Contractor personnel responsible for managing the HSSE Risks of the contracted activity have knowledge of the HSSE requirements of the contract and any associated Contract HSSE Plan related to their role.
- Require the Contractor to demonstrate that all Contractor personnel will be given an induction on the HSSE risks of the contracted activities including the controls to manage those Risks specified in the contract and any associated Contract HSSE Plan.

- Verify that the HSSE requirements of the contract and any associated Contract HSSE Plan are being implemented and are effective at managing the HSSE Risk of the contract. Where necessary implement actions for improvement.
- Regularly assess the HSSE performance of the Contractor, including its management of Subcontractors.

10.1.3 Contractor Competency Requirements and Assurance

The contractor is responsible for ensuring that all their personnel have the appropriate level of competence required to safely and effectively carry out the work. The contractor is also responsible for the development and implementation of a competence assurance plan. The contract holder is responsible for ensuring that the contractor's competence assurance system is reviewed, robust and meets the Shell requirements.

In addition to trade competencies and qualification requirements, the minimum competence requirements for key contractors working on Prelude are based on the required contractor work scope and are developed in consultation between Shell and the contractor. The minimum requirements for a contractor going offshore on the Prelude FLNG facility include the following:

- Facility Induction (such as Life Saving Rules, Emergency Response and Muster procedures, Incident Reporting, Waste Management, Oil Spill Awareness)
- Role-specific training such as Permit to Work, operating procedures of specific process units

10.1.4 Asset Integrity – Process Safety Management System (AI-PSM)

Shell AI-PSM focus areas are as follows:

Design Integrity:

- The aim is we design and build our assets so that risks are As Low As Reasonably Practicable (ALARP).

Technical Integrity:

- Barriers are put in place to manage Major Accident Events (MAEs). Technical Integrity ensures that we maintain the provided hardware barriers (from Design Integrity) to keep them effective. Section 11.1.6 describes the maintenance processes of the hardware barriers.

Operating Integrity

- Together with design and technical integrity, one key aspect of assuring our assets are safe is working within the operational barriers. Operational Integrity processes ensure that the facility is being operated within its design.

Leadership Integrity

- Leadership is the key enabler to ensure that we have assets that are safe to operate. Each leader plays an important role in safeguarding against process safety and environmental incidents and must demonstrate visible and felt leadership in the field.

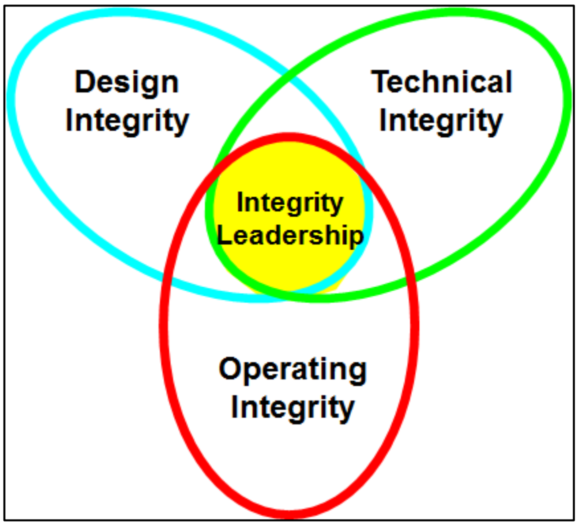


Figure 10-3: Shell AI-PSM Focus Areas

10.1.5 Asset Management System

Shell is implementing the global Shell Asset Management System (AMS) framework as a single, control framework for managing Producing Assets in Shell. Prelude is transitioning to the AMS and is targeting full compliance by the end of 2021.

The AMS framework describes a set of processes needed to organise asset management capabilities, ensuring that activities are performed consistently in a joined-up manner and systematically improved to deliver excellent sustainable business outcomes.

It includes mandatory elements (through Standards and Manuals) and non-mandatory elements (through Recommended Practices), and should be used in conjunction with other Shell Control Framework requirements; for example the HSSE & SP Control Framework.

The Asset Manager is accountable for ensuring adherence to the AMS. The AMS standard provides all the tools and processes which help an asset get to at least the minimum requirements comprising four major sections:

1. Leadership, Commitment & Accountability
2. Requirements Processes & Guides
3. Organisational Capability
4. Learning Loops

10.1.6 Design and Operational Envelope

Prelude FLNG facility has been designed and built to ensure that the risks associated with process safety and environmental events have been managed to ALARP. This is part of the “Design Integrity” focus areas of the AI-PSM.

Design limits define the boundary of the design envelope for each piece of equipment and if violated could potentially lead to a loss of containment. These limits (such as pressure, temperature and level) have been set using industry and company standards and assured via various process safety reviews (such as HAZOP and Desktop Safety reviews).

Another key aspect of assuring the facility is working safely within the operational envelope. This is part of the "Operating Integrity" focus area of the AI-PSM. Operating envelope identifies the integrity and capacity constraints of a system, which is within the boundary of the design envelope. Limits to operating envelope (such as process trips and set points) are set in conjunction with process engineering Technical Authority and Process Automation and Control (PACO) and documented in the alarms variable table, taking account of equipment constraints and operator response time.

10.1.7 Maintenance & Integrity Execution

The management of maintenance and integrity in Prelude is in accordance with the Shell Group Maintenance & Integrity Execution processes. Implementation and embedding the processes ensures that Prelude is in a position to operate the FLNG facility in a safe and environmentally-responsible manner and realize the benefits of a proven maintenance execution process. Excellence in maintenance execution means 'the right job, by the right person at the right time'; i.e. jobs that are approved, scoped, performed with the right competency and attitude, scheduled to be performed at a time that reflects the needs and risk of the business.

The proactive and visible management of critical equipment is a fundamental aspect of Technical Integrity Management. The execution of Integrity Assurance (IA) activities (the identification, prioritisation and subsequent execution of Integrity related corrective and preventative work) are executed through a common maintenance work management process. It is key that assurance/ IA tasks within the planned maintenance routines are identifiable and can be linked to the risk barriers; making it transparent that all risk barriers are in place and effective. The key IA activities within the maintenance process are summarized below and in Figure 10-4.

- Technical Integrity Data capture
  - Critical equipment including related equipment necessary for environmental protection are identified and then logged into the Shell MMS. Operate phase Performance Standards for this equipment are documented.
  - Integrity Assurance tasks against the relevant are logged into SAP.
- Training and coaching for managing & executing IA tasks
- Implementation of the process
  - Making sure all Preventive Maintenance work is executed to the correct standard and within the prescribed timeline.
  - Raising the need to attend to a breakdown and fixing it
  - Recording of history of work executed in the asset
  - Making sure the right work is being performed at the right time, with the right people, right tools, right access, etc. and that it is done safely.
  - Embed the use of Total Reliability measures
  - Activation and use of Facility Status Report (FSR) for Deviation Management and Visualisation. Further details on FSR are in Section 11.1.6.1 Key MIE Tools.

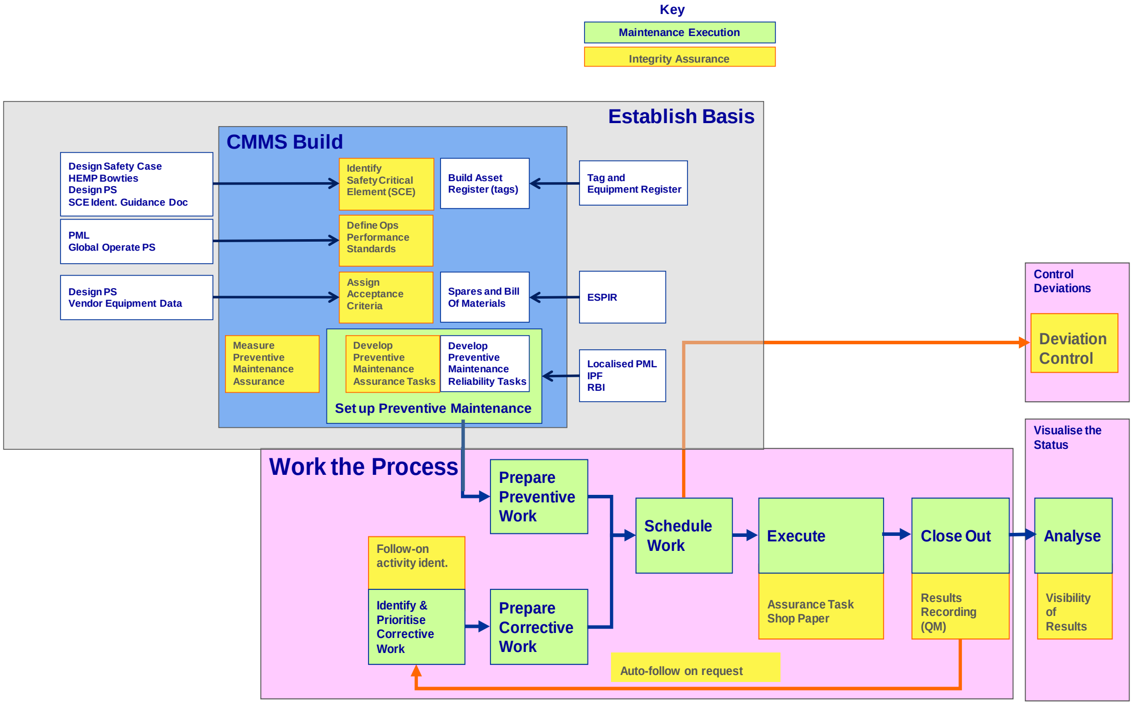


Figure 10-4: Maintenance & Integrity Execution Processes

11.1.6.1 Key MIE Tools

Table 10-2 lists the key tools currently used on Prelude to manage SCE hardware barriers. These tools may change over time as more effective options become available. Tools specific to SCE groups are discussed in the respective Integrity Management Plans.

Table 10-2: Technical Integrity management Tools

Tool	Name	Function
CMMS	Computerised Maintenance Management System	Contains Prelude Asset Register with SCE identified Maintenance work planning, scheduling and execution management Documentation of completion of maintenance work Business Warehouse function for maintenance KPI reporting and analysis Quality Module for analysis of maintenance work Integrated with other business systems for purchasing, materials management, finance and logistics
CIMS	Corrosion and Inspection Management System	Master source of inspection schedules and records for pressure equipment and structures Interfaces with CMMS for scheduling and status of inspection activities (as PM work orders)
IMSA	Integrity Management System Application	Integrity management software for pipelines and underwater assets (apart from wells).
FSR	Facility Status Report	Status of Preventive Maintenance and Corrective Maintenance work orders and deviations

eWIMS	Wells Integrity Management System	Management of wells specific integrity tasks. Interfaces with CMMS for scheduling and status of tasks (as CM or PM work orders)

10.1.8 Permit to Work (PTW)

The Permit to Work (PTW) process is used to control and approve work on the Prelude FLNG facility and within the Prelude Safety Zones. It ensures that adequate controls and measures are in place to safeguard people, asset and environment from work activity hazards. Details of the PTW process is described in the Permit to Work Manual (HSE_PRE_004404) and an electronic PTW system is used. There is a high level redundancy built into the electronic PTW tool.

A permit is required for activities that have the potential to adversely affect personnel's safety/health, cause damage to asset, the environment and reputation. Most activities on Prelude FLNG require a permit; examples include hot work, breaking containment and confined space entry. However, there are standard operational and marine operations activities that do not require permits and are managed through approved procedures; execution of these activities is allowed only after safety and environmental precautions have been put in place.

All permitted activities on Prelude are categorised based on their risk level: into low-low, low, medium or high risk. The level of risk assessment, review and approval are proportionate to the risk of the activity.

10.1.9 Management of Change (MOC)

The MOC process for Prelude FLNG is described in the Shell MoC Manual. The MoC process is designed to "provide assurance that, when changes are introduced, new risks are not knowingly incurred, or the prevailing risk profile is not adversely changed without appropriate mitigation".

The scope covered by this manual includes:

- Process Changes (Hardware, Process Control, Process Conditions)
- Procedural Changes that affect HSSE Critical Content
- Organisational Changes (Shell and Contractor) impacting HSSE Critical Roles.

The application of this scope includes:

- Permanent Change
- Temporary Change
- Emergency Change.

The MoC Manual is supported by specific procedures, templates and checklists. The progress of change requests is monitored through an electronic MoC system.

The MoC process is built around seven simple steps forming an overarching governance framework (Figure 10-5).

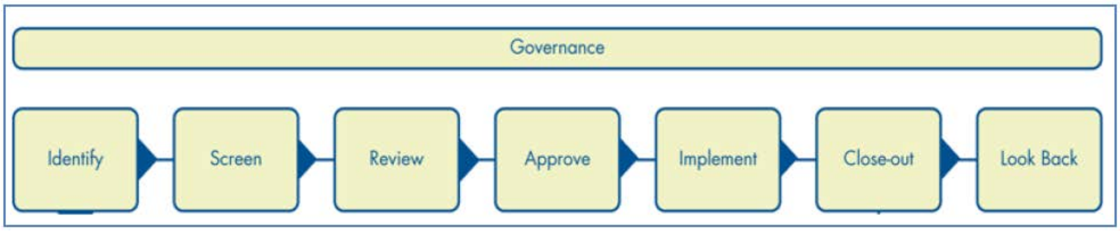


Figure 10-5: Management of Change Process Steps

The screening process for all new changes (hardware or software) require assessment of HSSE&SP aspects as per Management of Change (TEC_GEN_001465) this may result in a change being flagged as possibly needing a change to the EP which require compliance with Regulation 17 of the Environment Regulations. If a change is considered significant as per Regulation 17 (5) or (6) and as determined by the MOC process, then a revised or new EP will be submitted to NOPSEMA for acceptance. The following examples or scenarios would generally be considered significant changes:

- Tie-in of new wells, reservoirs or facilities
- Major unplanned subsea repairs
- Drilling new production wells
- Major process changes which result in significant increases in environmental risks or impacts.

The following will also trigger the review of the management of a particular environmental impact or risk to ensure that ongoing management of impacts and risks are at ALARP and Acceptable levels:

- Changes in regulatory requirements/standards
- Information which may suggest an increase in environmental risks or impacts to those outlined in the EP
- Prominent new scientific studies which may 'negatively' change the understanding of environmental risks and impacts
- Objections or claims raised which require changes in EP content following the process outlined in Section 5.0.

10.1.10 Chemical Selection Process

Shell has adopted a chemical selection and approval process in accordance with Shell's chemical selection and approval guidelines as indicated in Shell Chemical Management Process (HSE_GEN_007879) and Shell Global Product Stewardship guidelines to assess chemicals than may pose environmental impact via planned discharges.

All chemical applications are required to be screened in accordance with Shell Global Product Stewardship guidelines (Figure 10-6).

Where chemicals may be discharged to the marine environment preference shall be given to chemicals that are deemed environmentally acceptable (PLONOR, Gold, Silver, D and E) with no substitution warning under the Offshore Chemical Notification Scheme (OCNS) adopted in the United Kingdom and the Netherlands. Chemicals that fall within this banding require no further assessment and are deemed ALARP and accepted.

Chemicals that do not have an OCNS ranking or fall outside of the preferential banding (PLONOR, Gold, Silver, D and E with no substitution warning) are required to be assessed further incorporating seeking a suitable alternative chemical of lower environmental impact. If no alternative is technically suitable, the chemical is required to be assessed via Shell Global Product Stewardship guidelines and ALARP demonstration with risk reduction control measures (Figure 10-7). Approval will be provided by the Shell Production Chemist / Product Steward Focal Point. Chemicals that are not deemed ALARP will be not approved and an alternative product shall be requested.

To ensure that chemicals which may pose impact to the marine environment are managed appropriately on an ongoing basis, annual compliance checks will be made by Shell and chemical vendors of Shell's Chemical Programme Treatment Guide (TEC_PRE_006805) and Chemical Risk Assessment Register operational chemical registers. To accompany routine compliance checks, the impact of chemicals in key discharge streams will be assessed on an ongoing basis as indicated in Adaptive Management Framework outlined in Section 10.4.1.

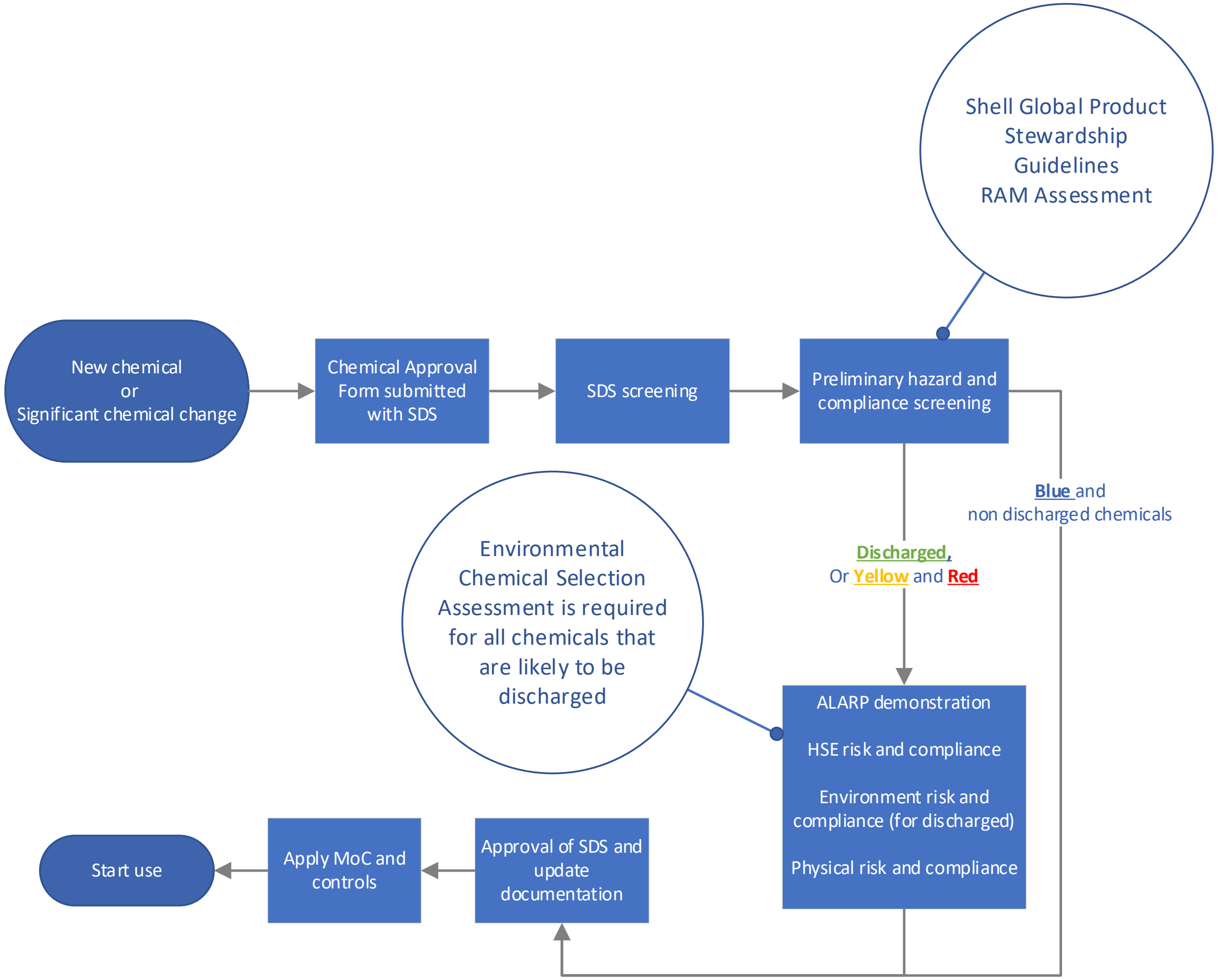


Figure 10-6: Chemical Approval Process

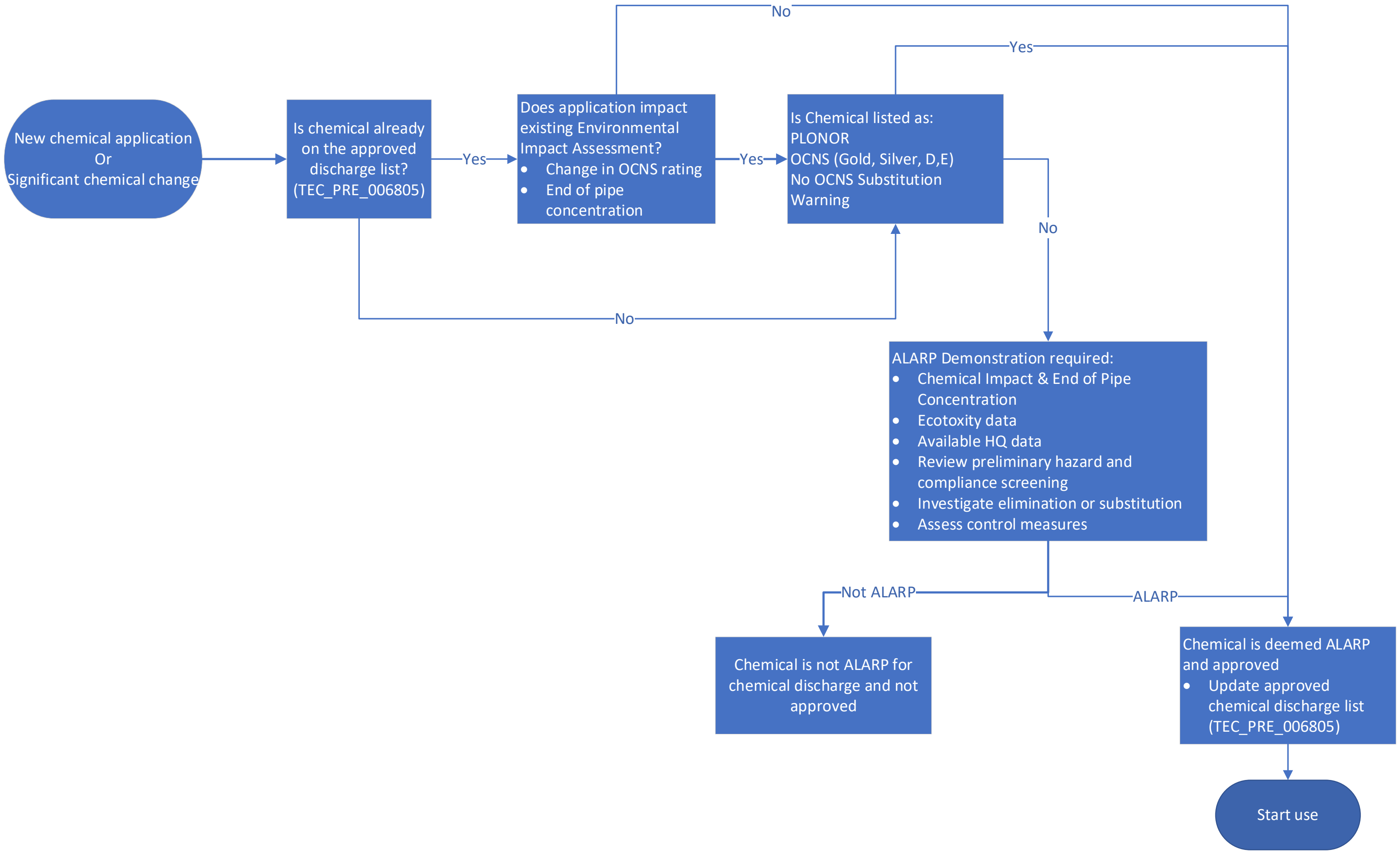


Figure 10-7: Environmental Chemical Impact Assessment

10.1.11 Greenhouse Gas and Energy Management System

Various elements of the Shell management system make up the overall GHGEM system. The AMS GHGEM is compatible and complementary with ISO-50001 international standard for Energy Management Systems, and the Shell Group HSSE & SP Control Framework GHGEM Manual. Key processes that form GHGEM on Prelude include:

1. Fuel and Flare Policy;
2. Leadership Commitment;
3. Annual GHG abatement workshop and process;
4. GHGEMP (including a Methane Improvement Plan);
5. OP Process; and
6. Fuel and Flare Forum

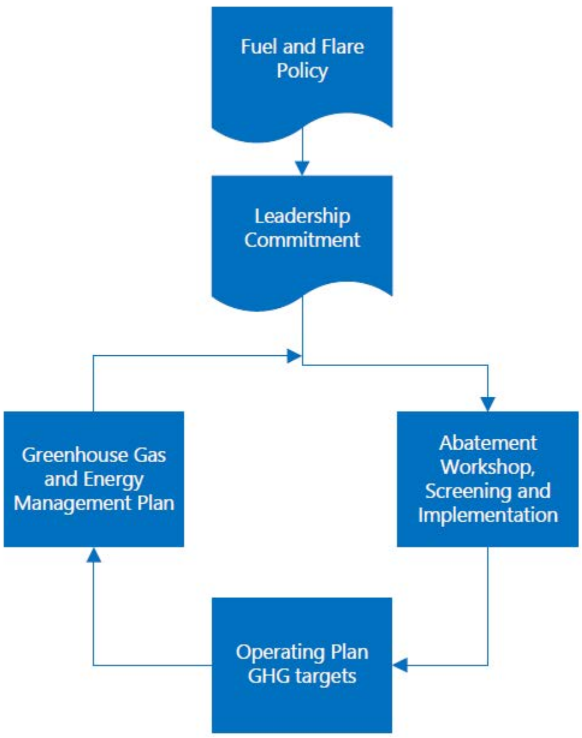


Figure 10-8: Greenhouse Gas and Energy Management Key Processes

Fuel and Flare Policy

The Fuel and Flare Policy provides that Shell Australia, as operator of Prelude FLNG, will:

1. *"In accordance with the HSSE & SP Control Framework - Greenhouse Gas and Energy Management ensure:*
    a. *Energy use and GHG emissions are monitored and managed for continuous improvement.*
    b. *The global GHG emission inventory is subject to independent assurance.*
    c. *Installations are designed not to flare or vent hydrocarbons continuously as a means of Disposal. Out of scope are flare pilot and purge gas.*
2. *Operate facilities to control Fuel, Flaring or Venting consistent with the facility design.*

   a. *Do not allow flaring or venting of hydrocarbons unless required for emergency, process safety reasons, start-up or during well clean-up or well flow tests.*
   b. *Manage changes from the design affecting fuel, flaring or venting in accordance with the Management of Change process.*
3. *Set availability targets and greenhouse gas emissions targets through annual Business Planning. Performance against these targets is reflected in the Company Scorecard (which is set at Shell Group level).*
4. *Pursue opportunities to minimise planned flaring events.*
   a. *Planned flaring events shall be minimised by using the Integrated Activity Planning process. The GHG impacts are available inputs into the planning process.*
5. *Pursue opportunities to minimize unplanned flaring events.*
   a. *Certain scenarios are captured in the Operations Playbook*
6. *Monitor, evaluate and record fuel and flaring events as input into continuous improvement initiatives.*
7. *Pursue opportunities to reduce fuel use to minimum thereby maximising feed gas available for sale.*
8. *Minimise methane emissions through a robust and risk-based Leak Detection and Repair program.*
9. *Prelude's GHGEM Plan shall be updated annually to reflect the latest GHG forecast and strategic management controls (e.g. abatement projects)."*

Leadership Commitment

Consistent with ISO50001, leadership for GHGEM is shown and demonstrated in various ways including:

- ensuring that the GHGEM scope and boundaries are established in GHGEM system;
- ensuring that the fuel and flare policy and GHG targets are established and are compatible with the strategic direction of Shell;
- ensuring the integration of the GHGEM requirements into Prelude's AMS processes;
- ensuring that action plans are approved and implemented;
- ensuring that the resources needed for the GHGEM are available;
- communicating the importance of effective energy management and of conforming to the GHGEM requirements;
- ensuring that the GHGEM achieves its intended outcome(s);
- promoting continual improvement of energy performance and the GHGEM;
- ensuring the formation of an GHGEM management team (fuel and flare forum);
- directing and supporting persons to contribute to the effectiveness of the GHGEM processes;
- supporting other relevant management roles to demonstrate their leadership as it applies to their areas of responsibility;
- ensuring that processes are established and implemented to identify and address changes affecting the GHGEM processes within the scope and boundary of the GHGEM.

The main leadership forums where GHGEM performance against targets and GHGEM action plans is tracked include:

- monthly forums: Prelude Asset Leadership Team, Shell Australia Country Leadership Team, Prelude HSSE management and the Prelude fuel and flare forum;
- Annual HSSE management review at Prelude and country levels.

Annual GHG Abatement Workshop and Process

An annual Prelude GHG abatement workshop identifies risks and opportunities which reduce GHG emissions through abatement or efficiency gains in operating Prelude. GHG abatement opportunities can be either operational improvements or capital projects. The first abatement workshop for Prelude occurred in November 2020. The workshop participants are comprised of a multidisciplinary team, which typically includes operators and engineers from various departments of Prelude FLNG facility. Outputs from the workshop include a list and description of abatement opportunities identified, high level technical feasibility screening of the opportunities, the estimated cost of such opportunities and abatement volume estimates. This first workshop in November 2020 delivered approximately a number of GHG opportunities which will be further screened and assessed.

All technically feasible abatement opportunities are then further screened and assessed through a GHG abatement funnel pipeline. Where assessment has been completed, relevant capital projects are assessed in accordance with relevant internal processes (e.g. ORA and Manage Threats and Opportunities (MTO)) along with all other abatement opportunities to determine the point at which GHG risks are reduced to ALARP. Those capital projects that are subsequently screened to be in-plan are then put into the proceeding OP cycle so that budgets and resources can be assigned according to the priority given. Projects (including out of plan) are reviewed on an annual basis by the Prelude asset team to see if the criteria for sanctioning a project are met.

A high level overview of this process is outlined below.

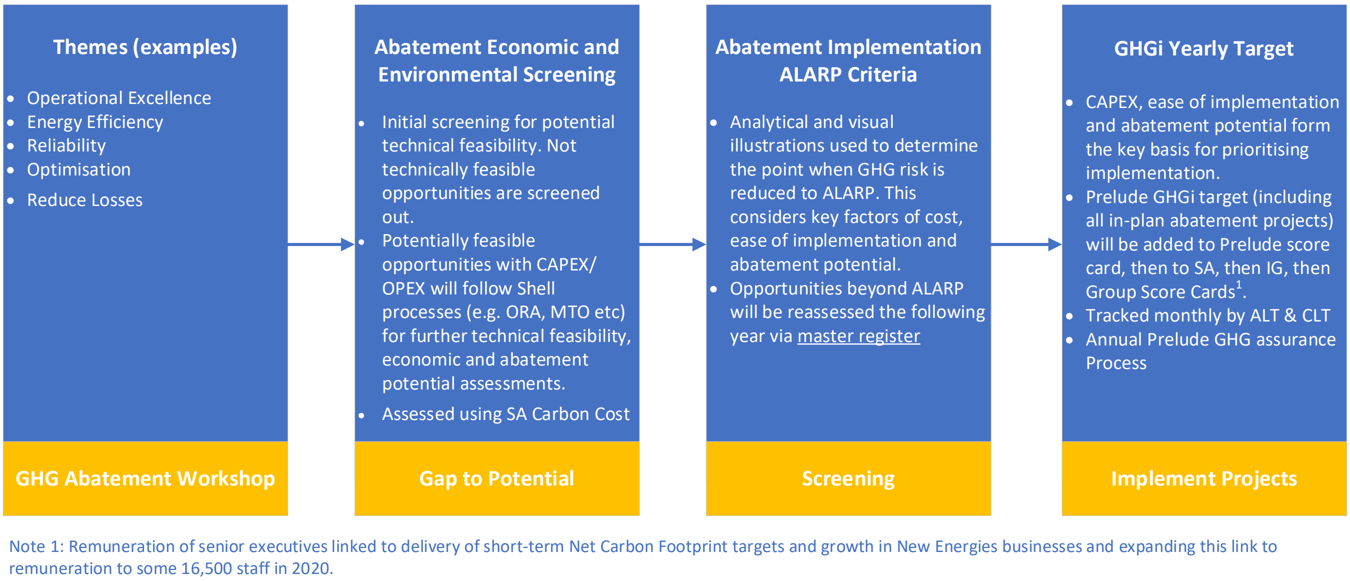


Figure 10-9: Prelude GHG Abatement Opportunity Identification and screening process

Abatement projects implemented between Prelude since 2019 commissioning and November 2020 have saved in excess of 30kt $CO_{2\text{-}e}$ being emitted. Abatement projects that have been implemented on Prelude since 2019 include:

- Perform minimum turndown tests for wells and flowlines with the aim to turn down to from 50 Mmscfd to 25Mmscfd (or lower). Minimised flaring when operating on Utility Island mode on wet fuel gas. – 10000tpa $CO_{2\text{-}e}$
- Upstream: Update Well Start-up procedure to optimise flaring by smooth transition to HP flowline mode and placing riser chokes in CAS - 11000tpa $CO_{2\text{-}e}$

- MEG pretreatment time reduction to reduce flaring caused by restart time.- 50% reduction in flaring during flowline pretreatment (1200t saved in total every time shut in occurs)
- HP separator pressure control issues due to operating in Manual mode for relief control valves – 500-1000tpd CO_{2-e}.

Table 10-3 below outlines the nine in plan projects accepted for implementation between 2020 and 2022 which make up the OP20 abatement target for 2021 of 90kt CO_{2-e} on a risked basis.

Future abatement workshops will consider BAT literature sources such as the IEA Methane Abatement Options.

Table 10-3: OP20 in plan abatement projects

Project Number	Category	Description
1	Steady & Flaring	Passing valves: Leaks to the flare from two identified locations.
2	Non Steady & Flaring	Well Start-up procedure to optimise flaring by smooth transition to high pressure flowline mode and placing riser chokes in cascade operation.
3	Steady & Flaring	Two identified passing valve rectifications.
4	Non Steady & Flaring	Reduced minimum turndown for Prelude. - Perform minimum turndown tests for wells & flowlines with aim to turn down to from 35 Mmscfd to 25Mmscfd (or lower). Minimised flaring when operating on Utility Island mode on wet fuel gas.
5	Non Steady & Flaring	Shut in wells (no flare excess - use line pack from flowlines)
6	Non Steady & Flaring	Warm End flaring optimisation opportunity - After NGL trip (Achieve zero flaring when NGL Column trips by operating AGRU and mole sieve at minimum turn down flow rates from one well operation (~35 Mmscfd) and continuously provide dry fuel gas supply downstream of the mercury removal unit)
7	Non Steady & Flaring	Warm End Start-up optimisation: (Maintain minimum turndown flow rate from one well (35 Mmscfd) *Change the CO_2 specification at the top of the absorber to be 100ppm instead of 50 ppm (during AGRU startup). *Pressurise mole sieve and start regeneration straight away after reach 100 ppm spec. *Use 1+1 mole sieve mode of operation and provide dry fuel gas from mercury removal unit once first bed regeneration is completed. *Add critical alarm at required inlet)
8	Non Steady & Flaring	NGL column Start-up / Cool down optimization opportunities: 1- NGL column cooldown on total recycle from NGB without flaring . This will result in eliminating ~ 3000t/d flaring for the NGL cooldown & thermosyphon requirements (~ 2 days)

Project Number	Category	Description
9	Non Steady & Flaring	Draining requirements after shut-down 1- Cooling Water Heat Exchangers and Main Cryogenic Heat Exchanger liquid draining after shut down 2- End flash column draining - valve opening requirements

Greenhouse Gas and Energy Management Plan

Management of GHG risk is one of the top priorities for Shell. As a result, specific requirements are integrated into Shell's management systems. The HSSE & SP Control Framework requires that assets establish and implement a GHGEMP:

A key objective of the GHGEMP is to manage impacts from GHGEM to ALARP. As of December 2020, the key objectives of the Prelude GHGEMP is to:

- Focus on GHG emissions, in particular flaring, during non-steady conditions which includes, trips, start-ups and shutdowns
- Provide an overview of abatement projects (both in and out of plan), to reduce GHG emissions to ALARP
- Establish GHG targets and set out GHG limits from external sources.
- Provide GHG forecasts over the life of the Prelude field.
- Demonstrate how Prelude FLNG manages GHG risk consistent with the GHGEM control framework requirements and local regulatory framework
- Document the Methane Improvement Plan

GHG targets and forecasts set out in the current GHGEMP for 2020 includes intensity target of 0.73t$CO_{2\text{-}e}$/tHC and total $CO_{2\text{-}e}$ forecast of 2.8Mt. GHG metrics which will be outlined in the next GHGEMP revision for 2021 includes intensity target of 0.6t$CO_{2\text{-}e}$/tHC, forecast total $CO_{2\text{-}e}$: 2.3Mt and an abatement target of $CO_{2\text{-}e}$: 90kt (risked). These Prelude targets are rolled up into Shell Group targets which are linked to the remuneration of senior executives for delivery of short-term Net Carbon Footprint targets and growth in New Energies businesses and expanding this link to remuneration to some 16,500 staff in 2020[50].

Shell Group has a target to maintain methane emissions intensity below 0.2% by 2025. This target covers all oil and gas assets for which Shell is the operator and therefore includes Prelude. From 2021 onwards, Prelude will have a MIP. The objective of the Prelude MIP, which will form part of the GHGEMP, is to improve methane emissions reporting, focusing on reducing uncertainty associated with methane emissions quantification. This will facilitate prioritisation of methane emission sources for targeted abatement projects.

Specific actions aimed at reducing methane emissions include:

[50] Shell Sustainability Report 2019

1) annual abatement project identification and assessment process (first workshop occurred in November 2020).
2) GHGEMP with emissions intensity and abatement targets linked to asset performance scorecard, required annual deliverable.
3) Asset QPA conducted and assessment of progress of MIP deliverables and abatement projects is tracked quarterly.
4) Fugitive (general leaks) methane sources are being addressed via comprehensive LDAR program.

Operating Plan

The OP process is a key deliverable of the Prelude asset that brings integrated value. The OP reflects and demonstrates how Prelude will, in a credible and affordable way, achieve its strategic ambitions (including GHG). Key deliverables for the OP process related to GHGEM include:

- integrated forecast of GHG emissions along with production;
- integrating in plan GHG abatement projects into business costs and establishing an associated risked GHG abatement target; and
- developing total GHG emission and intensity-based targets for the following calendar year.

The OP is developed using inputs and assumptions from various functions but for GHG, inputs and assumptions largely come from an integrated production system model and RAU assumptions developed based on known risks and opportunities documented in systems like MTO. GHG emissions are an integral part of the OP process, which uses information from development concepts, production inputs and assumptions, production forecasts and hydrocarbon maturation, well reservoir and facility management, decommissioning and restoration, cost, commercial, economic, financial inputs and assumptions, along with associated risks and opportunities.

Relevant technical authorities and management level signoffs occur from discipline lines. GHG signoffs are provided by the technical authority (TA2) for process engineering.

GHG outputs from the OP process include GHG targets (GHG intensity, total emission and abatement) approved by senior asset management, which are usually set based on the mid case (P50), are measured and regularly tracked. These targets provide input into Shell Group Scorecard. Targets also reflect Shell Group's climate ambitions, and reinforce its priorities and desired behaviours at Shell Group level. These may be different from the plan to set direction and apply stretch.

Fuel and Flare Forum

The Fuel and Flare Forum brings together expertise from relevant functions in Prelude FLNG to consistently manage the risks of GHG and Energy performance. The Fuel and Flare Forum's objective is to:

- Review Prelude's monthly GHG performance with discussion around the sources and reasons for flaring. Where applicable, develop and investigate how to learn from this and create opportunities to reduce emissions.

- Enable cross facility understanding and collaboration of Prelude's current threats/opportunities to reduce fuel emissions and achieve no routine operational flaring.
- Track implementation of the more operational abatement tactics and ensures that out-of-cycle abatement opportunities are identified and progressed without having to wait for the annual process.
- Review and prioritise GHG related technical queries raised by the asset team via the SAP Z8 process.
- Drive continuous improvement to reduce GHG emissions by monitoring and prioritising improvement opportunities for GHG reduction.
- Ensure accurate information and forecasting is available to support reporting and decision making activities.
- Ensures proactive action is taken to ensure EPO's are on track in line with EPS 9.14-9.16. This will include actions such as:
    - accelerate abatement projects already in plan
    - revisit ALARP assessment for abatement projects currently not in plan to see if ALARP criteria are met become in-plan now
    - review (and look to accelerate) maintenance priority for passing valves and other GHG abatement related maintenance items
    - review short-term fuel strategy (e.g. switching fuel source)

10.2 Organisation, Roles and Responsibilities

The overall structure of Prelude FLNG is summarised in Figure 10-10. The core organisation of Prelude consists of the Prelude FLNG Asset Manager, reporting to the Vice President Prelude. The Asset Manager is accountable for the safe and environmentally responsible operation of Prelude.

The facility Offshore Installation Manager (OIM) who reports into the Production Manager has overall field authority for work on and within the safety zone. The offshore organisation is supported by a core onshore organisation which includes Shell's technical and other support departments providing both frontline and long term engineering services including but not limited to:

- Engineering and maintenance standards/guidelines and supporting governance processes;
- Engineering and maintenance strategies, systems and applications to support and optimise operations; and
- Coordination of production engineering and maintenance execution processes and resources.

As required by Regulation 14(4) this section of the Implementation Strategy establishes a clear chain of command that sets out the roles and responsibilities of personnel in relation to the implementation, management and review of the EP, ranging from senior management to operational personnel that support Prelude and support vessels. Roles and responsibilities associated with emergency management arrangements are detailed in Table 10-14.

The roles, responsibilities and accountabilities for processes undertaken are detailed in the Business Management System and individual's job descriptions. General responsibilities associated with this EP for key personnel are summarised in Table 10-4.

Figure 10-10: Prelude Asset Core Organisation Structure

Table 10-4: Key Responsibilities

Position	Responsibilities
Prelude Asset Manager (EP Owner)	**Systems, Practices and Procedures** • Accountable for the overall operation of the Facility. • Accountable for ensuring all necessary regulatory approvals are in place to operate. • Accountable for the implementation and compliance of the EP. • Accountable for safe, efficient and environmentally sound operation of the Facility in accordance with the EP, legislative requirements and Shell's policies and standards. • Custodian of communication with all regulatory agencies required to operate the Facility. • Accountable and responsible for agreeing and meeting KPIs and environment initiatives from annual Plans and reviewing environmental performance to drive continuous improvement.

Position	Responsibilities
	• Accountable for the implementation of stakeholder consultation as per the description in this EP and in compliance with regulations.
Integrated Engineering Manager	**Systems, Practices and Procedures** • Accountable for overall engineering compliance with all legislative requirements. • Accountable for ensuring that the management of change and engineering support workflow systems and processes are adhered to. • Accountable for compliance with all engineering elements of business processes within the defined area/asset including the management of change workflow. • Accountable for achievement of all engineering KPIs, risk assessment and mitigation.
Production Support Manager	**Systems, Practices and Procedures** • Accountable for overall day-to-day process engineering, production chemistry and laboratory compliance with all legislative requirements. • Accountable for process optimisation. • Accountable for ensuring that the process surveillance, production chemistry and laboratory workflow systems and processes are adhered to. • Accountable for achievement of all Technology KPIs, risk assessment and mitigation.
Production Manager	**Systems, Practices and Procedures** • Responsible for the overall operation of the Facility. • Responsible for the implementation and compliance of the EP. • Responsible for safe, efficient and environmentally sound operation of the Facility in accordance with the EP, legislative requirements and Shell's policies and standards. • Responsible for agreeing and meeting KPIs and environment initiatives from annual Plans and reviewing environmental performance to drive continuous improvement. **Resourcing, Training and Competencies** • Puts in place adequate resources (technical, environmental, engineering, information, financial) to implement and meet all requirements of the EP. • Establishes and maintains a workforce with the necessary knowledge, skills and competencies to operate and maintain the Facility in accordance with the requirements of the EP. **Monitoring, Auditing, Non-conformance and Emergency Response** • Accountable for monitoring performance against the EP. • Accountable for implementing agreed assurance activities and monitoring close out of actions. • Accountable for incident notification, reporting and investigation in line with Shell and EP requirements.

Position	Responsibilities
OIM	**Systems, Practices and Procedures** • In charge of the Prelude FLNG facility and the field. • Accountable for the implementation of the EP at the facility. • Ensures offshore personnel comply with regulatory requirements and Shell's policies and standards. • Accountable for ensuring all teams operate in a safe and reliable manner to meet production targets within the defined operating and technical integrity envelopes. • Accountable for the Permit to Work governance, process and permit requirements. • Implements environment initiatives from the Integrated Activity Plan including review of environmental performance to drive continuous improvement. • Ensures effective communication with workforce on environmental performance. • Accountable for effective and appropriate handovers between shifts. **Resourcing, Training and Competencies** • Provides appropriate offshore resource allocation to meet the EP requirements including performance outcomes, standards and measurement criteria. • Accountable for the performance and development of production, services and maintenance teams and ensuring capability and competency across all shifts. **Monitoring, Auditing, Non-conformance and Emergency Response** • Accountable for monitoring performance against the EP. • Implements environmental assurance activities and audits and implementing and monitoring close out of recommended actions. • Ensures incidents are reported and investigated in line with Shell Australia standards and EP requirements, with appropriate actions initiated and closed out. • Responsible for acting as the Incident Controller during emergencies. • Responsible for ensuring exercises and drills are carried out such that the facility's ability to respond effectively to an emergency is assured.
Offshore Production and Services Coordinators	**Systems, Practices and Procedures** • Responsible for ensuring compliance to all environmental regulatory requirements as defined in this EP and Shell standards and procedures. • Accountable for the day-to-day operations of the facility including effective shift handover, completion and logging of operator routine environmental performance. • Responsible for leading and coordinating a multi-disciplined team performing specific duties to support the asset integrity of

Position	Responsibilities
	the facility, including helicopter operations, vessel movements and movement of goods and materials. • Implements environmental initiatives. **Resourcing, Training and Competencies** • Resource planning and allocation for the operations team • Management and coordination during emergencies **Monitoring, Auditing, Non-conformance and Emergency Response** • Responsible for assisting with assurance activities and incident reporting and investigation as required.
Offshore Maintenance Coordinator	**Systems, Practices and Procedures** • Responsible for ensuring compliance to all relevant environmental regulatory requirements as defined in this EP and Shell standards and procedures. • Responsible for the execution of the maintenance work plan to manage asset integrity of the facility and to support the EP. • Accountable and responsible for permits and isolation for all frontline maintenance activities. **Resourcing, Training and Competencies** • Resource planning and allocation for the maintenance team. • Management and coordination during emergencies **Monitoring, Auditing, Non-conformance and Emergency Response** • Responsible for assisting with assurance activities and incident reporting and investigation as required.
Offshore HSSE Advisors	**Systems, Practices and Procedures** • Liaises with OIMs and Coordinators/Team leads on day-to-day management of environmental risks and issues. • Identifies opportunities for continuous improvement and communicates these to the OIMs and Shell Australia Environment Team. **Resourcing, Training and Competencies** • Coaches and assists in implementing environmental improvement initiatives. • Coaches relevant personnel understand the requirements in the EP applicable to their role. **Monitoring, Auditing, Non-conformance and Emergency Response** • Assists with the ongoing promotion of environmental performance at the facility including environmental reporting, monitoring and review. • Assisting with assurance activities and incident reporting and investigation as required.

Position	Responsibilities
Shell Australia Environment Manager	**Systems, Practices and Procedures** • Overall coordination of environmental management across Shell Australia to ensure the performance outcomes, standards and measurement criteria of the EP are met. • Ensuring the organisation understands and adheres to regulatory requirements and environmental management system. • Guiding and driving the direction of environmental management across the organisation, maintaining alignment with Shell Group's environment direction. • Providing support on environmental standards and EP compliance through the Shell Australia assurance programs. • Monitoring and communicating to the organisation any relevant changes to legislation, policies and regulator organisation that may impact the EP or the business. • Functional support on developing and maintaining appropriate environmental processes for Prelude. **Resourcing, Training and Competencies** • Supporting the Divisional environmental performance through implementation of effective environmental training programs. **Monitoring, Auditing, Non-conformance and Emergency Response** • Monitor and review progress against environmental improvement plans, targets and KPIs with divisional management to drive continuous improvement.
Prelude HSSE manager	**Systems, Practices and Procedures** • Monitor and review progress against EP, targets and KPIs with Prelude management to ensure compliance with the EP and drive continuous improvement. • Escalate to Prelude Leadership Team any potential environmental issues and non-compliances to ensure ownership by the line.
Prelude Environment Lead	**Systems, Practices and Procedures** • Ensuring appropriate personnel have access to the EP and understand the outcomes, standards and measurement criteria and their environmental responsibilities for the activity. • Liaising with applicable regulatory authorities and stakeholders as required. • Develops risk reduction strategies and defines Performance Standards. • Facilitates ALARP & Acceptability reviews. • Update of the EP as required. • Facilitate and provide coaching for environmental improvement plans. **Resourcing, Training and Competencies** • Developing and maintaining environmental training, and coaching materials for deployment to Prelude organisation.

Position	Responsibilities
	Monitoring, Auditing, Non-conformance and Emergency Response • Responsible for environmental monitoring and reporting requirements from the EP including environmental performance and compliance reporting. • Monitoring progress against environmental improvement plans. • Participating in environmental audits/inspections to ensure regular checking of compliance to this EP. Communicating findings to management and assisting with close out of actions. • Assisting with review, investigation and reporting of environmental incidents.
External Relations Advisor	• Responsible for preparing and implementing Prelude Stakeholder Engagement Plan.
Vessel Masters	• Responsible for taking action immediately to rectify any environmental incident on the vessel. • Implementation of the EP on board the vessel. • Ensure effective operation of the vessel, taking into account relevant environmental aspects. • Communication of vessel environmental management activities on board. • Maintain administration of vessel's environmental management system requirements • Ensure all crew members comply with the EP. • Manage any spills per SOPEP. • Responsible for ensuring cetacean sighting recording is undertaken. • Maintain good housekeeping and cleanliness around the vessel. • Compliance with DAFF and other marine regulations.
Contract Holders	• Ensuring implementation of this EP for the contractor's scope of work. • Ensuring contractors have adequate environmental capability in order to execute their scope of work. • Reviewing and provide assurance over contractor environmental performance.
All personnel	• Complying with standards and procedures that apply to their area of work. • Immediate reporting of any environmental hazards or incident to the supervisor. • Understanding the environmental risks and controls applicable to work. • Following instructions from the OIM or supervisor with respect to environmental protection and measurement criteria outlined in this EP. • Undergo environmental training as required by role and activity.

Position	Responsibilities
	• Carry out assigned activities in accordance with approved procedures and the EP. • Stop any operation or activity that is deemed to present an unacceptable risk to the environment.

10.3 Competence and Inductions

10.3.1 Competency

All personnel required to work on Prelude installation activity are required to be competent to perform their required tasks. However, there is a subset of the workforce whose duties are sufficiently critical to the safe running of our operations that they require Competence Assurance. These are people in HSSE Critical Positions who are directly responsible for the safety of operations. These positions include the following:

- HSSE Critical Leader positions
  - Senior Management position at Leadership Team level with Operational, Technical or Engineering responsibilities with RAM red or yellow risks
  - Operational, Technical or Engineering position responsible for defining ALARP for RAM red or yellow Risks for a project, technical department or asset
    - Operational, Technical or Engineering position accountable for delivering ALARP for RAM red or yellow Risks for a major asset, group of small assets, major project or group of small projects.
- Technical Authority Level 1 and Level 2
  - Technical Authority Level 1 or 2 roles, which involve design, implementation and maintenance of barriers established for managing hazards with RAM red or yellow risks are deemed HSE Critical.
  - Required to be ‘Skill’ level at relevant technical and operational competencies.
- Frontline Barrier Management (FLBM)
  - Positions directly responsible for implementing or maintaining barriers established for managing hazards with RAM red or yellow risks. These are mainly the production, maintenance and service technicians.

Personnel in HSSE Critical Leader positions are required to demonstrate the required level of competency in Lead, Prepare and Apply HSSE & SP Risk Management, subject to their Proficiency Profile. The HSSE critical leader positions are required to be skilled on the Lead, Prepare and Apply HSSE & SP risk management competency elements. The current list of HSSE Critical Leader positions and their competence requirements is maintained by Shell Group.

Shell has a defined set of Technical Authorities. Where a Technical Authority is not available within Shell, access is available to the Shell Global Technical Authority pool. A list of competent TAs is maintained globally through the Discipline Authorities Manual (DAM).

The register assigns a HSSE profile to each role and defines required proficiency levels for each profile. After assessment of individual competencies against position requirements, proficiency gaps will be addressed in training and coaching.

Additionally, all Shell positions in the organisation have detailed job descriptions including Competency Requirements. Company personnel working offshore require mandatory training as defined in the Training Strategy and Competence Management Plan. This matrix specifies the required HSSE & SP competence and training requirements for Shell staff who carry out specific activities during the Offshore Execution Phase. This plan also specifies training providers who are approved to provide such training. The training matrix is built based on requirements for Shell Group HSSE & SP Control Framework and Australian regulatory requirements. This plan also covers the minimum HSE training requirements for visitors.

Contractors have their own Competence requirements in place as described in Section 10.1.3. Training records of all personnel will be maintained and the training program will be reviewed on a regular basis.

10.3.2 EP Training

OPGGS(E) Regulation 14(5) requires that the implementation strategy must include measures to ensure that each employee and contractor working on, or in connection with, the activity is aware of their roles and responsibilities in relation to the EP.

All employees and contractors working on or in connection with Prelude with defined responsibilities to fulfil as part of the EP are required to attend EP Training that is formally tracked.

The Prelude EP Training shall cover the following items:

- Legislative requirements
- Ecological and socio-economic values of the project area
- Key environmental aspects, impacts and risks
- Shell's key EP Commitments
- Environmental management requirements, such as:
  - Liquid discharges management
  - Drainage system management
  - Emissions management
  - Chemical and hydrocarbon management
  - Waste management
  - Marine fauna interaction
  - Reporting of environmental incidents (such as spills)
  - Emergency Response (including spill response).

On arrival at the facility or vessel, personnel (including short-term visitors) attend an onsite orientation designed to familiarise them with the general operations and location of key areas. The orientation explains the site-specific safety, environmental and emergency response aspects.

10.4 Monitoring, Assurance and Incident Investigation

This section of the EP outlines the measures undertaken by Shell to regularly monitor the management of environmental risks and impacts of the Prelude activities against the performance outcomes, standards and measurement criteria, with a view to continuous improvement of environmental performance. The effectiveness of the Management System is also reviewed periodically as part of the monitoring and assurance process.

10.4.1 Environmental Performance Monitoring

Monitoring and review of environmental performance of the Prelude FLNG facility is done in a number of ways including monitoring of emissions and discharges, and through the use of various tools and systems. These monitoring systems meet the requirements of the following:

- Shell Australia Environmental Reporting Procedure (HSE_GEN_003179)
- Shell Australia Offshore Environmental Regulatory Approvals & Compliance Procedure (HSE_GEN_003180).

In accordance with OPGGS(E) Regulation 14 (7), the implementation strategy must provide for sufficient monitoring of, and maintain quantitative records of, emissions and discharges (whether occurring during normal operations or otherwise), such that the record can be used to assess whether the EPOs and EPSs in the EP are being met.

Parameters that are monitored and recorded during operation of the FLNG facility are detailed in relevant parts of Section 5.0 and in the performance outcomes, standards and measurement criteria table in Section 6.0, and are summarised in Table 10-5. * Where online analysers are the primary monitoring equipment/methodology and where not specified, the intent is always that if the online analyser is not available, manual sampling or estimation would be used as a contingency.

Table 10-5: Emissions and Discharges Monitoring for Prelude FLNG Facility

Source	Parameter to be Monitored	Monitoring Frequency	Monitoring Equipment/ Methodology*	Records	EP Reference
Drainage Discharge	Oil Content Flow	On-line	On-line analysers	PI Database	Section 9.9
Treated Produced Water Discharge	Flow Total Petroleum hydrocarbons	On-line	On-line analysers	PI Database	Section 9.9
	Chemical characterisation and WET sampling analysis per Table 10-7	Per Table 10-7	Sampling and third-party laboratory analyses	External laboratory reports	
Cooling Water Discharge	Flow Free chlorine Temperature	On-line	On-line analysers	PI Database	Section 9.9

Source	Parameter to be Monitored	Monitoring Frequency	Monitoring Equipment/ Methodology*	Records	EP Reference
Brine Discharge	Flow	On-line	On-line analysers	PI Database	Section 9.9
Boiler Blow-down Discharge	Flow pH	On-line	On-line analysers	PI Database	Section 9.9
Neutralisation Tank Discharge	Flow pH	On-line	On-line analysers	PI Database	Section 9.9
Emissions from boilers	Fuel consumption GHG emissions	On-line (Flow) On-line Gas Chromatographs Engineering Calculations	Hydrocarbon & Air Emissions Accounting Methodology	PI Database NPI and NGER reports	Section 9.10 and Section 9.11
	Particulate matter (PM) Sulphur dioxide (SO_2) Nitrous oxide NOx) Carbon monoxide (CO)	Once off within 18 months performance testing completion for specified plant equipment. Frequency of this stack sampling will be reviewed based on performance.	Stack sampling and third-party laboratory analyses	External laboratory reports NPI Reports	Section 9.10
Diesel fuel used on the FLNG and support vessels	Sulphur content	As required (every delivery)	Delivery certificates Laboratory sampling	Delivery certificates	Section 9.10 and Section 9.11
	Volume used	Monthly	Delivery certificates and storage tank volumes	PI Database Delivery certificates	
Flaring emissions	Total gas flared GHG emissions Sulphur dioxide (SO_2) Nitrous oxide NOx) Carbon monoxide (CO)	On-line (flow) Engineering Calculations	Hydrocarbon Accounting Methodology	PI Database NPI and NGER reports	Section 9.10 and Section 9.11
Acid gas vented	Total gas vented GHG emissions	On-line (flow) Engineering Calculations	Hydrocarbon Accounting Methodology	PI Database NPI and NGER reports	Section 9.10 and

Source	Parameter to be Monitored	Monitoring Frequency	Monitoring Equipment/ Methodology*	Records	EP Reference
					Section 9.11
Fugitive emissions	GHG emissions	Online (HP separator flow) Engineering Calculations	Hydrocarbon Accounting Methodology	NPI and NGERS reports	Section 9.10 and Section 9.11
Waste generation	Hazardous Waste Non-Hazardous Waste	Monthly	Waste records/manifests	Monthly waste reports	Section 9.12
Accidental releases of hydrocarbons or chemicals	Volume of accidental release Characteristic of release	As required	If unmetered, volumes will be estimated based on technical data and evaluations (e.g. known well flow rates, production flowrates, pressure, duration of release and known inventory volumes)	Incident reports in Fountain Incident Management	Section 9.13.
Ad Hoc liquid discharges from FLNG	Water quality Volume of discharge	As required.	Laboratory sampling as required.	MOC records	Section 9.9.

10.4.2 FLNG Liquid Discharges Adaptive Monitoring and Management Framework

Overview

This section contains details of an adaptive monitoring and management framework (framework) for Prelude FLNG water discharges. The framework's overall aim is to continually manage impacts from Prelude FLNG water discharges to ALARP and acceptable levels. Note that the primary focus of this framework is on PW discharges given this stream presents the greatest predicted impact of all the discharges (Section 9.9) when assessed in isolation. However, potential contaminants from other discharges are also included where relevant based on nature and scale of the associated impacts. Methodologies for the monitoring program will be consistent, allowing results to be compared and trends to be analysed over time.

The framework ensures the nature, extent, and potential effect of the PW, CW and other discharges are adequately assessed, and helps determine and assess the nature and scale of changes to water quality in relation to applied triggers and thresholds. The framework comprises several monitoring program components, as summarised in Table 10-6 below and conceptualised in (Figure 10-11). The framework is further detailed and proceduralised in the Prelude Liquid Discharges Monitoring and Management Procedure.

Table 10-6: FLNG Wastewater Adaptive Monitoring and Management Framework – Monitoring Programs

Monitoring Program	Frequency	Further Detail
Topsides monitoring	Ongoing (Refer Table 10-5) Additional monitoring as a result of trigger exceedances	Refer to Table 10-5 and Table 10-7
PW Chemical Characterisation	Annually Additional testing as a result of trigger exceedances or significant change	Refer to Table 10-5 and Table 10-7
WET testing	Commence 6 monthly testing for 18 months starting no later than Q2 2021, then triennial thereafter. Additional WET testing as a result of trigger exceedances or significant change (Table 10-12) Mixed Discharges WET test: Once off, after initial field water sampling survey and coinciding with next scheduled PW WET testing	Refer to Table 10-8
Field water quality sampling	5-yearly Additional field sampling as a result of trigger exceedances	Refer to Table 10-9
PW Model verification	One planned model verification event within the 5-year validity period of this EP. Additional model verification as a result of a trigger exceedances	Refer to Table 10-10
PW sediment quality sampling	Initially by 2030 or sooner	Refer to Table 10-11

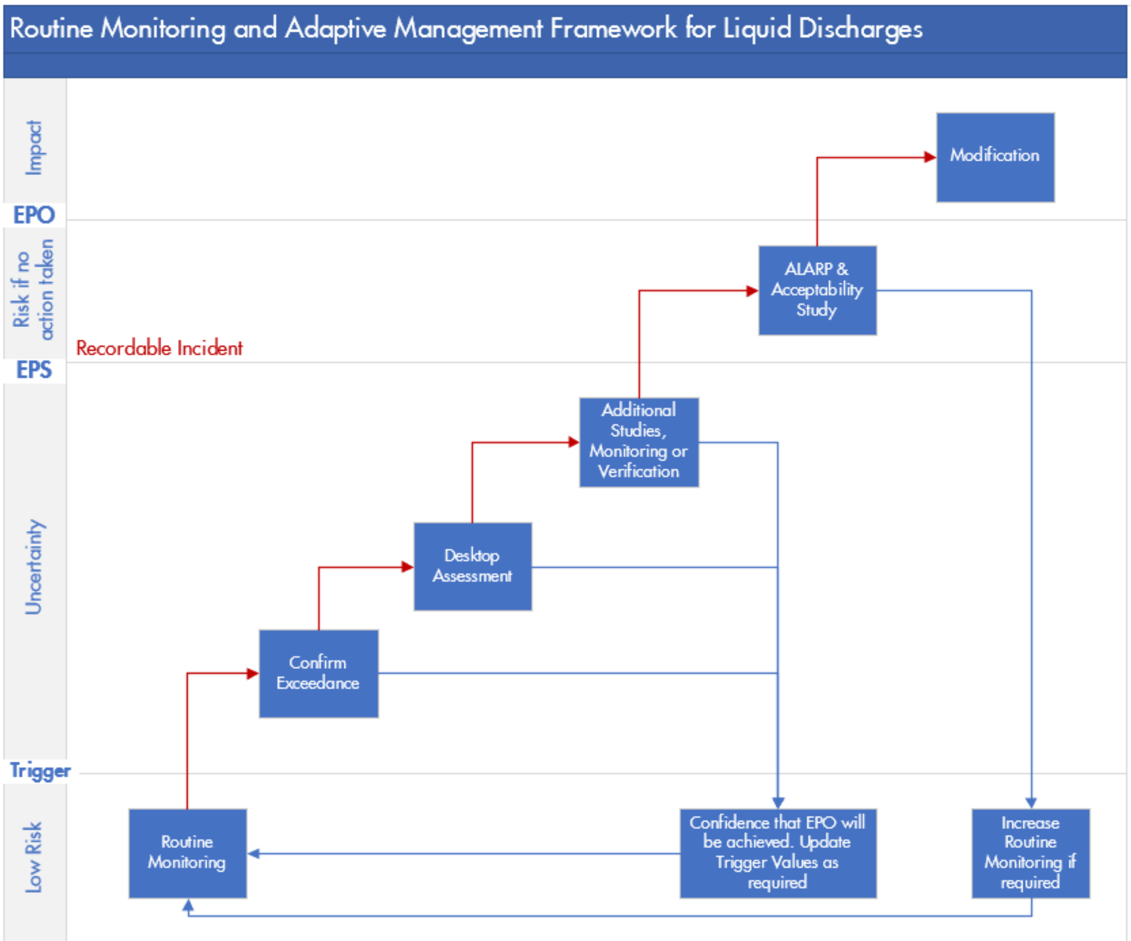


Figure 10-11: Conceptual diagram of adaptive monitoring and management framework

FLNG Topsides Monitoring

The overarching objective of the topsides monitoring program is:

- to use data collected topsides from PW and CW discharge, combined with modelling predictions, to assess whether the defined threshold/trigger values are likely to be exceeded beyond the predicted mixing zone(s) and for how long this has or will continue to occur (duration).

The main components of topsides monitoring to support the ongoing impact assessments, as well as other wastewater data are listed in Table 10-5, Table 10-7 and Table 10-8.

Table 10-7: FLNG Wastewater Discharges – Topsides Monitoring

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
Routine operational monitoring of discharges (Refer to Table 10-5 for specific components)	Enable management of key discharges within set triggers, EPS and EPOs.	Ongoing throughout operations at agreed intervals (see Section 9.9 and Table 10-5).	Refer to Table 10-5.	No action required if parameters/constituents are within predicted and assessed ranges. Where these levels are exceeded, the relevant actions in accordance with the Prelude Liquid Discharges Monitoring and Management Procedure (HSE_PRE_012355) are to be implemented and assessment undertaken against the relevant EPS to determine if the incursion constitutes a Recordable incident.
PW Chemical Characterisation	Determine PW chemical constituents and concentrations to monitor changes in chemical composition through time and identify long-term trends.	Annually Upon significant changes to the PW stream (Refer to Table 10-12)	Specific analyses, sample collection methods and storage times will be confirmed with a certified laboratory undertaking analyses. Where substantial chemical changes occur, these will be investigated for impact on effluent density, which may decrease mixing, and WET test toxicity.	An assessment of the annual PW chemical characterisation results will be made against the most recent WET testing results (noting that WET testing will move to a triennial basis). If the chemical characterisation data indicates WET testing thresholds would be exceeded (mixing zone extent based on dilution contours and 99% species protection concentration 99% times) the following actions would be undertaken: • compare composition against the applicable ANZECC DGVs, or other defined trigger values; • understand what is leading to changes in chemical composition (through analysis of operating conditions, topsides monitoring to understand the likely major contributors to changes in PW chemical composition). By no later than 2028, a review of PW monitoring information will be conducted, with the view to consider if it is suitable to still wait until 2030 to carry out the planned sediment monitoring field monitoring outlined in Table 10-11.

WET Testing

Table 10-8: Summary of WET Testing

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
PW WET Testing	Determine if predicted impacts are within the	Commence 6 monthly testing for 18 months	WET testing is done for the direct toxicity assessment of the whole PW	Dilution targets from the RPS model used to establish the Mixing Zone will be investigated after each round of WET

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
	mixing zone set for PW and monitor changes in toxicity through time.	starting no later than Q2 2021, then triennial thereafter. Upon significant changes (Refer to Table 10-12)	effluent in order to allow for the assessment of additive effects from different chemicals and constituents. This is carried out using recognised ecotoxicity assessment methodology defined in ANZECC/ARMCANZ (2000) in a NATA accredited laboratory. WET testing results may be used to derive more relevant site-specific thresholds for species protection, than the full suite of contaminants outlined in Table 10-7 for water quality. Testing on a full suite of species (minimum of five) for the initial two sampling occasions, then suite reduced to a minimum of two species for succeeding samples in first 18 months of the sampling regime. Full suite of species (minimum of five) will be conducted for each triennial sampling event thereafter.	testing, to determine performance against the Target and manage if necessary, following an assessment of the 'representativeness' of the effluent tested. The Target (mixing zone extent based on dilution contours and 99% species protection concentration) will be modified based on a rolling average of the 99% species protection concentration from the three most recent, and representative, WET test rounds, provided it never exceeds the current overall mixing zone of 1 km. The WET testing data would be extrapolated against the model to determine the number of dilutions required to achieve 99% species protection levels 99% of the time. If this result showed that the ANZECC/ARMCANZ 99% species protection levels were being exceeded more than 5% of the time beyond the predicted mixing zone, additional management measures would be considered. WET test results will be combined with the PW characterisation to investigate the chemical basis of effluent toxicity using such methods as generic environmental hazard evaluation based on chemical composition or Toxicity Identification Evaluation to understand drivers and identify possible mitigations. Changes (increased toxicity that results in mixing zone larger than predicted) in reduced suite of toxicity tests would trigger testing with full suite and chemical characterisation analyses if results were from the reduced WET testing suite. If the WET testing evaluations show that the discharge thresholds are potentially being exceeded at the edge of the predicted mixing zone, an investigation as to the cause of the higher than expected toxicity will be undertaken to determine likely causes and available management options: • Understand the magnitude of likely exceedance (via interrogation of the verified dispersion model) and check if it is greater than the impact footprint (mixing zone) predicted in the EP.

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
				• Understand what is leading to the increase in toxicity (through analysis of operating conditions, topsides monitoring and interrogation of the WET testing and chemical characterisation results to understand the likely major contributors to overall toxicity).
'Mixed discharges' WET Testing	To determine if the toxicity of potential comingled discharges are greater than the PW discharge alone and if so, to understand: • if is confirms the model is predicted to still be conservative. • if comingled discharges have significant additive or synergistic impacts • the likely major contributors to overall toxicity in comingled discharges	Once off, after initial field water sampling survey and coinciding with next scheduled PW WET testing To also be carried out at the same time as WET testing for PW.	Modelled dilution rates and results from the field water sampling survey will be used to identify the appropriate discharge co-mixing ratios to be used to mimic what is occurring around the FLNG. WET testing is done for the direct toxicity assessment of the whole PW effluent in order to allow for the assessment of additive effects from different chemicals and constituents. This is carried out using recognised ecotoxicity assessment methodology defined in ANZECC/ARMCANZ (2000) in a NATA accredited laboratory. WET testing results may be used to derive more relevant site-specific thresholds for species protection than the full suite of contaminants outlined in Table 10-7 for water quality. Chemical characterisation will be carried out on the same samples that have the WET test carried out on them to enable potential identification of the driver of toxicity.	No further action is required if the toxicity of the mixed discharge WET test is less than the corresponding PW WET test. In the event the mixed discharge WET test is found to be more toxic than the PW WET test; 1. The results of the monitoring will be validated when the next infield water quality monitoring occurs; and 2. A review of chemical characterization results will be used to help inform the source for potential increased toxic effects from the mixing of discharges including options to potentially reduce toxicity; and 3. If (1) above confirms toxicity of mixed discharge is still greater than PW, further mixed discharge WET tests will be carried in when future scheduled PW WET tests occur to enable further comparison.

Field Monitoring

Table 10-9: Summary of the routine/planned infield monitoring campaigns

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
Water Column Sampling[1]	Determine if the PW model is conservative or not (i.e. confirm the model underestimates the actual level of dilutions at the edge of the mixing zone).[51]	One planned routine sampling event within the 5-year validity period of this EP.	Specific sampling locations, contaminants, sample collection methods, including quality control and assurance, and storage times will be confirmed with the environmental consultants designing the programme to ensure the objectives of the field monitoring are met. The survey design and methods used will also be independently reviewed by a qualified subject matter expert prior to finalizing the design and methods as an additional assurance to ensure the objectives of the survey are achieved. There will be an initial need to confirm trajectory of the discharge to ensure sampling is occurring within the plume. This may be achieved by visual assessment, remote sensing or real time sensors deployed from vessels running transects, injection of dyes or other methods and will also help identify potential co-mingling zones. Given the FLNG weather vanes and orientation is predominantly influenced by the currents, discharges will typically flow along the hull towards the stern and away from the facility. Along this bow to stern gradient, different discharges can comingle and mix with discharges entering from upstream (for assessment of potential comingling liquid discharge plumes). The spatial separation and different chemistry of the various discharges enables the dilution of individual discharges as well as comingling of multiple discharges to be investigated. Sampling will occur at optimised locations along this gradient with precise	If results indicate the PW model is not sufficiently conservative, a new more accurate model will be established to determine with higher confidence if the PW is meeting compliance/non-compliance at the edge of the mixing zone for PW with WET test results and relevant ANZECC guidelines (99% species protection limits, 99% of the time). In the highly unlikely event the results indicate the PW model is not conservative and impacts to water quality are greater than have been predicted within the EP, an investigation will be initiated to determine the cause of the impacts and engineering and other solutions which could be considered to address the issues. In this circumstance also, further infield monitoring targeting potential additive effects from

[51] Preliminary scoping for infield water quality sampling studies carried out by Shell between 2018 and 2020 have shown that it is not reasonable or realistically achievable to extend the objectives of the study beyond those outlined above because of the complexities and realities of conducting infield water quality sampling for low concentration discharges in the open ocean environment at any meaningful distance from the discharge source around a mobile operating facility.

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
			locations adjusted to match the predicted levels of dilutions and proximity of the specific discharges relative to each other. Each water sample will be analysed for the full suite of measured contaminants to determine dilution of PW as a single waste stream as well as to assess the influence of comingling of different discharge streams on the PW plume. Sampling should be conducted within a single tidal cycle at a time of reasonable tidal flow and when thrusters or wind are not holding the FLNG against the tide. Under most conditions discharges are likely to flow along the hull of the FLNG towards the stern, restricted to a small distance laterally from the hull. Along this bow to stern gradient, different discharges are added and mix with any discharges entering from upstream. Given the results of the liquid discharges cumulative impact assessment outlined in section 9.9.3 has shown any consideration of other discharges will add further conservatism to the already conservative impact assessment, there is no planned infield monitoring and assessment of other discharges apart from the PW discharge.	other discharge streams or co-mingling with other discharges would be carried out.

1 – As further detailed in Section 9.9, routine monitoring of sediment quality and benthic habitats will not be undertaken for the duration of this EP due to no credible impact pathway or no environmental effects or damage predicted.

PW Model Verification

Table 10-10: Summary of the PW Model Verification

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
PW Model Verification	Verify through field sampling and observation that topside monitoring combined with the modelling predictions provides a conservative	One planned model verification event within the 5-year validity period of this EP.	Initially dye studies, or other suitably robust method, will be used to confirm the trajectory of discharges and, the spatial pattern of dilution and co-mingling of discharges. This may be achieved by visual assessment, remote sensing, real	Validate model predictions on mixing and/or adjust model to align with measured dilution. Confirm individual mixing zones and extent of co-mingling of different mixing zones (if reasonably practicable)

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
	prediction of the extent of the mixing zone for PW discharges		time sensors deployed from vessels running transects, injection of dyes or other methods and will also help identify co-mingling zones as a secondary objective.	Identify the relationship of the Target Dilution derived from WET testing with ANZECC guidelines for individual chemicals (99% species protection limits, 99% of the time). If results of the PW Model verification indicate the PW model is not sufficiently conservative, a new more accurate model will be established to determine with higher confidence if the PW is meeting compliance/non-compliance at the edge of the mixing zone for PW with WET test results and relevant ANZECC guidelines (99% species protection limits, 99% of the time). This would also trigger review of the PW impact assessment and assessment under the Shell MOC Manual as applicable to determine if any changes in the impact profile are significant. In the highly unlikely event the results indicate the PW model is not conservative and impacts to water quality are greater than have been predicted within the EP, an investigation will be initiated to determine the cause of the impacts and engineering and other solutions which could be considered to address the issues.

PW Sediment Quality Monitoring

Table 10-11: Summary of the PW Sediment Quality Monitoring

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
PW sediment quality sampling	Verify the predicted level of impacts to sediment quality immediately surrounding the Prelude FLNG facility from the PW	To be initially done by 2030 or sooner. Opportunities for cost efficiencies will be	The details of this study will be known once the relevant activities are conducted. However, a scientifically robust sampling design will be implemented to enable verification of the predicted level of	Update risk assessments/predictions. Determine major causes of benthic impacts by correlation of the concentration of the different

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
	discharge through field measurements.	considered in doing the monitoring earlier. e.g. conducting sediment monitoring in conjunction with water quality monitoring.	impacts to sediment quality immediately surrounding the Prelude FLNG facility from the PW discharge through field measurements. Suitably qualified personnel (e.g. external independent consultants) will be engaged to design and carry out the monitoring. Considerations of lessons learnt from other industry monitoring studies will be obtained where possible. Baseline monitoring suitability will also be considered in the design of the monitoring. Design will also consider where likely expected worst impacts are predicted given prevailing conditions onsite. Design of the study will be consistent with the relevant ANZECC study design approach available at the time, noting changes in technology, sampling design and methods are likely to change between now and when potential sediment quality monitoring is carried out.	contaminants from PW discharge (and others potentially) found in the sediments.

PW Changes Requiring Additional Assessment

In addition to the routine/planned monitoring activities outlined in Table 10-5 to Table 10-10, this adaptive management framework also contains potential triggers for additional studies/verification when there are significant changes to the PW discharge characteristics.

Additional studies may be in the form of desktop analysis, modelling studies, additional chemical characterisation and/or WET testing and monitoring of the receiving environment. If the assessment shows a potentially significant increase in the environmental impact consequence ranking, then further corrective and/or contingency actions may be required to ensure impacts are reduced to ALARP and acceptable levels. Potential triggers for additional studies associated with PW changes are presented in Table 10-12.

Table 10-12: Prelude PW Discharge Additional Studies Triggers Due to Potential Changes

Potential Changes	Triggers	Planned Verification Actions
Significant change to chemical additive profile	Change in process chemicals (increase in chemical concentration/dosing above the design envelopes or impact profile of chemicals proposed)	Changes to production or process chemicals are assessed in accordance to the Shell Australia Chemical Management Process (Section 10.1.10). If there is identified increase in environmental impact, additional desktop analysis (e.g. modelling study) and/or WET testing or chemical characterisation may be conducted. Active constituents of the process chemicals may also specifically be added to the topsides monitoring program if practicable.
Change in PW source characteristics	PW (formation water) comes into Prelude from a different reservoir.	If there is a change in reservoir characteristics (new wells or new reservoir), desktop analyses will be undertaken. If desktop analyses indicate potential increase in environmental risk, further characterization or toxicity assessments are conducted to verify environmental impacts.
	Increase in discharge rate or reservoir water cut from maximum design basis of the PW system (165m3/hr discharge capacity)	If there is increase from maximum design basis of the PW system (165m^3/hr) in the discharge rate, desktop analysis (including extrapolation from results of existing modelling studies) or additional dilution modelling is done to predict if the increased discharge rate exceeds the required dilution to meet acceptable concentration levels at the edge of the mixing zone.

Changes to the Adaptive Monitoring and Management Framework

Any proposed changes to the Adaptive Monitoring and Management Framework given it is a part of the broader LDMMP will be updated in line with the Shell document management system requirements.

10.4.3 IMS Monitoring, Reporting and Adaptive Management

10.4.3.1 FLNG

In accordance with the Prelude FLNG Biosecurity Management Plan (2000-010-G000-GE00-G00000-HX-5798-00003) the IMS monitoring and adaptive management for the Prelude FLNG that has been carried out is summarised in Figure 10-12.

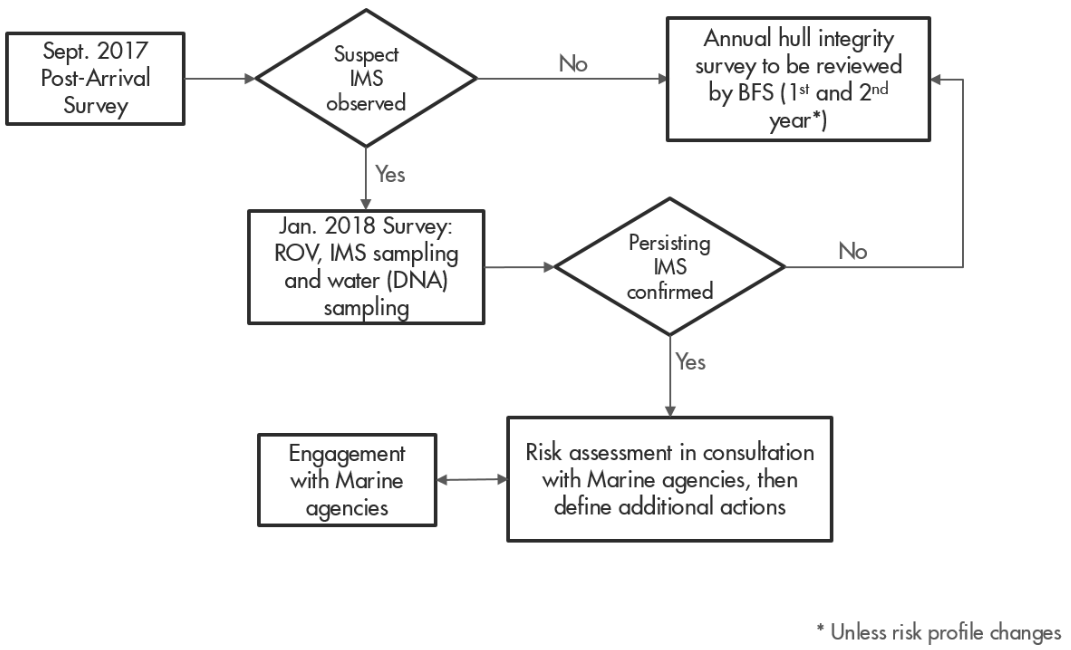


Figure 10-12: IMS Monitoring and Adaptive Management completed between 2017 and 2019.

Figure 10-12 illustrates the process described in the Prelude FLNG Biosecurity Management Plan that has been followed and involved the confirmation of the presence of suspected IMS of concern on the FLNG between 2017 and 2019. This employed a number of possible methods such as ROV surveys, collection of samples of biofouling growth/communities and water sampling for further molecular analysis (DNA/RNA sequencing) summarised in Section 9.8. The survey and sampling design involved liaison with numerous parties in order to determine a feasible plan which was realistic and could achieve the desired outcomes.

Since the last hull integrity survey completed in 2019 (Year 2) no IMS of concern have been detected on the FLNG. Following the completion of the year 1 and 2 hull integrity surveys, further monitoring of the Prelude hull will occur on a 5 yearly frequency unless a further inspection is triggered due to the outcomes of a marine vessel Class requirement inspection or as part of the Biofouling Risk Assessment for Domestic Vessels as described in Section 10.4.3.2 and Section 10.4.4.5 respectively.

10.4.3.2 Marine Vessels

Class requirements for hull integrity inspection of vessels include the following:

- In-water inspection every 2.5 years – will include inspection of the anti-fouling coating integrity. If anti-fouling coating needs re-application, then this will have to be done.
- Dry-docking every 5 years – this will include repair of the anti-fouling coating.

These hull integrity surveys can also determine if an IMS of concern has established on a vessel's hull. If there is reason to do an earlier inspection based on the residual risk from the FLNG, then this will be coordinated among the vessel owner, an IMS inspector and the State authority.

The biofouling risk assessment done for all vessels which will operate within the Prelude Operational Area using the Marine Vessel Biofouling Risk Assessment template is described in Figure 10-13.

10.4.4 Marine Vessel Assurance

All marine vessels which are planned to be used within the Operational Area are required to achieve "Positive Vetting" in accordance with the requirements specified in the HSSE & SP Control Framework – Transport Manual - Maritime Safety. Numerous assurers are required in order to assure a positive vetting, including Marine SME, Aviation SME and country security manager, Global Maritime Marine Warranty Surveyor and the project workstreams responsible for the particular activity to be conducted. The Marine Vessel Assurance process ensures that the physical controls are robust, including:

- Navigation Equipment and Aids
- Communication Equipment
- Dynamic Positioning System
- Lifting Equipment
- Emergency shut-down, alarm and lighting systems.

OCIMF OVID is the basis for all support vessel vetting. Additionally, vessels are screened for class and port state control infractions.

Offtake tankers are positively vetted against the OCIMF inspection.

The following compliance are required for "Positive Vetting" for vessel operating in the Prelude field, excluding equipment and material transportation vessels.

10.4.4.1 Marine Warranty Survey

All vessels and activities are assessed by the Marine Warranty Surveyor (MWS) on behalf of Shell's underwriter. Where required by the Marine Warranty Surveyor (MWS) and in accordance with Construction All Risk (CAR) insurance rules, a marine vessel inspection/suitability survey is performed and a Vessel Suitability Report issued by the MWS with all significant actions and findings closed.

10.4.4.2 Pre-Mobilisation Inspection Report

The Pre-Mobilisation Inspection is conducted to ensure compliance with HSSE, marine and technical requirements and readiness prior to commencing work. Vessels (inclusive of their equipment, processes and procedures) are thoroughly inspected and the inspection report items are closed prior to completion of mobilization.

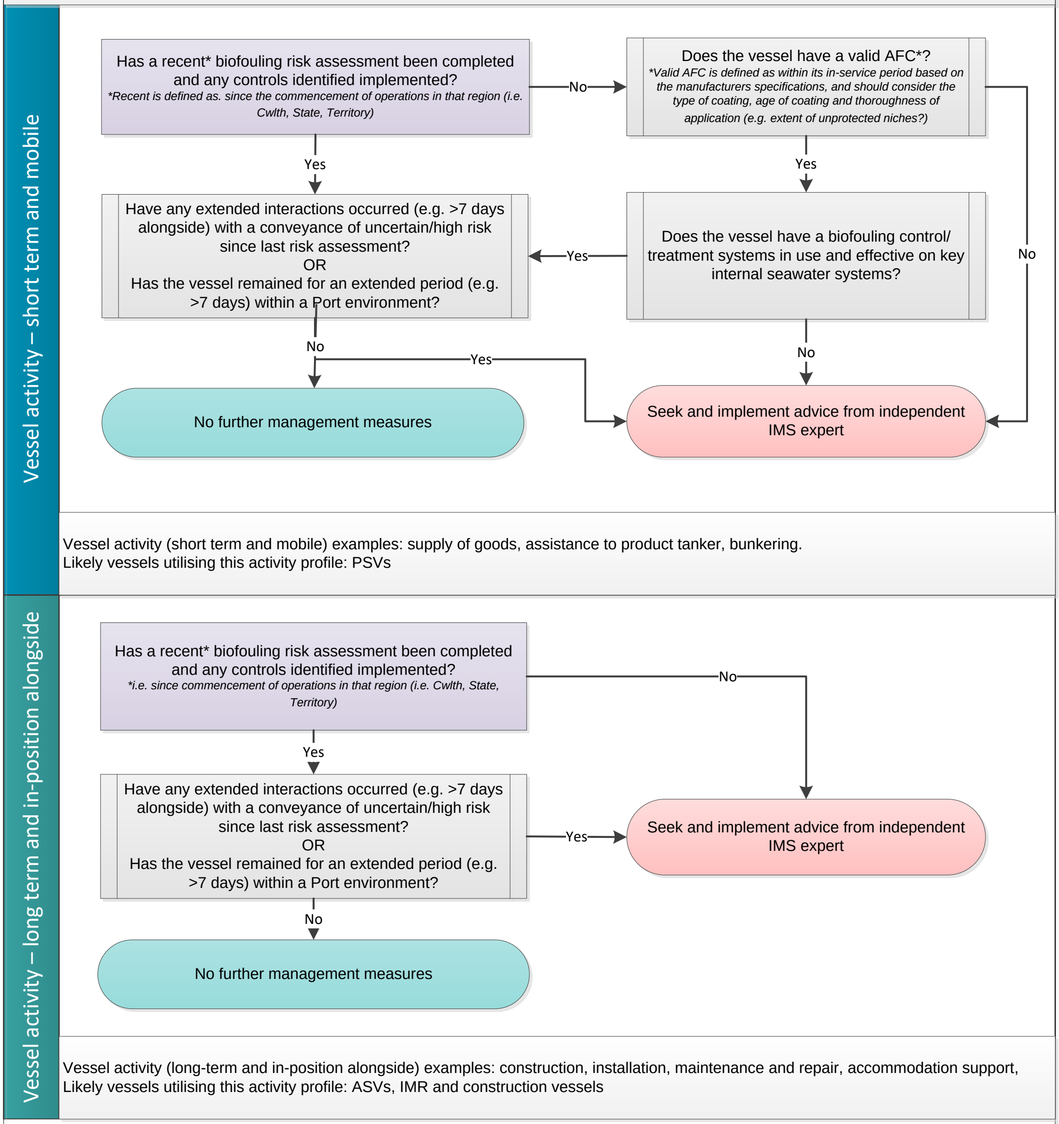
10.4.4.3 Shell Aircraft International (SAI) Approval

The Shell Aircraft International (SAI) approval ensures that all helidecks on any selected marine vessels utilized for personnel transport are approved. Furthermore, helicopters and helicopter refuelling equipment are approved by SAI.

Biofouling risk assessment for domestic movements

Activities covered: First mobilisation of domestically sourced vessels, either from domestic ports or from other operator facilities through vessel sharing arrangements

Ballast water excluded from decision tree, as it is to be managed in accordance with the Biosecurity Act, subordination legislation and the Australian Ballast Water Management Requirements.



Vessel name: *[Add here]*

Date of last IMS inspection and outcomes: *[Add here]*
Date of last AFC application: *[Add here]*
Validity of efficacy of AFC: *[Add here]*
Internal biofouling control treatment systems (e.g. MGPS): Y / N – details**:** *[Add here]*
Vessel history (commences from last known dry dock and AFC application): *[Add here]*
Biofouling management plan: Y / N – details: *[Add here]*

OUTCOME: *[Add here]*

Figure 10-13: Biofouling Risk Assessment Template for Domestic Movements

10.4.4.4 Group Maritime Assurance System (GMAS) Clearance

A GMAS clearance from the Shell Marine SME must be obtained prior to the commencement of marine operations on the Project and prior to the contracted marine vessel entering the Operational Area. This ensures that the above marine vessel assurance has been completed satisfactorily.

10.4.4.5 Biofouling Risk Assessment for Domestic Movements

In accordance with the Prelude FLNG Biosecurity Management Plan (2000-010-G000-GE00-G00000-HX-5798-00003) and to ensure the ongoing ‘Low Risk Status’ of the FLNG, the assessment of biofouling risk will be done for all vessels which will operate within the Prelude Operational Area using the Marine Vessel Biofouling Risk Assessment template (Figure 10-13).

The risk assessment will be done by the Vessel Owner/Operator with advice from the Prelude HSSE Advisor or Prelude Environmental Engineer.

10.4.5 Environmental Assurance

Shell and its contractor’s HSSE Plans make provisions for monitoring, audits and review. Annual HSSE Plans identify environmental audits and reviews that are to be conducted for the year. These audits and reviews include internal and external environmental audits, contractor HSSE audit, waste management audit/review and gap analyses against HSSE Control Framework Manuals,. As a minimum, an annual internal environmental audit is planned for the Prelude FLNG facility which will assess compliance with a risk based selection of internal and external environmental requirements (including EP requirements) This risk based approach will cover different aspects, topics and areas of focus areas with a target being to cover assurance of all internal and external environmental requirements in assurance activities over a minimum 5 year period.

Shell Group audits are undertaken across all Shell businesses on an intermittent basis. This auditing process assures the HSSE & SP management system as a whole.

The outputs of the audits and reviews are the corrective actions that feed the improvement process. Close-out of these corrective actions is monitored and reviewed.

Regular onsite HSSE assurance is conducted on a weekly basis which includes checking that environmental controls are implemented. Any specific environmental issues, like any HSSE issues, identified during these assurance checks are raised in the HSSE Leadership and Assurance meeting and resolved as part of continually reducing the risks to ALARP and Acceptable levels.

10.4.6 Environmental Knowledge Management Process

To manage the information and knowledge that underpins this EP, Shell has developed an Environmental Knowledge Management Process. The process involves the periodic review of EP knowledge against updated information (available to Shell or made publicly available) to identify any gaps or inconsistencies. The source of new information may include (but is not limited to):

- Shell Australia EPs, OPPs or other Shell EIAs (Australia and global) in development and/or accepted.
- Other operator EPs or OPPs as published on the NOPSEMA website.
- Other operator EIAs as made publicly available (Australia and global).

- Outcomes of Shell monitoring, surveys or other studies as relevant to the EP content.
- Published studies and/or literature relevant to the EP content.
- Legislation databases and government guidelines, policies etc.
- Technical details, operational changes or other information on the project and facilities as relevant to the EP content.
- Outcomes of stakeholder consultation as relevant to the EP content.

In the event that new information is available, Shell will consider the new information in accordance with the internal Management of Change processes (Section 10.1.9). The EP knowledge base has a scheduled annual review and the review is planned for in the Prelude FLNG Compliance Register (HSE_PRE_012227).

10.4.7 Management Review of EP

A review of the EP is to be done on an annual basis which will include review of the risk ranking of environmental impacts, effectiveness of controls, relevant records required as evidences of compliance, compliance issues and progress of any actions required to address any compliance issues. The annual HSSE Management System Review includes Environment and identifies areas of concern and improvement at a management system level which outputs the following year's HSSE Improvement Plan.

10.4.8 Management of Incidents and Non-Conformances

All Health, Safety, Security and Environmental incidents and non-conformances are managed in accordance with the Shell Australia HSSE Incident Reporting, Investigation and Follow up Procedure (HSE_GEN_000027) that describes the process of reporting, classification, investigation, follow-up and close out. Non-conformances are treated in the same way as incidents and for the purposes of this document are referred to as incidents.

All incidents records are managed in an online electronic system called Fountain Incident Management (FIM). Below is the overview of the incident management process:

- The system allows incidents to be raised by any employee of the company including offshore personnel.
- The incident is then assigned to a Responsible Supervisor (Incident Owner) who then retains the ownership of the incident until closeout.
- The Responsible Supervisor initiates the Incident Investigation the depth of which depends on the actual and potential risk ranking of the incident.
- The recommendations of the investigation team are reviewed by the Incident Owner who then assigns the corrective and preventative actions to the appropriate action party. Actions are tracked to closeout where the Incident Owner accepts that the remedial action is successfully completed based on the evidence recorded and logged in FIM.
- FIM provides functionality for automatic reminders for Incident Owner and Action Parties about the actions due. However, in addition reviews of outstanding actions are carried out both at asset/department level, and at the Shell Business Assurance Committee level at regular intervals to ensure timely closeout of actions.

All employees or contracted staff are encouraged to submit incident reports to alert the organisation about the occurrence of an incident or non-conformance.

In addition to the Incident Management Process outlined above, Shell also reports the number of non-compliances (incidents/ non-conformance) to the Shell Group on a quarterly basis, along with other HSE data in accordance with Shell Group Performance Monitoring and Reporting (PMR) standard. This information is reviewed in a dedicated HSE Business Performance Review where Shell Australia performance is reviewed by the Shell Group.

The incident investigation process works to understand the cause of an incident and the reason why a control/ mitigation measure has failed and to rectify the fault to prevent recurrence and the reporting process works to track performance and allows sharing of learnings. This process contributes to reducing the risks to ALARP and Acceptable Levels.

10.5 Reporting

10.5.1 Annual Environmental Performance Reporting

Regulation 14(2) and 26C requires that an Environmental Performance report will be submitted to NOPSEMA in intervals of not more than one year. Annual Environmental Performance Reports will contain a full year (1 July – 30 June the following year) and will be submitted to NOPSEMA by 31 December.

Shell is also required to report annual GHG emissions and energy usage and pollutants emissions under the NGER Scheme and NPI reporting, respectively. The reporting period for these also cover a full year (1 July – 30 June the following year).

10.5.2 External Incident Reporting

Reportable Incidents

NOPSEMA will be notified of all reportable incidents under Regulation 26 of the OPGGS (E) Regulation within two hours of the incident and in writing within three days. Under the OPGGS (E) Regulations, Reportable Incidents are defined as *'an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage'*. The Shell Risk Assessment Matrix (refer to Section 9.2) uses severity levels 0 to 5 to define environmental consequences (no effect, slight effect, minor effect, moderate effect, major effect and massive effect'). All environmental effects with a severity 3 or greater (i.e. moderate to massive) are considered Reportable Incidents. Based on the risk assessment (Table 9-32 and Table 9-82), five events are considered to be of moderate or higher consequence:

- Any confirmed introduced marine pest species in Australian waters attributable to the petroleum activities
- Diesel spill resulting from a collision with another vessel
- HFO spill due to rupture of storage tank of a product offtake tanker
- Condensate spill due to rupture of storage tanks on the FLNG as a result of breach of the hull
- An uncontrolled hydrocarbon release from the wellhead similar to a well blow-out.

The reportable incident report contains all material facts and circumstances concerning the reportable incident, actions taken to avoid or mitigate any adverse impacts and corrective action taken. This report will be submitted to NOPSEMA.

Recordable Incidents

For the purpose of this activity, in accordance with the OPGGS (E) Regulations, a recordable incident, for an activity, means '*a breach of an environmental performance outcome or environmental performance standard, in the environment plan that applies to the activity, that is not a reportable incident*'.

NOPSEMA will be notified of all Recordable Incidents, according to the requirements of Regulation 26B of the *OPGGS (E) Regulations*. A report of Recordable Incidents must be given to NOPSEMA *'as soon as practicable after the end of each calendar month, and in any case not later than 15 days after the end of the calendar month'*.

As per the OPGGS (E) Regulations, the report will comprise:

- *'A record of all Recordable Incidents that occurred during the calendar month*
- *All material facts and circumstances concerning the Recordable Incidents that the operator knows or is able, by reasonable search or enquiry, to find out*
- *Any action taken to avoid or mitigate any adverse environment impacts of the Recordable Incidents*
- *The corrective action that has been taken, or proposed to be taken, to prevent similar Recordable Incidents'*.

Other Externally Notifiable Incidents

Other externally notifiable incidents are captured in Table 10-13.

Table 10-13: Other Externally Notifiable Incidents

Incident	Legislation	Timing of Notification with respect to the occurrence of the incident.	Contact Details
Any breach in the quarantine regulations, including exchange of ballast water within the twelve nautical mile limit.	Biosecurity Act 2018, Australian Ballast Water Management Requirements 2017	As soon as practicable	Department of Agriculture, Water and the Environment (Maritime National Coordination Centre) Phone: 1300 004 605
Any confirmed introduced marine pest species in Western Australian state waters.	Fish Resources Management Regulations 1995 r176(1)	Within 24 hours.	DPIRD FishWatch 1800 815 507 Email: aquatic.biosecurity@dpird.wa.gov.au Aquatic Pest Biosecurity Section: 08 9203 0111
Death or injury of threatened, migratory or cetacean species from collision with a vessel.	EPBC Act 1999, Chapter 5, Part 13, Division 3, subdivision C, 232 (2)	Within 7 days, including the time, place, circumstances, species affected and the consequences of the action.	The Secretary, DAWE

10.5.3 Internal Reporting

Shell has internal reporting requirements against environment parameters identified in the Shell Group Performance Monitoring and Reporting (PMR) standard. This data is used as the basis for an annual Shell Group Sustainability Report.

10.5.4 Notifications

In accordance with Regulation 19 of the OPGGS (E) Regulations, this EP remains valid from NOPSEMA acceptance for a period of five years, or until NOPSEMA has accepted an end-of- activity notification under Regulation 25A or Shell Australia revise and resubmit this EP.

10.5.5 Details of Titleholder and Liaison Person

In accordance with Regulation 15 of the OPGGS (E) Regulations, details of the titleholder, liaison person and arrangements for notifying of changes are described below.

Titleholder:

Shell Australia Pty Ltd (can: 009663576/ABN: 14009663876)

562 Wellington Street, Perth 6000 WA

Activity Contact:

Peter Norman

Prelude FLNG Asset Manager

Email address: SDA-preludeflng@shell.com

Contact numbers: 1800 059 152

Should the titleholder, titleholder's nominated liaison person or the contact details for either change, NOPSEMA is to be notified in writing of the change within two weeks or as soon as practicable.

10.6 Record Keeping

Compliance records will be maintained. Record keeping will be in accordance with OPGGS (E) Regulation 14(7) that addresses maintaining quantitative records of emissions and discharges which is accurate and can be monitored and audited against the EPSs and MC.

10.7 Emergency Preparedness and Response

Under Regulations 14(8) the Implementation Strategy must contain an OPEP and provide for the updating of the OPEP. Regulation 14(8AA) outlines the requirements for the OPEP which must include adequate arrangements for responding to and monitoring of oil pollution.

A summary of Shell Australia's emergency and incident management framework and arrangements are presented in Figure 10-14 and described in the following sections.

10.7.1 Shell HSSE & CP Control Framework

The Shell HSSE & SP Control Framework is a comprehensive corporate management framework that applies to every Shell company, contractor and joint venture under

Shell's operational control. The framework contains a simplified set of mandatory requirements that define high level HSSE & SP principles and expectations. Emergency Response Management and Spill Preparedness and Response are two areas covered in the Shell HSSE & SP Control Framework.

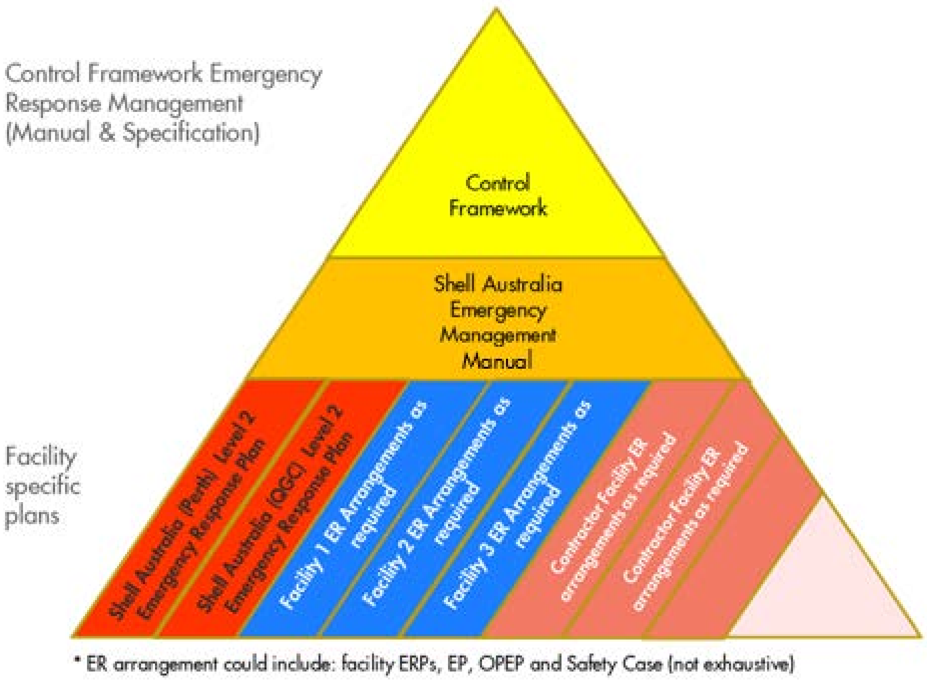


Figure 10-14: Shell Australia Emergency and Incident Management System Overview

10.7.2 Shell Australia Emergency Management Manual

The Shell Australia Emergency Management Manual (HSE_GEN_010996) provides a tiered response framework which classifies incidents based on the level of resourcing and support required. It also outlines communication arrangements associated with each level of emergency, emergency response roster arrangements, emergency response training and competencies, and requirements for emergency management drills and exercises.

10.7.3 Incident Management Team (West) (IMT(W)) Emergency Response Plan

The Incident Management Team (West) (IMT(W)) Emergency Response Plan (HSE_GEN_011209) is a supporting document to the Shell HSSE & SP Control Framework, Shell Australia Emergency Management Manual (HSE_GEN_010996) and is consistent with Australian Commonwealth and State Emergency Management Arrangements. The purpose of the IMT (W) Emergency Response Plan (HSE_GEN_011209) is to provide specific assistance and guidance to Shell Australia IMT (W) in support of Shell owned, operated or contracted facilities. The following topics are detailed in the document:

- Shell Australia emergency management arrangements;
- Shell Australia IMT(W) role checklists and duty cards;
- Incident management, action planning, ICS forms and briefing templates;
- IMT (W) communications;
- Guidance for responding to emergencies;
- Supporting subject matter expert units; and
- De-escalation and recovery.

10.7.4 Prelude Facility Emergency Response Plan

Prelude Facility Emergency Response Plan (HSE_PRE_005612) defines emergency response arrangements for the Prelude FLNG, including detailed checklists for all credible incidents, including well blow out and vessel collision. It describes the interface arrangements between the IMT, CMT and ERT and provides roles and responsibilities of personnel involved in the response.

Scenario-based drills are performed to test the emergency response arrangements and updates are made to improve the ERP, if required.

10.7.5 Oil Pollution Emergency Plan

The Prelude OPEP (HSE_PRE_013075) outlines emergency management arrangements to respond to credible spill scenarios associated with the Prelude activity. The OPEP provides the information required for an effective response in the unlikely event of an unplanned release of petroleum products. The OPEP details the actions to be taken in response to the incident and provides contact details of emergency specialist response groups, statutory authorities and other external bodies requiring notification.

10.7.6 Operational and Scientific Monitoring Framework

Shell is required to have in place arrangements for monitoring oil pollution as part of its OPEP. Shell is adopting use of the Joint Industry OSMP Framework (APPEA, 2020) and its associated OMP’s and SMP’s to guide environmental monitoring that may be implemented in the event of a Level/Tier 2-3 spill of hydrocarbons. Further information on how the Joint Industry OSMP Framework interfaces with Shell’s activities, spill risks and internal management systems is presented in Shell’s Operational and Scientific Monitoring Bridging Implementation Plan (HSE_PRE_16370).

10.7.7 Shell Australia’s Emergency Management Structure

Shell Australia applies the Incident Command System (ICS) methodology for emergency management. The ICS is a management system designed to enable incident management through integrating facilities, equipment, personnel, procedures and communications operating under one structure. An ICS is commonly structured into functional areas that facilitate incident management activities, including operations, planning, logistics, finance and incident command.

Shell Australia also applies a graduated response framework that increases resource involvement based on the significance and escalation potential of the incident. This graduated framework involves three key emergency management teams, as described below:

- Emergency Response Team (ERT) which is based on the facility and is responsible for the initial response to the incident. The Facility Incident Commander (Offshore Installation Manager (OIM)) will liaise closely with the IMT West Leader (onshore) and will identify when additional support is required to respond to an incident
- Incident Management Team (West) (IMT(W)) is based onshore and supports the ERT, by providing advice, logistical support and managing the operational and technical aspects of the response; and
- Crisis Management Team (CMT) is based onshore and is responsible for the overall management of the incident from a strategic, commercial, legal, reputational and high level liaison perspective.

The ERT and IMT (W) are scalable to the nature and scale of the response i.e. one person can take on multiple roles where circumstances permit. The mobilisation of the ERT is at the directive of the Facility Incident Commander or delegate. The mobilisation of the IMT (W) will occur by the Facility Incident Commander contacting the on-duty IMT (W) Leader who will then mobilise the IMT (W) as the situation warrants. Duty positions within IMT (W) area are staffed by a roster system where each position has required personnel identified for the role. On-call positions within IMT (W) provide specific functional expertise that helps the business respond to relevant incident scenarios. On-call positions are activated as part of the IMT(W) at the discretion of the IMT Leader based upon known or potential requirements. A number of people are identified and trained for each on-call position, with a rotating on-call list used to contact these personnel.

Figure 10-15 outlines the emergency management escalation process adopted by the IMT (W) and the IMT (W) structure is shown in Figure 10-16.

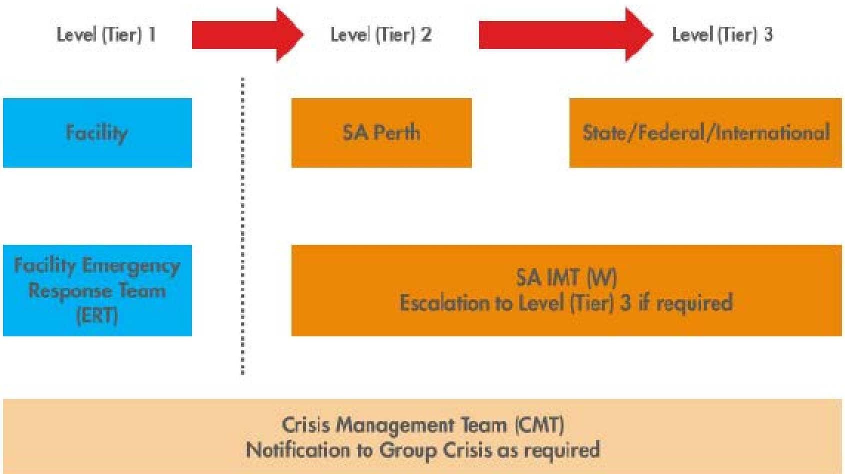
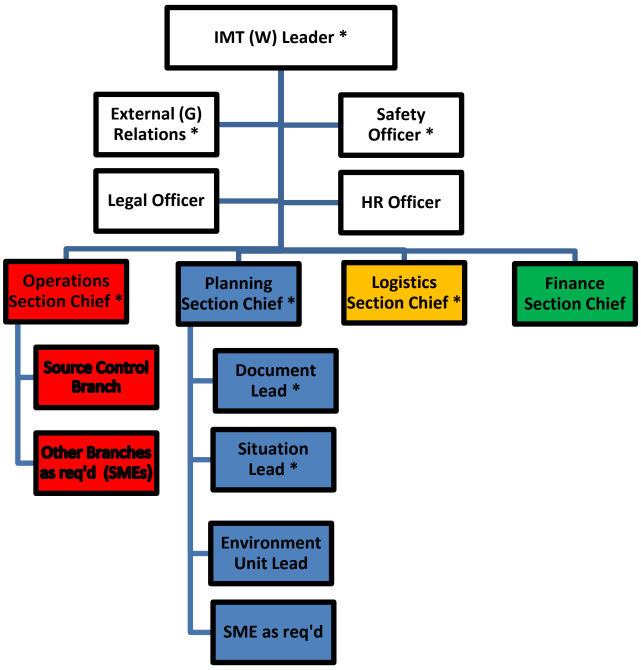


Figure 10-15: Emergency Management Escalation Process Adopted by IMT (W)

Interface between the IMT and Crisis Management Team (CMT) is outlined in the Shell Australia Weekly Contact List (HSE_GEN_011648). The affected facility business executive will have been notified by the IMT (W) Leader and will in turn notify the Shell Australia CMT leader.

In addition to these resources, Shell Australia can activate additional support through the Shell Global Response Support Network (GRSN). The GRSN is a network of emergency response trained Shell Staff employed in a wide range of positions within Shell's global and local businesses who have received specific training related to oil spill response and who may be called upon to support any business or country globally which is responding to a large scale incident. Shell Australia also has access to the Well Control Virtual Emergency Response Team (WCVERT), which provides virtual or physical mobilisation of a wide range of technical expertise.

Shell Australia could also activate external additional resources for Level/Tier 2-3 spills to fill various ERT and IMT roles for the duration of the response, if they were required. This includes Oil Spill Response Organisation (OSRO) personnel and trained mutual aid personnel (as per AMOSPlan), as outlined in Section 3.2 of the Prelude OPEP (HSE_PRE_013075).



*indicates duty roles, all other positions are on-call

Figure 10-16: Incident Management Team (West) (IMT (W)) Structure

The Source Control Branch (if required), falls under the Operations Section of the IMT and develops and implements strategies and tactics to regain control of the well, and stop or contain the discharge of hydrocarbons. This strategy includes:

- Development of solutions;
- Coordination of engineering safety and operational activities;
- Development of task-specific plans and procedures;
- Identification of required tools and equipment; and
- Monitoring progress in achieving well control.

The activities of the Source Control Branch in Australia will be organised into additional groups, according to the specific requirements of the incident. These additional groups may include a Capping and Subsea Intervention Group, Well Control Group and Offset Installation Taskforce. All source control personnel complete ICS 100 and 200 training.

10.7.8 Emergency Management Roles and Responsibilities

Shell Australia's Incident Management Team (West) (IMT(W)) Emergency Response Plan (HSE_GEN_011209) and Prelude Facility Emergency Response Plan (HSE_PRE_005612) provide detailed guidance on roles and responsibilities for all emergency management personnel.

A summary of key roles and responsibilities for Shell Australia personnel for incident response are outlined in Table 10-14. Also provided are the roles and responsibilities of Shell Australia personnel required to work within the WA Department of Transport (DoT) organisational structure (Table 10-15), where DoT has responsibilities for spill response as a Control Agency, as per DoT's Offshore Petroleum Industry Guidance Note – Marine Oil pollution: Response and Consultation Arrangements. DoT will provide two roles to Shell's IMT/CMT in a coordinated response. These roles and responsibilities are provided in Table 10-16.

Table 10-14: Summary of Roles and Responsibilities of Key Emergency Management Personnel

Key Roles	Responsibilities
Facility Incident Commander (OIM) (Offshore)	Maintain the safety of all Prelude personnel and initiates actions to protect the environment and the Prelude asset Ensure all first strike actions carried out as per OPEP Control source of spill (if practicable) Classify the Level/Tier of spill Notify and maintain regular communications with Incident Management Team Leader (West) of incident Verbally notify NOPSEMA (within 2 hours of spill) if spill is within Commonwealth waters Initiate monitor and evaluate activities, as per OPEP
On-scene Commander (Offshore)	Responsible for emergency scene coordination and safety of all personnel at the emergency scene Move ERT forward when authorised by Incident Commander (OIM) Provide regular situation updates to the Operations Section Chief on incident progress against response plan priorities
IMT (W) Leader (Onshore)	Ensure all first strike actions carried out per OPEP Activate IMT, if required Conduct overall management of incident response operations Assess the situation and confirm or adjust the spill classification Level/Tier in consultation with the OIM and Operations Section Chief Notify CMT Leader of event and initial response level Determine incident priorities and objectives for IMT Confirm Incident Action Plan (IAP) is being developed, approve and authorise implementation of IAPs Confirm all external notifications and reporting have been made, as outlined in OPEP Mobilise external support, if required, as per OPEP

Key Roles	Responsibilities
Operations Section Chief (OSC) (Onshore)	Oversees all operational resources and activities supporting an emergency Establish communications with ERT Provide overview of response operations at initial IMT brief Communicate incident updates provided by the ERT to IMT through meetings and team briefs Provide incident details to the Planning Section Chief and Situation Unit Lead for development of Initial IAP and help develop incident objectives and strategies Determine operational areas e.g. staging areas, forward command, incident area, oiled wildlife receiving and demobilisation areas Executes IAPs for each operational period Responsible for safety of all personnel involved in response
Planning Section Chief (PSC) (Onshore)	Facilitate all IMT meetings Assist the IMT (W) Leader in development of incident objectives Facilitate development of IAP for next operational period Mobilise Environment Unit Monitor situation reports and update status displays with additional information and adjust IAP as necessary
Logistic Section Chief (LSC) (Onshore)	Source all logistical requirements to complete response operations, including personnel, equipment and supplies for ongoing incidents Liaise with Planning Section Chief on specialist resource requirements being considered in response strategies. Verify availability as this may affect strategy selection Where required incident resources are not immediately available through existing contracts, liaise with Contracts & Procurement to develop contractual arrangements as required
Environment Unit Lead (EUL) (Onshore)	Conduct relevant external notifications, as outlined in OPEP Review OMP initiation criteria and activate OSMP contractor where required Confirm protection priorities Validate strategic SIMA and generate the initial operational SIMA Provide guidance to the OSC on environmental management measures to be followed during response operations.
Source Control Branch Director	Develops and implements strategies and tactics to regain control of the well, and stop or contain the discharge of hydrocarbons. This strategy includes: • the development of task-specific plans and procedures • the identification of required tools and equipment • monitoring progress in achieving well control Assign a person or persons to liaise with the SIMOPS unit (if assigned) under the Operations Section, which is overall in charge of simultaneous operations and maintenance of the Common Operating Picture Activate specialist Source Control Groups as required

Key Roles	Responsibilities
Situation Unit Lead (Onshore)	Responsible for collecting, processing and organising incident information relating to the growth, mitigation or intelligence activities taking place on the incident Manages all situational awareness and intelligence information relating to the incident, including geospatial/meteorological information Ensure status boards updated, retain clear records of out of date vs current information Prepare and disseminate resource and situation status information as required, including special requests.
Documentation Unit Lead (Onshore)	Responsible for the maintenance of accurate, up-to-date incident files i.e. IAP, incident reports, communications logs Compiles and collates all unit logs, communications and other records so that a consolidated set of incident documentation is maintained. Liaise with the Situation Unit Lead to collate and store all relevant documentation produced for Situation Updates
External (Government) Relations/ Public Information Officer (PIO) (Onshore)	Conduct relevant external notifications, as outlined in OPEP Manages all external communications until CMT assumes responsibility Evaluate the need for a joint information communication centre Ensure active and ongoing engagement with all relevant stakeholders and external response agencies. Prepare stakeholder management plan for approval by IMT Develop material for use in media releases
Safety Officer (Onshore)	Conduct hazard assessment and advise OIM of recommended safety actions and safe approach routes Assist the OSC and LSC by facilitating risk assessments during event response and recovery plan development as required Review IAPs for safety implications
Finance Section Chief (Onshore)	The Finance (& Admin) Section Chief is responsible for all financial, administrative and cost analysis aspects of an emergency Provide financial and cost analysis information as requested

Table 10-15: Shell Personnel Roles Positioned within the State Maritime Environmental Emergency Coordination Centre (MEECC)/ DOT IMT

Key Roles	Responsibilities
CST Liaison Officer	Provide a direct liaison between the Shell and the State MEECC Facilitate effective communications and coordination between the Shell CMT Leader and the State Maritime Environmental Emergency Coordinator (SMEEC) Offer advice to SMEEC on matters pertaining to Shell crisis management policies and procedures
Deputy Incident Officer	Provide a direct liaison between the DoT IMT and the Shell IMT Facilitate effective communications and coordination between the Shell IMT (W) Leader and the DoT Incident Controller Offer advice to the DoT Incident Controller on matters pertaining to the Shell incident response policies and procedures

Key Roles	Responsibilities
	Offer advice to the Safety Coordinator on matters pertaining to Shell safety policies and procedures particularly as they relate to Shell employees or contractors operating under the control of the DoT IMT
Intelligence Support Officer	As part of the Intelligence Team, assist the Intelligence Officer in the performance of their duties in relation to situation and awareness Facilitate the provision of relevant modelling and predications from the Shell IMT Assist in the interpretation of modelling and predictions originating from the Shell IMT Facilitate the provision of relevant situation and awareness information originating from the DoT IMT to the Shell IMT Facilitate the provision of relevant mapping from the Shell IMT Assist in the interpretation of mapping originating from the Shell IMT Facilitate the provision of relevant mapping originating from the Shell IMT
Deputy Planning Officer	As part of the Planning Team, assist the Planning Officer in the performance of their duties in relation to the interpretation of existing response plans and the development of incident action plans and related sub plans Facilitate the provision of relevant IAP and sub plans from the Shell IMT Assist in the interpretation of the Shell OPEP from Shell Assist in the interpretation of the Shell IAP and sub plans from the Shell IMT Facilitate the provision of relevant IAP and sub plans originating from the DoT IMT to the Shell IMT Assist in the interpretation of Shell's existing resource plans Facilitate the provision of relevant components of the resource sub plan originating from the DoT IMT to the Shell IMT (Note this individual must have intimate knowledge of the relevant Shell OPEP and planning processes)
Environmental Support Officer	As part of the Planning Team, assist the Environmental Officer in the performance of their duties in relation to the provision of environmental support into the planning process Assist in the interpretation of the Shell OPEP and relevant TRP plans Facilitate in requesting, obtaining and interpreting environmental monitoring data originating from the Shell IMT Facilitate the provision of relevant environmental information and advice originating from the DoT IMT to the Shell IMT
Public Information Support & Media Liaison Officer	As part of the Public Information Team, provide a direct liaison between the Shell Media team and DoT IMT Media team Facilitate effective communications and coordination between Shell and DoT media teams Assist in the release of joint media statements and conduct of joint media briefings Assist in the release of joint information and warnings through the DoT Information & Warnings team Offer advice to the DoT Media Coordinator on matters pertaining to Shell media policies and procedures Facilitate effective communications and coordination between Shell and DoT Community Liaison teams Assist in the conduct of joint community briefings and events Offer advice to the DoT Community Liaison Coordinator on matters pertaining to Shell community liaison policies and procedures

Key Roles	Responsibilities
	Facilitate the effective transfer of relevant information obtained from through the Contact Centre to the Shell IMT
Deputy Logistics Officer	As part of the Logistics Team, assist the Logistics Officer in the performance of their duties in relation to the provision of supplies to sustain the response effort Facilitate the acquisition of appropriate supplies through Shell's existing OSRL, AMOSC and private contract arrangements Collects Request Forms from DoT to action via the Shell IMT (Note this individual must have intimate knowledge of the relevant Shell logistics processes and contracts)
Deputy Operations Officer	As part of the Operations Team, assist the Operations Officer in the performance of their duties in relation to the implementation and management of operational activities undertaken to resolve an incident Facilitate effective communications and coordination between the Shell Operations Section and the DoT Operations Section Offer advice to the DoT Operations Officer on matters pertaining to Shell incident response procedures and requirements Identify efficiencies and assist to resolve potential conflicts around resource allocation and simultaneous operations of Shell and DoT response efforts
Deputy Waste Management Coordinator	As part of the Operations Team, assist the Waste Management Coordinator in the performance of their duties in relation to the provision of the management and disposal of waste collected in State waters Facilitate the disposal of waste through Shell's existing private contract arrangements related to waste management and in line with legislative and regulatory requirements Collects Waste Collection Request Forms from DoT to action via the Shell IMT
Deputy Finance Officer	As part of the Finance Team, assist the Finance Officer in the performance of their duties in relation to the setting up and payment of accounts for those services acquired through Shell's existing OSRL, AMOSC and private contract arrangements Facilitate the communication of financial monitoring information to the Shell to allow them to track the overall cost of the response Assist the Finance Officer in the tracking of financial commitments through the response, including the supply contracts commissioned directly by DoT and to be charged back to Shell
Deputy On Scene Commander (FOB)	As part of the Field Operations Team, assist the On Scene Commander in the performance of their duties in relation to the oversight and coordination of field operational activities undertaken in line with the IMT Operations Section's direction Provide a direct liaison between Shell's Forward Operations Base/s (FOB/s) and the DoT FOB Facilitate effective communications and coordination between Shell On Scene Commander and the DoT On Scene Commander Offer advice to the DoT On Scene Commander on matters pertaining to Shell incident response policies and procedures Assist the Safety Coordinator deployed in the FOB in the performance of their duties, particularly as they relate to Shell employees or contractors Offer advice to the Safety Coordinator deployed in the FOB on matters pertaining to Shell safety policies and procedures

Table 10-16: Roles and Responsibilities of DoT Personnel to be Positioned in Shell's IMT/CMT

Key Roles	Responsibilities
DoT Liaison Officer	Facilitate effective communications between DoT's SMEEC and Incident Controller and Shell's appointed CMT Leader and Incident Controller Provide enhanced situational awareness to DoT of the incident and the potential impact on State waters Assist in the provision of support from DoT to Shell Facilitate the provision technical advice from DoT to Shell's Incident Controller as required
Media Liaison Officer	Provide a direct liaison between Shell's Media team and DoT IMT Media team Facilitate effective communications and coordination between Shell and DoT media teams Assist in the release of joint media statements and conduct of joint media briefings Assist in the release of joint information and warnings through the DoT Information and Warnings team Offer advice to the Shell Media Coordinator on matters pertaining to DoT and wider Government media policies and procedures

10.7.9 Emergency Management Exercises, Training and Competencies

Shell Australia follows the approved ICS and IMO emergency management training requirement for ICS command and general staff. Specific competencies for IMT members are defined in the Shell Operational HSSE Competence Framework and are tracked in the Shell Open University. A summary of training requirements and core competencies for Shell key ERT, IMT and CMT personnel are outlined in Table 10-17.

Only persons that have completed all mandatory training requirements can be placed on the IMT roster. Training status of IMT personnel is reviewed monthly (or following significant personnel or policy change by the SA Emergency Response Coordinator) and notifications issued in advance to personnel requiring re-validation by training and/or emergency response exercise participation.

Oil spill responder training requirements are outlined in Table 10-18.

Table 10-17: Exercise and Training Requirements for Key ERT, IMT and CMT Personnel

Key Roles	Exercises	Training
ERT Personnel OIM	Weekly muster alarm drill (may be combined with Level/Tier 1 exercise) 1 x Level/Tier 1 exercise per swing Level/Tier 2/3 exercise 6 monthly in accordance with 3 year exercise plan.	Some offshore roles may have AMOSC - IMO training.
IMT Personnel IMT (W) Leader	It is required that 80% of personnel will participate in an IMT exercise annually.	All IMT personnel complete ICS 100, 200 and IMT induction. IMT (W) leader undertakes - IMO3 Oil Spill Command & Control

Key Roles	Exercises	Training
Operations Section Chief (OSC) Planning Section Chief (PSC) Logistic Section Chief (LSC) Environment Unit Lead (EUL)	It is a target that 80% of personnel will participate in an IMT exercise annually. Participation in exercises is tracked in the Shell Australia Exercises & Training Schedule and is reviewed monthly or following significant personnel or policy change by the Shell Australia Emergency Response Coordinator.	AMOSC – IMO2 Oil Spill Management
CMT Personnel	Level/Tier 2/3 exercise on a biennial basis	Shell specific – Group Crisis training

Table 10-18: Oil Spill Responder Training and Resources

Key Roles	Exercises/Training	Available Resources
Shell AMOSC Core Group members	AMOSC Core Group Workshop (refresher training undertaken every 2 years) Operations stream and management stream	As defined in AMOSC contractual core group requirements
Prelude FLNG ERT Personnel	Training as per Prelude Asset Training Strategy and Competence Management Plan (HRS_PRE_004622) Weekly muster alarm drill (may be combined with Level/Tier 1 exercise) 1 x Level/Tier 1 exercise per swing Level/Tier 2/3 exercise according to 3 year exercise plan (6 monthly). Level/Tier 2 and 3 exercises are planned and scheduled as per the Prelude Operations Desktop (ODT) portal.	1 per swing
AMOSC Core Group Responders	AMOSC Core Group Workshop (refresher training undertaken every 2 years)	As defined in AMOSC contractual core group requirements
OSRL Oil Spill Response Personnel	As per OSRL training and competency matrix	As defined in OSRL Service Level Agreement
AMOSC Oil Spill Response Specialists	As per AMOSC training and competency matrix	As defined in AMOSC Master Services Agreement
Operational and Scientific Monitoring Service Providers	As defined in the Shell Australia Operational and Scientific Monitoring (OSM) Bridging Implementation Plan (HSE_PRE_16370).	As per Standby Capability and Competency Report

Key Roles	Exercises/Training	Available Resources
Oiled Wildlife Responders (Level 2-4) Shoreline clean-up personnel	As per DBCA OWR requirements (WA OWRRP) As per WA DoT requirements	As per OWR stateboard (AMOSC & DBCA) As defined in AMOSC Master Services and OSRL Service Level Agreements. Team members available through labour hire contracts (training provided prior to deployment)

Shell Australia maintains an Exercise and Training Schedule as detailed in the Shell Australia Emergency Management Manual (HSE_GEN_010996) to ensure its competency in responding to and managing major incidents, including oil spills. The Exercise and Training Schedule is reviewed and revised (if required) annually.

As part of this schedule, Shell conducts a number of different exercise types, which are further described in Table 10-19.

Table 10-19: Exercise Types, Objectives and Frequency

Exercise Type	Objective	Frequency
Notification exercise	To test all communication and notification processes to service providers and regulatory agencies defined within the OPEP	At least annually When OPEP is accepted or introduced When response arrangements have been significantly amended If a new location for the activity is added after the response arrangements have been tested
Equipment deployment exercises	To focus on Shell's deployment capability To inspect and maintain the condition of Shell's oil spill response equipment To maintain training of field response personnel	Level /Tier 1 – Annually Level/Tier 2 – Every 2 years
Tabletop exercise	To encourage interactive discussions of a simulated scenario amongst IMT members and refresh roles and responsibilities	As per Shell Australia's Exercise and Training Schedule
Incident Management Exercise	To activate IMT and establish command, control, and coordination of a simulated Level/Tier 2 or 3 incident and test response arrangements in OPEP	Minimum of one oil spill exercise per year for Shell Australia's activities. Where response arrangements are the same for a number of activity-specific OPEPs, one exercise may be used to test these response arrangements for these OPEPs at the same time
National Plan Exercises or WA DoT exercises	Participate as required to ensure alignment between National/State	As determined by AMSA and/or WA DoT, Shell may not be requested to participate every year

Exercise Type	Objective	Frequency
	Response Framework and Shell Australia's Response Framework	
Shell Global Response Support Network (GRSN)	Test the functionality of Shell's Regional Core Group Level/Tier 3 oil spill response capabilities Target of 100% for participation of Shell Australia's Core Group personnel in GRSN regional exercises as required.	Annually Every 2 years
AMOSC Audit	To test deployment readiness and capability of AMOSC as per its Master Services Agreement with Shell	Annually
OSRL Audit	To test deployment readiness and capability of OSRL in Singapore as per OSRLs Service Level Agreement with Shell	Every 2 years

As part of the exercise process, a number of documents are prepared to ensure exercises are well planned, conducted and evaluated. To support this, the following documents are used:

- Exercise scope document – provides background context to the exercise, outlines the exercise need, aim, objectives, details of the scenario, participating groups and agencies, exercise deliverables and management structure. This document can be used to engage a third-party contractor to assist in conducting the exercise
- Exercise plan and instructions – provide instructions and 'play' (including any injects) for conducting the exercise
- Post exercise report – includes an after-action review of the exercise, evaluating how the exercise performed against meeting its aim and objectives.

10.7.10 Mechanism to examine the effectiveness of the response arrangements

Shell Australia routinely undertakes post-exercise debriefings following Level/Tier 2-3 OPEP exercises to evaluate effectiveness of response arrangements against the exercise objective/s, identify opportunities for improvement and communicate lessons learned. Shell sets Specific, Measurable, Achievable, Realistic and Timely (SMART) objectives for oil spill exercises so that they can be clearly evaluated as being met or not.

An independent assessor (either internal or external) will examine the effectiveness of the response arrangements during a spill exercise. The assessor will make written findings and recommendations from the test for consideration by Shell to assist in identifying deficiencies with response arrangements and continually improve the overall response readiness of Shell.

Recommendations from the tests will have SMART actions put against them where appropriate and they will be tracked to closure in Shell's Action Tracking System, Fountain Incident Management (FIM). The FIM system assigns a responsible person and due date against each action to ensure they are tracked to closure.

Assurance of Shell Group Response Arrangements

The major advantage of the GRSN/WCVERT is the ability to leverage the resources and support from the Shell Group for a local operations team, which may have a reasonably small footprint, in the event of an incident. However, it is recognised and must be made clear that during an incident the accountability for the response remains with the local organisation, in this case Shell Australia. It is therefore a requirement that the local organisation has the ability to test, evaluate and assure the capability of the Shell GRSN and WCVERT to meet their response needs on an ongoing basis.

The GRSN and WCVERT partake in frequent exercises around the world to ensure a state of readiness; these may be validated by local operating units as follows.

- upon request the GRSN/ WCVERT will share an updated drill schedule for forthcoming global drills in which they will partake;
- where practicable and under instruction from Shell Australia GM Wells some of the Shell Australia Source Control team may attend such drills to enhance training and validate response capability; or
- where practicable reports from previously conducted drills including learnings may be requested by Shell Australia to validate GRSN/ WCVERT response capabilities.

In order to monitor and track the availability of personnel, the WCVERT simulates regular call out drills. This involves sending a group communication to the WCVERT Source Control Branch members and recording the response, availability and response time.

- As required, a local operating unit may request from the Well Control PTE an overview of the recent call out drills to validate response capabilities.

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12.0 Disclaimer

This document contains data and analysis from Shell's Sky scenario. Unlike Shell's previously published Mountains and Oceans exploratory scenarios, the Sky scenario is based on the assumption that society reaches the Paris Agreement's goal of holding the rise in global average temperatures this century to well below two degrees Celsius (2°C) above pre-industrial levels. Unlike Shell's Mountains and Oceans scenarios, which unfolded in an open-ended way based upon plausible assumptions and quantifications, the Sky scenario was specifically designed to reach the Paris Agreement's goal in a technically possible manner. These scenarios are a part of an ongoing process used in Shell for over 40 years to challenge executives' perspectives on the future business environment. They are designed to stretch management to consider even events that may only be remotely possible. Scenarios, therefore, are not intended to be predictions of likely future events or outcomes.

Additionally, it is important to note that as of 5 January 2021, Shell's operating plans and budgets do not reflect Shell's net-zero emissions ambition. Shell's aim is that, in the future, its operating plans and budgets will change to reflect this movement towards its new net-zero emissions ambition. However, these plans and budgets need to be in step with the movement towards a net-zero emissions economy within society and among Shell's customers.

Also, in this document we may refer to "Shell's Net Carbon Footprint", which includes Shell's carbon emissions from the production of our energy products, our suppliers' carbon emissions in supplying energy for that production and our customers' carbon emissions associated with their use of the energy products we sell. Shell only controls its own emissions but, to support society in achieving the Paris Agreement goals, we aim to help and influence such suppliers and consumers to likewise lower their emissions. The use of the terminology "Shell's Net Carbon Footprint" is for convenience only and not intended to suggest these emissions are those of Shell or its subsidiaries.

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This document contains forward-looking statements (within the meaning of the U.S. Private Securities Litigation Reform Act of 1995) concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as "aim", "ambition', ''anticipate'', ''believe'', ''could'', ''estimate'', ''expect'', ''goals'', ''intend'', ''may'', ''objectives'', ''outlook'', ''plan'', ''probably'', ''project'', ''risks'', "schedule", ''seek'', ''should'', ''target'', ''will'' and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this document, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; (m) risks associated with the impact of pandemics, such as the COVID-19 (coronavirus) outbreak; and (n) changes in trading conditions. No assurance is provided that future dividend payments will match or exceed previous dividend payments. All forward-looking statements contained in this document are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional risk factors that may affect future results are contained in Royal Dutch Shell's Form 20-F for the year ended December 31, 2019 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward-looking statements contained in this document and should be considered by the reader. Each forward-looking statement speaks only as of the date of this document, 5 January 2021. Neither Royal Dutch Shell plc nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this document.

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List of Acronyms

Acronym	Definition
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHO	Australian Hydrographic Office
AHTS	Anchor Handling Tug Supply Vessel
AIS	Automatic Identification System
ALARP	As low as reasonably practicable
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment Conservation Council
APPEA	Australian Petroleum Production & Exploration Association Limited
ASV	Accommodation Support Vessel
AusSAR	Australian Search and Rescue
BAT	Best Available Technology
Bbl	Barrels
BIAs	Biologically Important Areas
BOD	Biological oxygen demand
BOP	Blowout Preventer
BTEX	Benzene, toluene, ethylbenzene, xylenes
BTU	British Thermal Unit
CAMBA	China-Australia Bilateral Agreement on the Protection of Migratory Birds
CHARM	Chemical Hazard Management Risk Management
CMT	Crisis Management Team
CO	Carbon monoxide
CO_2	Carbon dioxide
COLREGS	International Regulations for Preventing Collisions at Sea 1972
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTA	Cable Termination Assembly
CW	Cooling Water
DAFF	Department of Agriculture, Fisheries and Forestry (now known as the Department of Agriculture, Water and the Environment)
DAWE	Department of Agriculture, Water and the Environment (represents the former Department of Agriculture and Department of Environment and Energy)
DoEE	Department of Environment and Energy (now known as the Department of Agriculture, Water and the Environment)
dB	Decibels

DBCA	Department of Biodiversity, Conservation and Attractions (WA)
DC	Drill centre
DEWHA	Department of Environment Water Heritage and Arts (formally DEH, Department of Environment and Heritage)
DMIRS	Department of Mines, Industry Regulation and Safety (WA)
DMR	Double mixed refrigerant
DP	Dynamic positioning
DPIRD	Department of Primary Industries and Regional Development (WA)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
DVA	Direct vertical access
EAAF	East Asian-Australasian Flyway
ECE	Environmentally Critical Elements
ECU	Electrochlorination Unit
EDG	Emergency Diesel Generators
EEZ	Exclusive economic zone
EGR	External and Government Relations
EIS	Environmental Impact Statement
ENVID	Environmental Risk Identification
EP	Environment Plan
EPO	Environmental Performance Outcome
EPS	Environmental Performance Standard
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
ERP	Emergency Response Plan
ERT	Emergency Response Team
ESD	Ecological Sustainable Development
EUL	Environment Unit Lead
FID	Final Investment Decision
FIM	Fountain Incident Management
FLNG	Floating Liquefied Natural Gas
FO	Fibre optic
FRC	Fast rescue craft
FWAD	Fixed Wing Aerial Dispersant
GHG	Greenhouse gas
HEMP	Hazards and Effects Management Process
HFO	Heavy Fuel Oil
HLIV	Heavy Lift Installation Vessel
HOCNF	Harmonized Offshore Chemical Notification Format
HSE	Health, Safety and Environment

HSSE and SP	Health, Security, Safety, Environment and Social Performance
ICS	Incident Command System
IFC	International Finance Corporation
IFO	Intermediate Fuel Oil
IOPP	International Oil Pollution Prevention
IMO	International Maritime Organisation
IMR	Inspection, Maintenance and Repair
IMS	Invasive Marine Species
IMT (W)	Incident Management Team West
IPEICA	The International Petroleum Industry Environmental Conservation Association
ISPP	International Sewage Pollution Prevention
ISVs	Infield Support Vessels
ITF	Indonesian Throughflow
IUCN	International Union for the Conservation of Nature
JAMBA	Japan-Australia Bilateral Agreement on the Protection of Migratory Birds
KEFs	Key Ecological Features
LNG	Liquefied Natural Gas
LOC	Loss of containment
LOWC	Loss of well containment
LPG	Liquefied Petroleum Gas
LQ	Living quarters
LWI	Light well intervention
MAE	Major Accident Events
MARPOL	The International Convention for the Prevention of Pollution from Ships, adopted by the International Conference on Marine Pollution, convened by IMO, 1973/78.
MBP	Mixed bed polisher
MC	Measurement criteria
MEG	Mono-ethylene Glycol
MFO	Marine fauna observer
MGC	Marine growth covers
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MNES	Matters of National Environmental Significance
MoC	Management of Change
MODU	Mobile Offshore Drilling Unit
MOPO	Manual Of Permitted Operations
MOU	Memorandum of Understanding

MPPE	Macro Porous Polymer Extraction
MPV	Multi-Purpose Vessel
MS	Management System
MSL	Mean Sea Level
MW	Mega watt
NEPM	National Environment Protection Measures
NGO	Non-Government Organisations
Nm	Nautical mile
NMR	North Marine Region
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NORM	Naturally Occurring Radioactive Materials
NO_x	Nitrogen oxides, typically expressed as NO_2
NPI	National Pollutant Inventory
NT	Northern Territory
NT DENR	Northern Territory Department of Environment and Natural Resources
NT DIPL	Northern Territory Department of Infrastructure, Planning and Logistics
NWMR	North West Marine Region
NWS	North West Shelf
OCNS	Offshore Chemicals Notification Scheme
ODS	Ozone depleting substances
OGP	Oil and Gas Producers
OIE	Offset Installation Equipment
OIM	Offshore Installation Manager
OPEP	Oil Pollution Emergency Plan
OPGGS (E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPRC 90	International Convention on Oil Pollution Preparedness, Response and Cooperation 1990
OSMP	Operational and Scientific Monitoring Plan
OSPAR	Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic
OWR	Oiled Wildlife Response
PAH	Polycyclic Aromatic Hydrocarbon
PFW	Produced Formation Water
PLET	Pipeline End Termination
PLONOR	Poses Little or No Risk
PM	Particulate matter

PMR	Pre-cool mixed refrigerant
PMST	Protected Matters Search Tool (EPBC Act)
PNEC	Predicted no effect concentration
POB	Persons on Board
POP	Persistent Organic Pollutant
PPM	Parts per million
PPT	Parts per trillion
PSV	Platform Supply Vessel
PSZ	Petroleum Safety Zone
PTS	Permanent threshold shift
PTW	Permit to work
PW	Produced Water
RAM	Risk Assessment Matrix
RBM	Riser Base Manifold
RFSU	Ready for Start-Up
RIH	Run in hole
ROV	Remotely Operated Vehicle
ROKAMBA	The Republic of Korea Migratory Birds Agreement
SCAT	Shoreline clean up assessment technique
SCE	Safety Critical Elements
SCM	Subsea control module
SCSSV	Surface Controlled Sub-Surface Safety Valve
Shell	Shell Australia Pty Ltd
SEWPAC	Department of Sustainability, Environment, Water, Population and Communities
SFRT	Subsea First Response Toolkit
SG	Specific gravity
SGG	Synthetic greenhouse gases
SID	Subsea Intervention Device
SIRT	Subsea Incident Response Toolkit
SIMA	Spill impact mitigation assessment
SIMOPs	Simultaneous Operations
SOLAS	International Convention for the Safety of Life at Sea 1974
SOPEP	Shipboard Oil Pollution Emergency Plan
SO_2	Sulphur dioxide
SSD	Species Sensitivity Distribution
SSDI	Subsea dispersant injection
SURU	Start-up Ramp-up
TACL	Threshold Activity Concentration Limits
TEC	Threatened Ecological Communities

tpa	Tonnes per annum
tpd	Tonnes per day
TMS	Turret Mooring System
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TTS	Temporary Threshold Shift
UTA	Umbilical termination assemblies
VOC	Volatile Organic Compounds
WA	Western Australia
WA DoT	Western Australia Department of Transport
WB	World Bank
WCVERT	Well Control Virtual Emergency Response Team
WET	Whole Effluent Toxicity
WHA	World Heritage Area
WOMP	Well Operations Management Plan
WRFM	Well, Reservoir and Facility Management (WRFM)
XT	Xmas tree for wellheads
ZPI	Zone of potential impact

13.0 Appendix A: Detailed Facility Description

13.1 Gas Process Facilities

Feed from the turret enters feed gas receiving and condensate stabilisation (Unit 10000). The gas, condensate and water phases are separated in two trains of inlet HP separators and one low pressure separator. The aqueous phase is routed for processing either in MEG regeneration (Unit 52000) or water treatment (Unit 64000). The separated field condensate is stabilized in the condensate stabilizer and sent to condensate storage (Unit 33000). The separated gas is routed to the Acid Gas Removal Unit (AGRU, Unit 11000). The feed gas receiving unit is also provided with depletion compression facility to compress the inlet gas once the reservoir pressure is reduced.

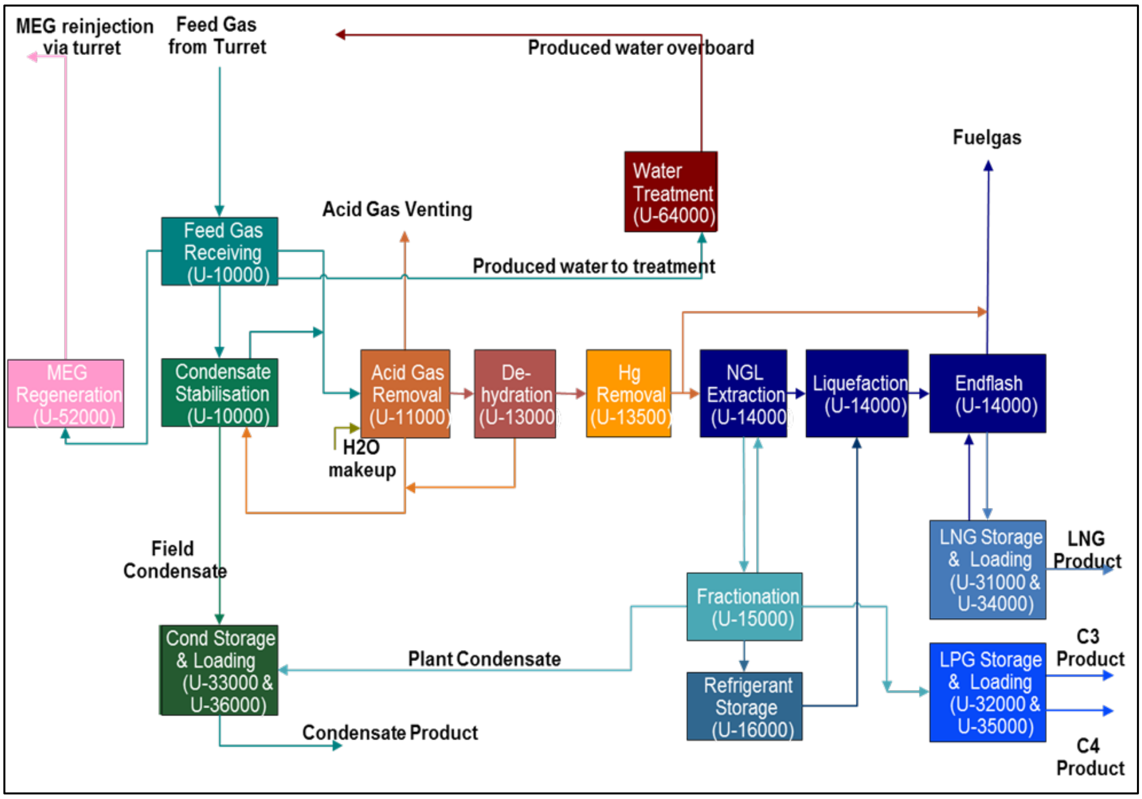


Figure 13-1: FLNG Process Unit Block Diagram

The AGRU removes the acid gases (CO_2, traces of H_2S and mercaptans) from the feed gas by contact with a lean amine based solvent stream. The resulting rich amine is then regenerated and the separated CO_2 rich acid gas stream is routed for safe venting. The sweet gas passes through the dehydration (Unit 13000) unit for removal of moisture and mercury removal (Unit 13500) unit for removal of mercury. The sweet, dry and impurity free gas then enters Unit 14000 consists of NGL extraction, liquefaction and end flash.

Natural Gas Liquid (NGL) within the feed gas stream is separated in the NGL extraction column. The separated NGL is routed to Unit 15000, fractionation, and the natural gas is sent to the liquefaction section of Unit 14000. The natural gas is pre-cooled and then liquefied using closed loops of pre-cooled mixed refrigerant (PMR) and mixed refrigerant (MR). The produced LNG is let down to close to atmospheric pressure in a turbo expander, before being routed to an end flash column. The resulting atmospheric LNG stream is gravity rundown to storage in Unit 31000 and the end-flash gas produced is compressed for use as fuel gas (Unit 44000).

Within the fractionation Unit 15000, the NGL is separated into ethane, propane, butane and condensate streams. The ethane stream is either: re-injected into the liquefaction unit, routed as vapour for use as fuel gas, or stored in refrigerant storage tank in Unit 16000 as a make-up to the refrigerant loop. Commercial grade propane and butane are produced and routed to LPG storage in Unit 32000. Provision is made to re-inject LPG to liquefaction unit as required. Pure Propane is stored in dedicated refrigerant storage tank in Unit 16000 as a make-up to the refrigerant loop. The plant condensate stream produced from the fractionation unit (U15000) is combined with the field condensate from Unit 10000 and routed to condensate storage Unit 33000. LNG and LPG products are offloaded to ship tankers by side by side offloading in Unit 34000 and 35000, whereas the produced stabilized condensate is offloaded tandem to the condensate tanker by using hose reel in Unit 36000.

The majority of the process facilities are located on the topsides, with some facilities such as tank storages and loading pumps located within the substructure.

13.2 Pressure Relief System

The purpose of the pressure relief and liquid disposal systems (U63000) is to collect and safely dispose of hydrocarbon-containing vapour and liquid streams that are released during start-up, shutdown, venting, draining, upsets, maintenance and emergency situations. The pressure relief system composes of:

- **Dry Flare System -** comprising of a HP system which protects primarily process equipment and a LP system which provides relief for storage tanks.
- **Wet Flare System -** comprising of a HP system which protects primarily process equipment and a LP system which provides relief for storage tanks.
- **Acid Gas Vent** - where CO_2 extracted from the gas is vented to atmosphere.
- **Marine Vent** - final pressure protection for the condensate and cryogenic tanks. It is not expected that significant GHG emissions will be emitted from the Marine Vent which has a flow meter.
- **Maintenance Vent -** final pressure protection for the condensate and cryogenic tanks during maintenance activities on the flare system. The maintenance vent is located in a different area to the main flare, to allow for safe maintenance on the flare system in the event of a gas release through the maintenance vent. The maintenance vent is also used during maintenance of the tanks (e.g. warming up, purging, aerating and gassing-up procedures). It is not expected that significant GHG emissions will be emitted from the Maintenance Vent which has a flow meter.

13.3 Steam, Power Generation & Condensate Recovery

Prelude Steam and Power Generation and Distribution design is based on a steam cogeneration system to supply services to the FLNG facility at the required quality, availability and reliability during all operation modes. Since the plant is an offshore unit, the power generation system is based on a stand-alone operation. The purpose of Steam and Power Generation and Distribution System (Unit 40000) is to generate electricity in the plant and supply heat in the form of steam to generate power.

Prelude total design power requirement is 74.9 (64.9+10) MW including the thrusters. Total design steam requirement is around 1300 tons/hr. Based on this total, 7 (6+1) steam generator boilers are installed on the topsides, each with a Maximum Continuous Rating (MCR) of 220 tons/hr capacity. The main electrical power generation is produced by 3 (2+1) steam turbine generators of 40 MW Extraction/Condensing Steam Turbines. Steam turbine generators are supplied with HP Steam directly from Marine Steam Boilers to produce electricity for all the process and non-process electrical consumers.

In addition to the main power generation, three Essential Marine Diesel Generators (EDG), (3 x 7.68 MW), are on stand-by during normal operations. The function of these EDGs include providing power to critical instrumentation load during process shut down.

Emergency power is provided by two SOLAS designated emergency generator sets (A-40210) having capacity 1250kw, located aft, supplemented by (A-40220) emergency generator having capacity 750kw, located forward for secondary refuge power.

Autonomy of the Emergency power generator is 24hr in accordance with SOLAS requirements in order to supply electricity to SOLAS critical equipment (e.g. control and safety systems, Navigational aids, Communications used in emergency, Emergency lighting; and Fire-fighting foam pumps).

In addition, uninterruptible power supply (UPS) supplies for a limited amount of time systems such as the DCS, HVAC system, telecommunications, navigational aids or other vital systems.

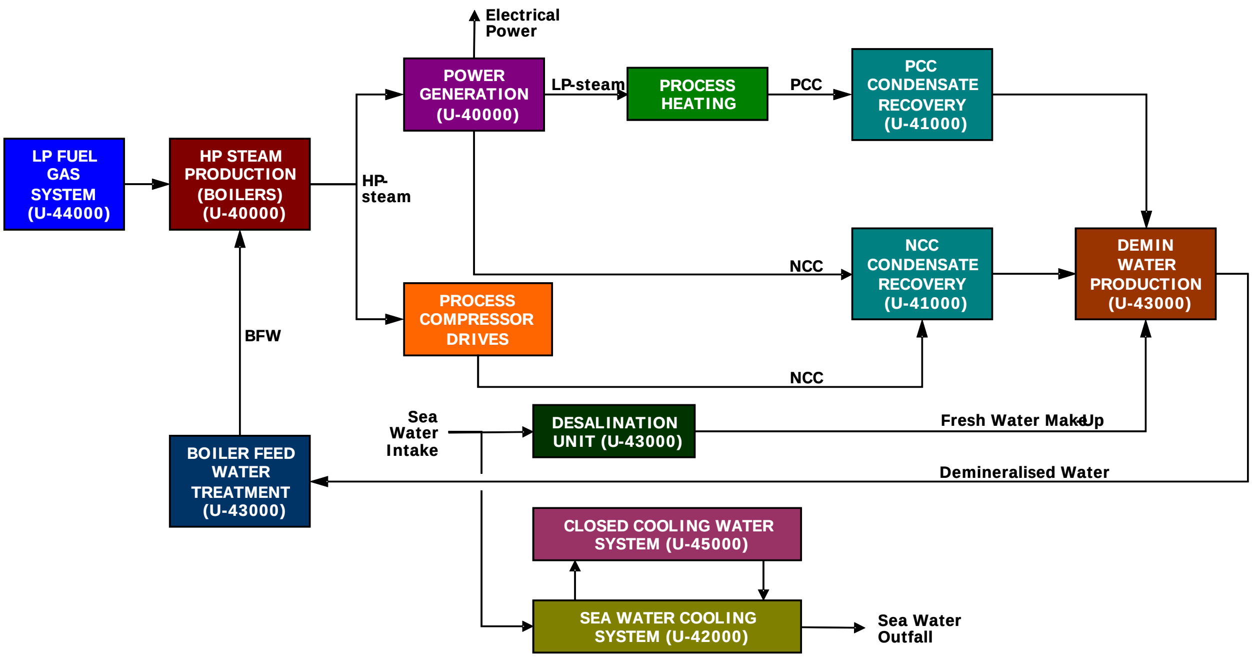


Figure 13-2: Prelude Utility Concept and Block Scheme

Fuel Gas System

Fuel Gas System Unit U-44000 is designed to collect different sources of process gases, to heat them via heater and mix them in order to supply fuel gas to identified consumers at defined pressure, temperature, flow rate and quality (wet or dry). In order to improve the reliability and availability of the fuel gas to consumers, several sources of process gas are provided to the unit with available back-up sources. Dry fuel gas is used as purge to dry flare and blanketing of LNG/LPG tanks. Whereas the mixed fuel gas is used for the boilers, purge to wet flare and blanketing of condensate tanks.

Total fuel gas design demand for Prelude is about 97tons/hr corresponding to the total required HP steam production for the operation of 6 boilers. In addition to fuel gas requirements for steam boilers, 80kg/hr of continuous fuel gas is accounted for all flare pilot burners consumption.

Diesel System

Diesel fuel is used for backup power generation in case of non-availability of fuel gas. The design of the diesel oil system includes receipt through diesel bunker, store, treat and distribute low Sulphur diesel oil to various consumers in the Hull and Topsides and to occasionally refuel the supply boats.

Diesel fuel is transported by a supply boat and transferred through hose reel (or alternatively through a secondary diesel oil loading station located at the aft deck boarding) via the diesel filter and a bidirectional metering unit to the storage tanks.

Four diesel storage tanks, each with 750m^3 storage volume have been provided for diesel storage in the FLNG's substructure. The Essential diesel generators, aft fire water pump and aft emergency diesel generator have their own day storage tanks. Similarly, the forward Emergency diesel generator and forward fire water pump have their day storage tanks for storing the diesel oil.

13.4 Seawater Cooling & Essential Seawater Cooling System

The Sea Water Cooling Systems 2, 3 and 4 (U42000) and Essential Sea Water Cooling System 1 (U42500) are to provide sea water for cooling of the following systems:

- Essential Diesel Generators Closed Cooling Water loops, by Essential Sea Water Cooling System 1 (SW1)
- Closed cooling water 2 loop, by Sea water cooling system 2 (SW2)
- Closed Cooling Water 3 loop, by Sea Water Cooling System 3 (SW3)
- Steam Turbine Generators condensers, by Sea Water Cooling System 4 (SW4).

The purpose of the Essential Closed Cooling Water System 1 (CCW1) is to provide the continuous cooling water to the Essential Diesel Generator packages. The purpose of Closed Cooling Water System 2 (CCW2) is to provide cooling water for cooling requirement of the topsides process users of the FLNG facility. The purpose of Closed Cooling Water System 3 is to provide the cooling requirement of HVAC, IA compressors and dryers, hydraulic power units, electrical users, STG auxiliaries, thrusters, steam/condensate system users, and HP Nitrogen Compressor.

13.5 Water Distillation

The purpose of Seawater Distillation, Service Water, Potable Water, Demineralisation Water Storage and Boiler Feed Water Facilities (Unit U43000) is:

- To supply water in the form of:
  - Potable Water to its respective users
  - Service Water for utility stations and hose connection
  - Make-up water for steam and condensate systems losses and for mixed beds
  - Regeneration.
- To treat Potentially Contaminated Condensate with Heavy Hydrocarbons (PCH).
- To supply de-mineralized water (DMW) to its respective users.
- To supply Boiler Feed Water (BFW) to boilers and de-superheating water to its respective users.

Seawater Distillation

The seawater distillation system removes salts from seawater to produce desalinated water. The produced distillate is then distributed to the service and potable water facilities and as make-up water for replacement of condensate and steam losses.

As the seawater is chlorinated to limit marine growth in the system it must be de-chlorinated prior to entering the distillation units to prevent contamination. The seawater is vaporised and the resulting distillate is cooled and routed to downstream users. The brine produced from the distillation process is routed overboard.

To clean the unit and remove the scale which has not been eliminated by the continuous feed water chemical treatment, an acid cleaning of the unit is performed using a weak acid (sulfamic acid or equivalent). The weak acidic solution remaining after cleaning is sent to the neutralisation tank to be neutralised before being discharged to the sea.

Desalinated water from the distillation unit is re-mineralised in a hardener bed to produce potable water.

Demineralised and Boiler Feed Water Facilities

The demineralised and BFW facilities are provided to generate water with the required specification to allow for HP steam generation. Impure water will cause corrosion and scaling in the steam system and cause unnecessary downstream intervention and maintenance.

Power generation is based on a steam cogeneration system. Electrical power generation is by STGs. Heat is supplied by marine boilers fed with BFW to produce HP steam. The steam is then routed to downstream process and non-process users. The resulting steam condensation are treated to produce demineralised water which is then used as BFW.

To produce de-mineralised water (DMW) of the desired specification, mixed bed exchange polishers (two in operation, one stand-by/regeneration) are provided. The DMW further passes through three spray type de-aerators to produce boiler feed water. The BFW is then pumped to the boilers. BFW is also used as medium for de-superheating and turbine washing. After BFW has been used for boiler operations, boiler blowdown is discharged to sea with flashed steam.

There is a neutralisation tank associated with the mixed bed polisher (MBP) regeneration process, which is a water treatment package prior to being fed into the boiler feed water tank. The MBP regeneration process uses acid (HCl) and base (NaOH) to remove anions and cations from the beads in MBP unit. This regeneration waste liquid is then sent to the neutralisation tank for treatment ('pH neutralisation') before being discharged to sea. The neutralisation tank recirculation line and discharge lines also have an online analyser and alarm systems set on them which measures pH.

13.6 Electro-chlorination Unit

The Unit 46000 Seawater Fouling Inhibition is also known as electro chlorination unit. The function of the Electro chlorination unit is to generate, store and inject sodium hypochlorite into following systems containing seawater:

- Cooling sea water circuits to protect equipment against bio-fouling (SW2 intake risers, SW1/SW3/SW4 sea chest intakes)
- Seawater Distillation Packages A-43010/43020/43030 seawater intake
- Firewater pumps P-60001A/B and firewater jockey pumps P-60002/P-63003 circuits
- Diesel firewater pumps P-60000 A/B sea chests.

By using the process of electrolysis of seawater, the sodium hypochlorite required to treat the seawater can be produced from the seawater itself. This is achieved by passing a quantity of seawater through an electrolyser cell and applying a DC current across the cell. The resulting electrolytic reaction produces sodium hypochlorite and hydrogen.

Continually dosing into seawater systems at low concentrations effectively prevents organic and bacteriological (mussels, barnacles and sea anemones) growth which could cause fouling/plugging or corrosion in the system. However over a period of time microorganisms (bacteria, slime and algae) can become chlorine resistant therefore an intermittent (once or twice a day) shock dose at a higher concentrations is required.

Local generation onboard removes the need to import and store large quantities of sodium hypochlorite solution.

On rare occasions such as during maintenance or shutdown periods, not all seawater systems on the FLNG will be in operation. When the seawater systems are not operational, the ECU will continue to generate hypochlorite that will be disposed to sea for example via the sea chests. This is also the case for the firewater sea chests where any excess hypochlorite will be discharged to sea if the firewater systems are not in operation.

13.7 Mono-ethylene Glycol (MEG) System

The purpose of the MEG unit U52000 is to concentrate and reclaim rich MEG coming from Produced Water Treatment Unit (U64000) prior to reinjection into subsea facilities or topsides for hydrate prevention. Lean MEG is injected intermittently to the subsea facilities during following cases. The first four of these cases make up the primary use of MEG during SURU and normal operations:

- Before a planned shutdown
- When plant is down after any planned or unplanned shutdown (at each well)
- During any start-up

- During adverse weather, to pre-treat flow lines in the event of an unplanned shutdown
- During gas sweeping operations (before start-up)
- For well annulus management, during normal operation.

Lean MEG is also injected topsides in the inlet facilities (U10000) for hydrate prevention in the flare lines.

For rich MEG storage, there are two tanks in the substructure with a capacity of 6000 m3 each and one forward rich MEG tank with a capacity of 2000 m3. The MEG regeneration system has a design capacity to regenerate about 30 m3/day at 20 wt % rich MEG.

13.8 Effluent Treatment and Disposal System

Prelude Effluent and Waste Treating and disposal U64000 is divided into three main sections, each with different objectives:

- Degassing section
- Hydrocarbon extraction section, Macro Porous Polymer Extraction (MPPE)
- Disposal section.

The inlet facilities U10000 receive produced water (PW) from production wells. This produced water along with oily contaminated streams from other units is routed to U64000, on either continuous or intermittent basis as indicated below:

Continuous produced water flow is from inlet facilities U10000:

- Produced water from LP separators
- Condensate stabilizer draw vessel.

The following intermittent streams are routed to the water treatment unit:

- Water from sand handling package (A-10010)
- Wash water bleed from AGRU solvent regeneration reflux pumps
- Dehydration unit regeneration water (U13000)
- Contaminated steam condensate from PCL and PCH collection headers (U41000)
- Clean Slop tank
- Produced water from MEG Regeneration and Reclaiming package A-52010.

The degassing section refers to the section between produced water inlet and produced water buffer tank. This first section collects produced water and other effluents from several sources and achieves their degassing, primary hydrocarbon removal and cooling. This section includes Produced Water Flash Gas Package (A-64030), Produced Water Cooler (E-64001A/B/C) and a Produced Water Buffer Tank (T-64001). The inlet produced water streams are first routed to a water flash gas vessel where the pressure is reduced to the LP wet flare operating pressure. This degasses the dissolved hydrocarbon in the produced water inlet streams. The degassed stream is then cooled to 34ºC by the produced water cooler; this is the optimum operating temperature for the downstream Macro Porous Polymer Extraction (MPPE). The water is stored in a buffer tank, before being processed in the MPPE unit.

Pumps from the produced water buffer tank transfer water with traces of hydrocarbon to the hydrocarbon extraction section i.e. the MPPE package (A-64010). One MPPE package (A-64010) is designed to remove dispersed and dissolved hydrocarbons from the water via extraction. After treatment, the treated water is checked to ensure specifications for overboard discharges are satisfied. To meet the oil discharge limit, the MPPE system removes dissolved and dispersed hydrocarbons from the feed water by means of extraction in a MPPE bed.

The unit consists of four columns (two in service: one in extraction mode and one in regeneration mode, and two in stand-by) containing a packed bed of macro porous polymer extraction material which is oleophilic and hydrophobic. Two spared columns located within the package allow for the change-out of the extraction columns for onshore regeneration. Each column will have its installed spared column with a set of manual valves to allow operator manual change over. It runs continuously to treat water from produced water buffer tank. It can also receive off-spec water from Clean Slop tanks via the produced water tank. Clean water from the Slop Tanks is normally discharged overboard to sea under oil in water content monitoring. However, in case concentrations exceed specified discharge limits, the overboard discharge is ceased, and oily water is routed to the Produced water buffer tank after recycle within slop tanks. During the column regeneration phase, very low pressure steam is used to evaporate the components from the macro porous polymer extraction material, resulting in a vapour flow of mixed hydrocarbons and steam. The vapour is routed through a condenser where condensation of both steam and hydrocarbons takes place by cooling with closed cooling water (CCW3). The extracted hydrocarbon (BTEX rich) as a by-product is collected in the overhead vessel, which is pumped back to the hydrocarbon condensate streams at the upstream of rundown cooler in U10000.

The treated water is monitored for oil content and reprocessed if found off-spec. The on-spec water is routed overboard for disposal to the sea.

13.9 Drains

The intent of the drain system is to provide a safe and environmentally acceptable method of collecting and disposing of:

- Cleaning water
- Recyclable liquid hydrocarbons as oily water
- Separately collected “other” liquids handled on the FLNG.

The drain systems are segregated into different zones and separate systems to avoid cross contamination, thus allowing for more efficient, safer spill and drain management taking into account:

- Cryogenic modules and fluids
- Non-Hazardous areas and fluids
- Hazardous areas and fluids.

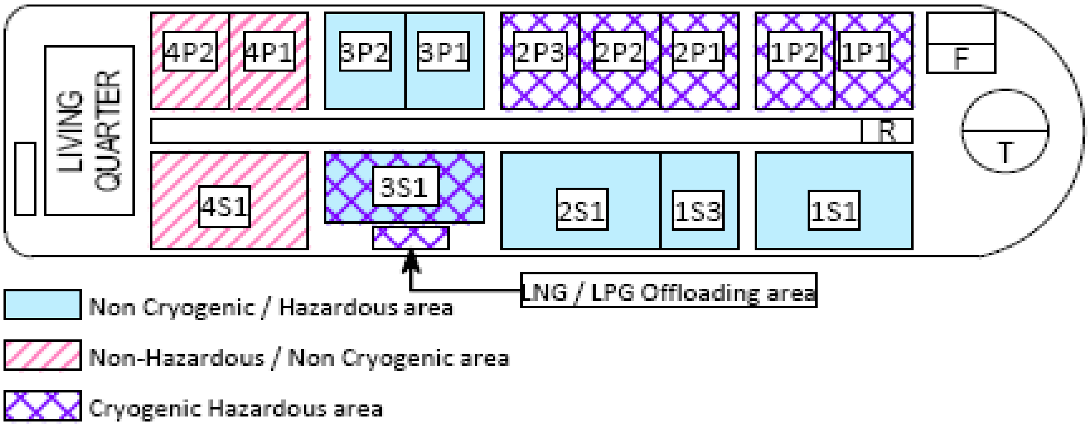


Figure 13-3: Drainage Zone Areas

Open Drains

The open drain system is composed of several segregated sub-systems, each with a different function and hierarchy. The open drains systems (U65000) are used only after unit depressurization for maintenance works and are also used to collect rain water, firewater deluge, washing water and lube oil leaks from drip trays of equipment. The intent of the open drain system is not to collect the liquid products during emptying of the connected hydrocarbon processing system. There is no hard piping connected from process equipment to the open drain system. The open drain material is either treated in effluent water treatment unit or reprocessed in U10000 or stored in dirty Slop/ bilge tank. The open drain systems include the;

- Open Hazardous Drain System (OHD)
- Open Non-Hazardous Drain System (OD)
- Open Chemical Drain System (OCD)
- Open Steam Condensate Drain System (OSD)
- Open Bilge Drain (OBD).

The Open Hazardous Drain system (OHD) and Open Non-Hazardous Drain System (OD), drain headers are sloped towards the respective open drain vessels. The fluids from the drip trays and tundishes are gravity-fed into the open drain vessels where oily water is separated and transferred to the Slop /bilge tanks respectively.

In the hazardous areas drains system, any oil/accidentally oil contaminated water is sent to the Dirty Slop tanks via the Open Hazardous Drain pumps. Oil Discharge Monitoring Equipment (ODME) is provided to monitor oil/condensate content in water before being discharged overboard from Clean Slop tanks. In case of off-spec water stream, the recirculation valve is open to return the off-spec stream back to Dirty Slop tanks, or to MPPE package for treatment. Open non-hazardous area drains are completely segregated from any other open or closed drain system to avoid hydrocarbon vapour transmission from one drain to a nonhazardous one.

The Open Chemical Drain (OCD) system collects chemical spills from open drip trays and tundishes from topsides process modules, main deck and turret area. Drip pans in

U50000 (Chemical Injection), U11000 (Acid Gas Removal Unit) and U52000 (MEG Regeneration Unit) are connected to both the open bilge drain header and open chemical drain header. The chemical spills drain header from hazardous and nonhazardous areas are segregated. The chemical spills drain header from the hazardous areas are sloped towards the Chemical Spills Collection tank. Collected chemicals are pumped via Chemical Spills Collection pump to portable containers (tote tanks) before onshore treatment.

The open steam condensate drain system (OSD) is provided to collect the Steam Condensate from the steam traps of the Steam Turbine, from the drip holes (located on Relief Valve discharge lines), from the silencers lines and from the level instruments.

The Open Bilge Drains System (OBD) covers the open drains facilities on the Main Deck (e.g. Aft/Forward Coamings, exposed deck scupper system, etc.), void space, insulation space (IS), cofferdam (C/D), bunker stations and machinery space. The liquid collected is drained by gravity and discharged closed to pneumatic pumps and then pumped to the dirty Slop Tanks (for hazardous areas) or dirty bilge tanks (for nonhazardous areas). However, the cofferdam bilges is routed to the dirty slop tanks.

Closed Drains

Two closed systems exist for the HC drainage, which divert liquids to the flare system (U63000). These closed drains are used for emptying vessel inventories after depressurisation and prior to maintenance. The closed systems are:

- Closed hydrocarbon Drain (CD)
- Cryogenic Drain (CRD).

All deck areas where there is a risk of cryogenic/LPG spill hazard are freely drained directly overboard. This is to avoid the risk of explosive clouds when cryogenics/LPG spills vaporise. The primary steel structure is protected from cryogenic spills by suitable coatings. Equipment and piping in cryogenic service have minimum flanges and maximum welded connections. However, cryogenic protection on the main deck is provided on location where there is high volume of cryogenic liquid is handled e.g. offloading area, 3S1 based on the cryogenic spill risk assessment.

14.0 Appendix B: EPBC Act Protected Matters Reports

This appendix consists of two reports issued by the Australian Government Department of the Environment and Energy (renamed to Department of Agriculture, Water and the Environment at the time of submission of this EP):

- EPBC Act Protected Matters Report, Report created: 27/02/19 08:09:05 (13 pages)
- EPBC Act Protected Matters Report, Report created: 03/09/19 15:03:57 (33 pages)

Australian Government
Department of the Environment and Energy

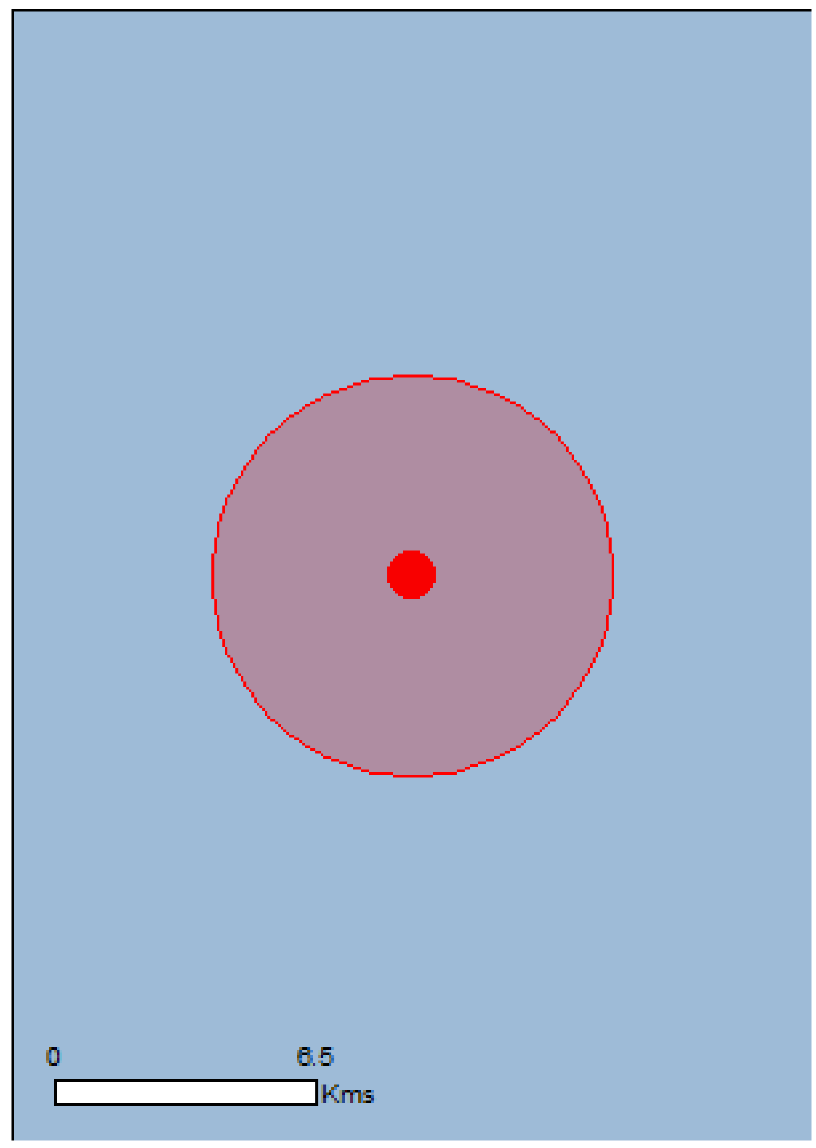
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

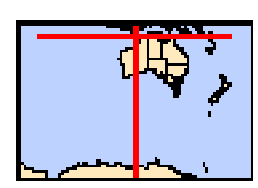
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 27/02/19 08:09:05



Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	19
Listed Migratory Species:	31

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	59
Whales and Other Cetaceans:	22
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat may occur within area
Anous tenuirostris melanops		
Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
[Fregata ariel](#) Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
[Fregata minor](#) Great Frigatebird, Greater Frigatebird [1013]		Foraging, feeding or related behaviour likely to occur within area
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
[Papasula abbotti](#) Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Fish		
[Bhanotia fasciolata](#) Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
[Campichthys tricarinatus](#) Three-keel Pipefish [66192]		Species or species habitat may occur within area
[Choeroichthys brachysoma](#) Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
[Choeroichthys suillus](#) Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
[Corythoichthys amplexus](#) Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
[Corythoichthys flavofasciatus](#) Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
[Corythoichthys intestinalis](#) Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
[Corythoichthys schultzi](#) Schultz's Pipefish [66205]		Species or species habitat may occur within area
[Cosmocampus banneri](#) Roughridge Pipefish [66206]		Species or species habitat may occur within area
[Doryrhamphus dactyliophorus](#) Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
[Doryrhamphus excisus](#) Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
[Doryrhamphus janssi](#) Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
[Filicampus tigris](#) Tiger Pipefish [66217]		Species or species habitat may occur within area
[Halicampus brocki](#) Brock's Pipefish [66219]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area

Name	Status	Type of Presence
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Extra Information

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-13.78637 123.31754

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Australian Government
Department of the Environment and Energy

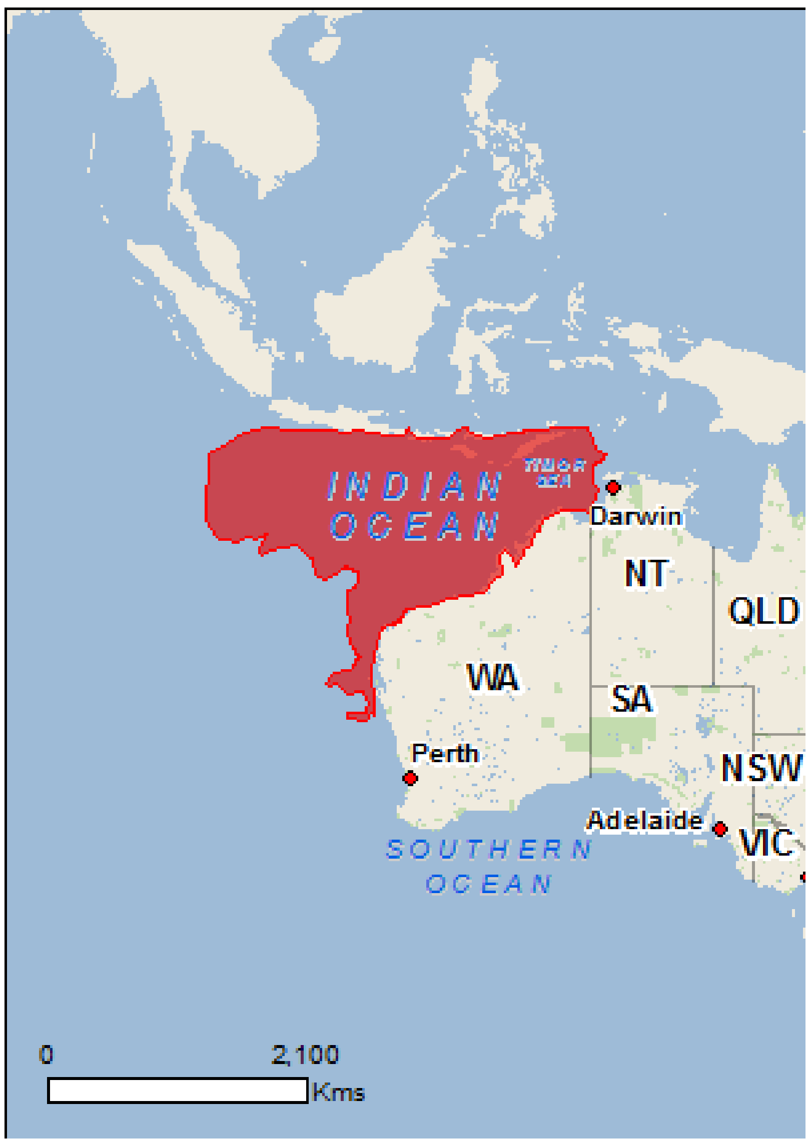
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

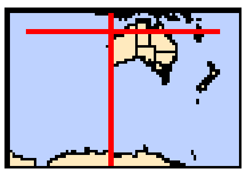
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 03/09/19 15:03:57



Coordinates
Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	2
National Heritage Places:	6
Wetlands of International Importance:	5
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	100
Listed Migratory Species:	99

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	9
Commonwealth Heritage Places:	18
Listed Marine Species:	195
Whales and Other Cetaceans:	34
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	1
Australian Marine Parks:	31

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	63
Regional Forest Agreements:	None
Invasive Species:	38
Nationally Important Wetlands:	15
Key Ecological Features (Marine)	20

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Shark Bay, Western Australia	WA	Declared property
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
Shark Bay, Western Australia	WA	Listed place
The Ningaloo Coast	WA	Listed place
The West Kimberley	WA	Listed place
Indigenous		
Dampier Archipelago (including Burrup Peninsula)	WA	Listed place
Historic		
Dirk Hartog Landing Site 1616 - Cape Inscription Area	WA	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Ashmore reef national nature reserve	Within Ramsar site
Eighty-mile beach	Within Ramsar site
Hosnies spring	Within Ramsar site
Roebuck bay	Within Ramsar site
The dales	Within Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North
North-west
South-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Accipiter hiogaster natalis		
Christmas Island Goshawk [82408]	Endangered	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Chalcophaps indica natalis Christmas Island Emerald Dove, Emerald Dove (Christmas Island) [67030]	Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Geophaps smithii blaauwi Partridge Pigeon (western) [66501]	Vulnerable	Species or species habitat likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Malurus leucopterus leucopterus White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren [26004]	Vulnerable	Species or species habitat likely to occur within area
Ninox natalis Christmas Island Hawk-Owl, Christmas Boobook [66671]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Turdus poliocephalus erythropleurus Christmas Island Thrush [67122]	Endangered	Species or species habitat likely to occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Fish		
Milyeringa veritas		
Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Ophisternon candidum		
Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies		
Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Bettongia lesueur lesueur		
Burrowing Bettong (Shark Bay), Boodie [66659]	Vulnerable	Species or species habitat likely to occur within area
Bettongia penicillata ogilbyi		
Woylie [66844]	Endangered	Species or species habitat known to occur within area
Conilurus penicillatus		
Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat known to occur within area
Crocidura trichura		
Christmas Island Shrew [86568]	Critically Endangered	Species or species habitat likely to occur within area
Dasyurus geoffroii		
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Isoodon auratus auratus		
Golden Bandicoot (mainland) [66665]	Vulnerable	Species or species habitat likely to occur within area
Isoodon auratus barrowensis		
Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus		
Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies		
Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Lagorchestes hirsutus dorreae		
Rufous Hare-wallaby (Dorre Island) [66663]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Lagostrophus fasciatus fasciatus Banded Hare-wallaby, Merrnine, Marnine, Munning [66664]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesembriomys gouldii gouldii Black-footed Tree-rat (Kimberley and mainland Northern Territory), Djintamoonga, Manbul [87618]	Endangered	Species or species habitat may occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Perameles bougainville bougainville Western Barred Bandicoot (Shark Bay) [66631]	Endangered	Species or species habitat known to occur within area
Petrogale concinna monastria Nabarlek (Kimberley) [87607]	Endangered	Species or species habitat known to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Phascogale tapoatafa kimberleyensis Kimberley brush-tailed phascogale, Brush-tailed Phascogale (Kimberley) [88453]	Vulnerable	Species or species habitat known to occur within area
Pipistrellus murrayi Christmas Island Pipistrelle [64383]	Critically Endangered	Species or species habitat known to occur within area
Pteropus natalis Christmas Island Flying-fox, Christmas Island Fruit-bat [87611]	Critically Endangered	Roosting known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Plants		
Asplenium listeri Christmas Island Spleenwort [65865]	Critically Endangered	Species or species habitat known to occur within area
Keraudrenia exastia Fringed Keraudrenia [66301]	Critically Endangered	Species or species habitat known to occur within area
Pneumatopteris truncata fern [68812]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Tectaria devexa [14767]	Endangered	Species or species habitat likely to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Cryptoblepharus egeriae Christmas Island Blue-tailed Skink, Blue-tailed Snake-eyed Skink [1526]	Critically Endangered	Species or species habitat likely to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Cyrtodactylus sadleiri Christmas Island Giant Gecko [86865]	Endangered	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Egernia stokesii badia Western Spiny-tailed Skink, Baudin Island Spiny-tailed Skink [64483]	Endangered	Species or species habitat known to occur within area
Emoia nativitatis Christmas Island Forest Skink, Christmas Island Whiptail-skink [1400]	Critically Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Lepidodactylus listeri Christmas Island Gecko, Lister's Gecko [1711]	Critically Endangered	Species or species habitat known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Ramphotyphlops exocoeti Christmas Island Blind Snake, Christmas Island Pink Blind Snake [1262]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Breeding likely to occur within area
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to

Name	Threatened	Type of Presence
		occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur

Name	Threatened	Type of Presence
		within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat known to occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Christmas Island National Park
Defence - BROOME TRAINING DEPOT
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH VLF TRANSMITTER STATION
Defence - LEARMONTH RADAR SITE - VLAMING HEAD EXMOUTH
Defence - NORFORCE DEPOT - DERBY
Defence - RAAF BASE CURTIN
Defence - YAMPI SOUND TRAINING AREA

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Ashmore Reef National Nature Reserve	EXT	Listed place
Christmas Island Natural Areas	EXT	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place
Scott Reef and Surrounds - Commonwealth Area	EXT	Listed place
Yampi Defence Area	WA	Listed place
Indigenous		
Oombalai Area	WA	Within listed place
Historic		
Administrators House Precinct	EXT	Listed place
Bungalow 702	EXT	Listed place
Drumsite Industrial Area	EXT	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place
Industrial and Administrative Group	EXT	Listed place
Malay Kampong Group	EXT	Listed place
Malay Kampong Precinct	EXT	Listed place
Phosphate Hill Historic Area	EXT	Listed place
Poon Saan Group	EXT	Listed place
Settlement Christmas Island	EXT	Listed place
South Point Settlement Remains	EXT	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		

Name	Threatened	Type of Presence
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous minutus Black Noddy [824]		Breeding known to occur within area
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area

Name	Threatened	Type of Presence
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Pterodroma macroptera Great-winged Petrel [1035]		Foraging, feeding or related behaviour known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Puffinus assimilis Little Shearwater [59363]		Foraging, feeding or related behaviour known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Sterna albifrons Little Tern [813]		Breeding known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Stiltia isabella Australian Pratincole [818]		Roosting known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys sculptus Sculptured Pipefish [66197]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish,		Species or species

Name	Threatened	Type of Presence
Network Pipefish [66200]		habitat may occur within area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Cosmocampus maxweberi Maxweber's Pipefish [66209]		Species or species habitat may occur within area
Doryrhamphus baldwini Redstripe Pipefish [66718]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus macrorhynchus Whiskered Pipefish, Ornate Pipefish [66222]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Halicampus mataafae Samoan Pipefish [66223]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys parvicarinatus Short-keel Pipefish, Short-keeled Pipefish [66230]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippichthys spicifer Belly-barred Pipefish, Banded Freshwater Pipefish [66232]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area

Name	Status	Type of Presence
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Commonwealth ReservesTerrestrial [Resource Information]

Name	State	Type
Christmas Island	EXT	National Park (Commonwealth)

Australian Marine Parks [Resource Information]

Name	Label

Name	Label
Abrolhos	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Abrolhos	Special Purpose Zone (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Ashmore Reef	Recreational Use Zone (IUCN IV)
Ashmore Reef	Sanctuary Zone (IUCN Ia)
Cartier Island	Sanctuary Zone (IUCN Ia)
Dampier	Habitat Protection Zone (IUCN IV)
Dampier	Multiple Use Zone (IUCN VI)
Dampier	National Park Zone (IUCN II)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Gascoyne	National Park Zone (IUCN II)
Joseph Bonaparte Gulf	Multiple Use Zone (IUCN VI)
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)
Kimberley	Habitat Protection Zone (IUCN IV)
Kimberley	Multiple Use Zone (IUCN VI)
Kimberley	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Oceanic Shoals	Habitat Protection Zone (IUCN IV)
Oceanic Shoals	Multiple Use Zone (IUCN VI)
Oceanic Shoals	Special Purpose Zone (Trawl) (IUCN VI)
Roebuck	Multiple Use Zone (IUCN VI)
Shark Bay	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Adele Island	WA
Airlie Island	WA
Bardi Jawi	WA
Barrow Island	WA
Bedout Island	WA
Bernier And Dorre Islands	WA
Bessieres Island	WA
Boodie, Double Middle Islands	WA
Broome Bird Observatory	WA
Broome Wildlife Centre	WA
Browse Island	WA
Bundegi Coastal Park	WA
Cape Range	WA
Coulomb Point	WA
Dambimangari	WA
Dirk Hartog Island	WA
Jurabi Coastal Park	WA
Karajarri	WA
Lacepede Islands	WA
Lesueur Island	WA
Locker Island	WA
Low Rocks	WA
Lowendal Islands	WA
Mitchell River	WA
Montebello Islands	WA
Muiron Islands	WA
Murujuga	WA
North Turtle Island	WA
Nyangumarta Warrarn	WA
Prince Regent	WA

Name	State
Round Island	WA
Serrurier Island	WA
Swan Island	WA
Tanner Island	WA
Unnamed WA26400	WA
Unnamed WA28968	WA
Unnamed WA36907	WA
Unnamed WA36909	WA
Unnamed WA36910	WA
Unnamed WA36913	WA
Unnamed WA36915	WA
Unnamed WA37168	WA
Unnamed WA37338	WA
Unnamed WA40322	WA
Unnamed WA40828	WA
Unnamed WA40877	WA
Unnamed WA41080	WA
Unnamed WA41775	WA
Unnamed WA44665	WA
Unnamed WA44669	WA
Unnamed WA44672	WA
Unnamed WA44673	WA
Unnamed WA44674	WA
Unnamed WA44677	WA
Unnamed WA51105	WA
Unnamed WA51162	WA
Unnamed WA51497	WA
Unnamed WA51583	WA
Unnamed WA51617	WA
Unnamed WA51932	WA
Unnamed WA52354	WA
Uunguu	WA
Wilinggin	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Gallus gallus Red Junglefowl, Domestic Fowl [917]		Species or species habitat likely to occur within area
Lonchura oryzivora Java Sparrow [59586]		Species or species habitat likely to occur within area
Meleagris gallopavo Wild Turkey [64380]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus exulans Pacific Rat, Polynesian Rat [79]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus Gamba Grass [66895]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Cylindropuntia spp. Prickly Pears [85131]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Lycodon aulicus Wolf Snake, Common Wolf Snake, Asian Wolf Snake [83178]		Species or species habitat likely to occur within area
Lygosoma bowringii Christmas Island Grass-skink [1312]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
"The Dales", Christmas Island	EXT
Ashmore Reef	EXT
Big Springs	WA
Bunda-Bunda Mound Springs	WA
Cape Range Subterranean Waterways	WA
De Grey River	WA
Eighty Mile Beach System	WA
Hosine's Spring, Christmas Island	EXT
Mermaid Reef	EXT

Name	State
Mitchell River System	WA
Prince Regent River System	WA
Roebuck Bay	WA
Shark Bay East	WA
Willie Creek Wetlands	WA
Yampi Sound Training Area	WA

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Carbonate bank and terrace system of the Van	North
Pinnacles of the Bonaparte Basin	North
Shelf break and slope of the Arafura Shelf	North
Ancient coastline at 125 m depth contour	North-west
Ashmore Reef and Cartier Island and surrounding	North-west
Canyons linking the Argo Abyssal Plain with the	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Carbonate bank and terrace system of the Sahul	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Pinnacles of the Bonaparte Basin	North-west
Seringapatam Reef and Commonwealth waters in	North-west
Wallaby Saddle	North-west
Ancient coastline at 90-120m depth	South-west
Perth Canyon and adjacent shelf break, and other	South-west
Western demersal slope and associated fish	South-west
Western rock lobster	South-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-14.26314 100.97127,-9.8201 101.10456,-9.10922 102.59298,-8.28726 103.63709,-8.0651 105.36988,-8.10953 107.14709,-8.08732 109.39083,-8.08732 110.36829,-8.3539 111.19026,-8.22061 112.03443,-8.30947 113.3007,-8.48719 114.43367,-8.55384 115.41114,-7.95403 115.85544,-8.3539 116.01095,-8.66491 116.32196,-8.82042 116.8107,-8.7982 118.05475,-8.70934 118.76563,-8.15396 119.20994,-8.02067 120.00968,-8.3539 120.27627,-8.66491 121.4981,-8.62048 122.58664,-8.3539 123.27531,-8.10953 125.18582,-8.04289 126.80753,-8.02067 128.02936,-8.04289 128.87354,-8.88707 129.27341,-9.62017 129.62886,-9.86453 130.18424,-10.37548 129.80658,-10.64206 129.27341,-11.55289 129.18455,-12.06384 129.29563,-12.46371 129.56221,-13.99656 129.09569,-13.88548 128.42924,-13.86327 127.11854,-14.70744 125.58569,-15.3739 125.31911,-15.57384 124.87481,-16.3958 124.76373,-16.66238 124.16392,-17.16723 124.11563,-17.79535 123.56411,-17.35105 123.36418,-16.79567 122.76437,-17.10668 122.34228,-18.46181 122.52,-18.75061 121.9424,-19.75029 121.27595,-20.12795 118.78785,-20.48339 117.92146,-20.59447 116.94399,-20.83883 115.58886,-21.59415 115.18899,-21.99402 113.745,-23.19364 113.4562,-24.882 113.03412,-27.0813 113.25627,-27.83662 113.3007,-27.70333 113.07855,-28.23649 112.7231,-28.12541 111.39019,-27.68111 111.32355,-27.74776 112.58981,-27.03687 112.83418,-26.32598 112.45652,-26.48149 111.23469,-25.70396 110.54602,-25.99276 110.14614,-25.81503 109.72405,-25.08193 110.41272,-24.90421 111.41241,-24.10447 112.16772,-23.08257 111.56791,-22.14953 111.34576,-21.48307 111.47905,-20.90548 111.2569,-19.97244 111.34576,-19.52814 111.23469,-19.26156 111.8345,-18.95054 112.10108,-18.17301 112.10108,-17.92864 111.03475,-18.21744 110.70152,-18.72839 109.70184,-18.37295 109.03538,-17.23997 108.72437,-17.30662 108.48,-16.32915 107.52475,-16.61795 106.88051,-16.64016 105.56981,-17.08447 105.05886,-16.64016 104.85893,-15.61827 105.36988,-15.95149 104.61456,-15.84042 104.03697,-16.21808 103.215,-16.01814 102.59298,-15.92928 101.85988,-14.97403 101.23785,-14.26314 100.97127

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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15.0 Stakeholder Engagement Materials

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xx xxxx 20xx

To Whom It May Concern,

Prelude FLNG Environment Plan

The Prelude FLNG facility is an offshore development producing natural gas from a remote field approximately 475km north-north east of Broome in Western Australia and is operated by Shell in joint venture with INPEX (17.5%), KOGAS (10%) and OPIC (5%).

Shell received an accepted Environment Plan under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E) Regulations* at the end of 2016 and is now submitting a revised Environment Plan updated with the latest information collected since Prelude has commenced operating.

As part of the Environment Plan process and in accordance with Shell standards, Shell Australia continues to consult with those who may be impacted by Prelude's activities to ensure relevant persons have received sufficient information and been given a reasonable period to raise any claims or objections.

If you would like further information in relation to these activities:

- see the enclosed/attached Prelude Environment Plan Factsheet with key risks and mitigations outlined
- for a more detailed breakdown of the Prelude Environment Plan, visit www.shell.com.au/prelude
- to view the full draft copy of the Prelude Environment Plan, visit www.tbc
- to raise any claims or objections or request a face to face briefing, please contact xx, via email: xx or call: (08) 9338 xx.

Shell intend to submit the Environment Plan to NOPSEMA in early 2020. Accordingly, should you or your organisation have any further questions, or potential claims or objections, please respond within 30 days, and no later than xx date.

Yours faithfully,

Sue Beattie
Prelude Asset Manager

PRELUDE FLNG ENVIRONMENT PLAN

Prelude has been designed to operate in a way which reduces greenhouse gas emissions including:

- Locating Prelude in close proximity to the gas field eliminates the need for long pipelines to shore.
- Integrating product offloading facilities into Prelude's design avoids additional energy use for gas compression which is needed to export gas to an onshore terminal.
- Using Shell's proprietary double mixed refrigerant process ensures efficient use of power and less fuel gas demand.
- Using colder seawater from a depth of 150m, rather than surface water, reduces the need to cool the water and leads to greater LNG production using the same energy inputs.

ABOUT PRELUDE

The Shell-operated Prelude FLNG facility is a floating liquefied natural gas facility located approximately 475km north-north east of Broome in Western Australia. Prelude is the first deployment of Shell's Floating Liquefied Natural Gas (FLNG) technology, which extracts, liquefies and stores gas at sea, before it is exported to customers around the globe.

Prelude is operated by Shell in joint venture with INPEX (17.5%), KOGAS (10%) and OPIC (5%).

Location of Prelude (Permit Area WA-44-L)

Location:
WA-44-L, in Commonwealth marine waters, 475 km north-north east of Broome in Western Australia

Facility Type:
Floating liquefied natural gas (FLNG) facility

Number of wells:
Seven

Production capacity:
3.6 million tonnes per annum (mtpa) LNG, 1.3 mtpa LPG, 1.3mtpa condensate

Water depths:
250m

Status:
In operation

For further detail on the location of Prelude and safety zones, visit www.shell.com.au/prelude

FEEDBACK

Shell welcomes any feedback on the revised Environment Plan resubmission including requests to receive further information. Please contact us using the following details.

CONTACT US

Community Hotline: 1800 059 152
Email: SDA-preludeflng@shell.com
www.shell.com.au/prelude

/shell
@shell_australia

NOVEMBER 2019

www.shell.com.au/prelude

THE PRELUDE FLNG ENVIRONMENT PLAN

The Prelude Environment Plan covers the following activities within permit area WA-44-L and infrastructure license WA-2-IL:

- Operations and maintenance turnarounds of Prelude and its subsea facilities
- Operation within the designated safety zone of the installation, support, supply and in-field support vessels and helicopters required for the offshore works, commissioning & maintenance activities and operate phase
- Product offtake tankers or bunkering vessels only when they are attached to Prelude (considered as petroleum activity)
- Well intervention activities using a light well intervention vessel
- Inspections, maintenance and repairs of systems and subsea infrastructure
- Installation, commissioning and start-up activities for future tie-ins (e.g. the proposed Crux project - see www.shell.com.au/crux)
- Potential future tie-ins from within the Prelude field
- Emergency Response events

If a project scope has the potential to result in significant change to Prelude, or has potential environmental or social impacts, an assessment of whether an Environment Plan revision is required.

ENVIRONMENTAL APPROVAL

Before Shell begins substantial work on major projects or existing facilities, regulatory, environmental and social impacts are assessed, alongside commercial and technical considerations.

This process includes environmental, social and health impact assessments to help understand and manage risks and opportunities.

For Prelude's current operations, the Environment Plan was accepted by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) in 2016.

Shell plans to submit a revised Prelude Environment Plan in early 2020 for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009.*

ENVIRONMENTAL MANAGEMENT

Prelude has been designed to operate to manage environmental risks to as low as reasonably practicable (ALARP) and acceptable levels. The table below provides a summary of key environmental aspects identified for Prelude's operations. The mitigations for these environmental aspects and risks are outlined in detail at www.shell.com.au/prelude.

Risk	Summary
Physical Presence	Prelude, its supporting subsea infrastructure and additional support vessels all have a physical presence in the operating area including lighting, noise, vessel movements and seabed disturbance.
Biosecurity	Invasive Marine Species are marine animals or plants which may be transported or introduced into an environment outside of their normal habitat. The primary means of introduction is via transport on one of the service vessels which support Prelude.
Liquid Discharges	These may include: ▪ Drainage and bilge effluent ▪ Food waste, greywater and sewage ▪ Cooling water ▪ Desalination brine, boiler blowdown and mixed bed polisher effluent ▪ Produced water ▪ Use and release of chemicals in ad-hoc discharges
Atmospheric Emissions	These may include: ▪ Gas combustion for power generation and compression ▪ Flaring of gases for safety purposes ▪ Disposal (venting) of reservoir CO2 ▪ Fugitive emissions ▪ Emissions from vessels supporting the operations ▪ Power generation (using diesel fuel) for essential or emergency duties
Waste Management	Both hazardous and non-hazardous wastes are generated by Prelude and other supporting vessels. Non-hazardous wastes include domestic and industrial wastes such as: ▪ bottles ▪ paper and cardboard ▪ scrap steel Examples of hazardous wastes include: ▪ oil contaminated materials (filters, rags) ▪ empty chemical containers ▪ empty aerosol containers ▪ light tubes Other wastes include by-products of production on Prelude, like sludges and sands. In some cases, these wastes may contain mercury or low level naturally occurring radioactive materials.
Unplanned Events	This covers: ▪ Risk of an unplanned emergency event ▪ Types of loss of containment which might result in an emergency response ▪ Potential impacts on the environment; ▪ Potential impacts of clean-up activities

NOVEMBER 2019 www.shell.com.au/prelude