

CHAPTER 6

IMPACTS AND RISK



6. IMPACTS AND RISK

6.1 Introduction

An assessment of the impacts and risks associated with the proposed Browse to NWS Project has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline. This procedure and guideline set out the broad principles and highlevel steps for assessing environmental impacts and risks across the lifecycle of Woodside's activities and their management. The key steps of the Woodside impact and risk management process are:

- + the environmental impact and risk assessment
- + the communication and consultation that informs the assessment and ongoing performance
- + the steps required during implementation of the activity including to monitor, review and report.

The risk management process is shown in [Figure 6-1](#).

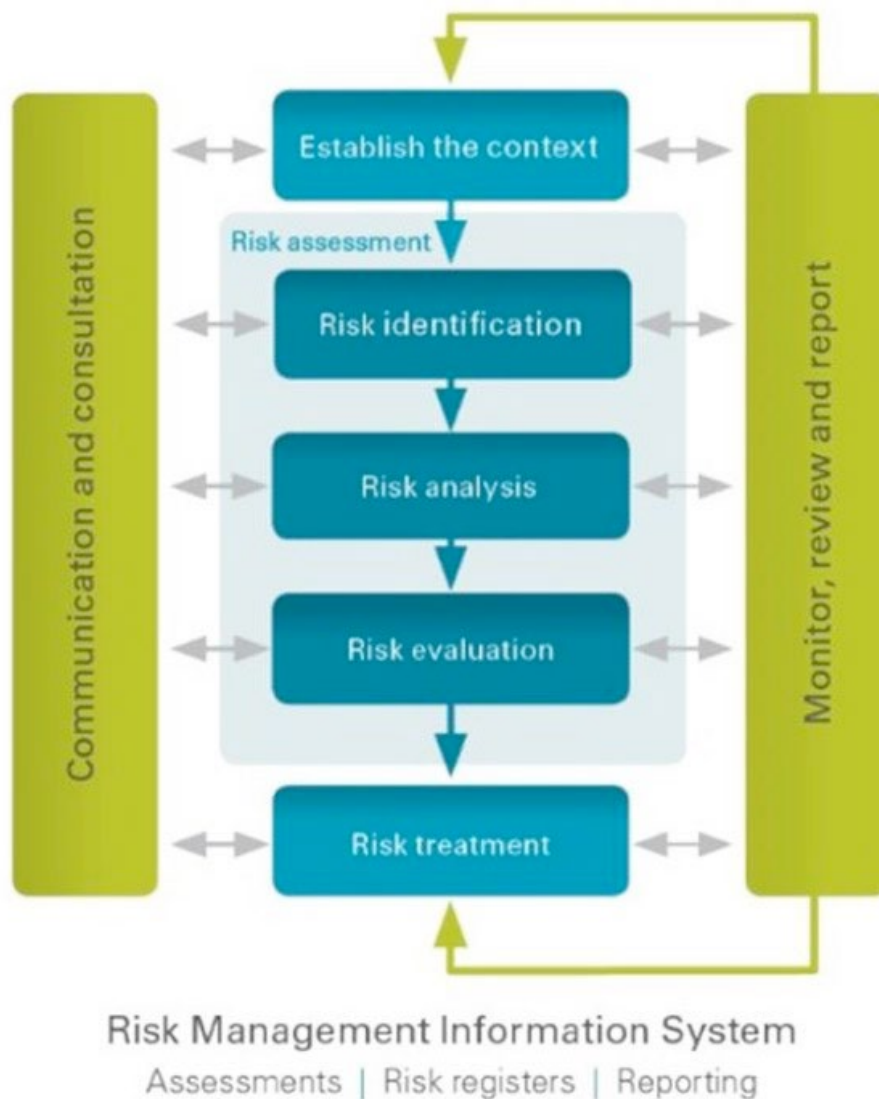


Figure 6-1 Woodside's Risk Management Process (based on European Commission, 2019)

This Section presents:

- + the impact and risk assessment stage of the risk management process, including the assessment of the acceptability of the proposed Browse to NWS Project ([Section 6.2.3](#))
- + a detailed impact and risk assessment for each aspect, including an assessment of acceptability ([Section 6.3](#)), including:
 - + the environmental objectives applicable for each aspect
 - + relevant policy and guidance
 - + the source of the aspect
 - + the relevant receptors and receptor sensitivity to the aspect (including physical, ecological and socio-economic)
 - + predicted environmental impact from planned routine and non-routine events
 - + potential environmental risk from unplanned events
 - + cumulative impacts from multiple sources of the same aspect
 - + proposed mitigation and management
 - + an overall assessment on the acceptability of the impacts and risks.

A qualitative assessment of cumulative impacts is presented as part of the overall conclusion in [Chapter 9](#).

6.2 Impact and Risk Assessment Process

6.2.1 Overview

This Section provides an overview of Woodside's approach to undertaking impact and risk assessments for the proposed Browse to NWS Project.

The impact and risk assessment has been undertaken in accordance with Woodside's Risk Management Procedure, Impact Assessment Procedure and Environment Impact Assessment Guideline. These documents support the implementation of impact and risk assessment and set out the broad principles and high-level steps for assessing environmental impacts and risks across the lifecycle of Woodside's activities.

Within this process, a distinction is made between an 'impact' and a 'risk' as follows:

- + **Environmental Impact:** An expected change to the environment, whether adverse or beneficial, wholly or partially resulting from the planned routine and non-routine project activities (e.g. routine liquid discharges).
- + **Environmental Risk:** An unplanned event or incident which impacts the achievement of the stated environmental objectives.

Potential impacts and risk from activities during all phases of the proposed Browse to NWS Project have been evaluated.

The key steps of the Process are shown in [Figure 6-2](#). A description of each step and how it is applied to the scope of the activity is provided in [Section 6.2.2](#) to [Section 6.2.3](#).

6.2.2 Context Setting

6.2.2.1 Activity Description

The activity description describes the key activities associated with the proposed Browse to NWS Project and identifies the environmental aspects for each activity (i.e. the elements of the activity (planned or unplanned) that have the potential to impact on the environment). [Table 6-1](#) shows the relationships between the proposed Browse to NWS Project activities and the aspects. [Chapter 3](#) describes all components of the proposed Browse to NWS Project which are relevant to this assessment.

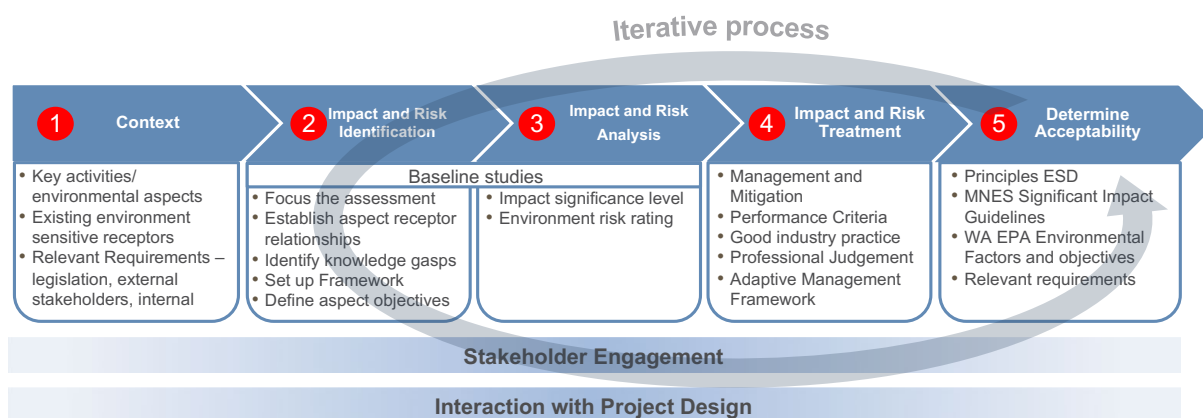


Figure 6-2 Overview of approach for impact and risk assessments

Table 6-1 Activity – Aspect Relationship

Aspect Name	Development Drilling	Installation of Subsea Umbilicals, Risers and Flowlines (SURF)	Installation of FPSO facilities	Installation of BTL and Inter-Field Spur Line	Extraction (including operation of subsea infrastructure	Processing (FPSO facilities)	Condensate Offload (FPSO facilities)	Gas Export (to NWS infrastructure)	Inspection, Maintenance and Repair (IMR) Activities	Decommissioning	Support Activities Inc. Vessels and Helicopters
Physical Presence: Seabed Disturbance	✓	✓	✓	✓					✓	✓	
Physical Presence: Disturbance to Other Users	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Physical Presence: Light	✓	✓	✓	✓		✓			✓	✓	✓
Physical Presence: Electromagnetic Emissions				✓	✓						
Atmospheric Emissions: Offshore Activities	✓	✓	✓	✓		✓	✓		✓	✓	✓
Atmospheric Noise	✓	✓	✓	✓		✓	✓		✓	✓	✓
Underwater Noise	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Marine Discharges: Sewage and Sullage	✓	✓	✓	✓		✓	✓		✓	✓	✓
Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	✓	✓	✓	✓		✓	✓		✓	✓	✓
Marine Discharges: Putrescible Waste	✓	✓	✓	✓		✓	✓		✓	✓	✓
Marine Discharges: Produced Water	✓					✓					
Marine Discharges: Cooling Water	✓	✓	✓	✓		✓	✓		✓	✓	✓
Marine Discharges: Hazardous and Non-Hazardous Inorganic Waste	✓	✓	✓	✓		✓	✓		✓	✓	✓
Marine Discharges: Drilling and Completions Discharges	✓										

Aspect Name	Development Drilling	Installation of Subsea Umbilicals, Risers and Flowlines (SURF)	Installation of FPSO facilities	Installation of BTL and Inter-Field Spur Line	Extraction (including operation of subsea infrastructure	Processing (FPSO facilities)	Condensate Offload (FPSO facilities)	Gas Export (to NWS infrastructure)	Inspection, Maintenance and Repair (IMR) Activities	Decommissioning	Support Activities Inc. Vessels and Helicopters
Marine Discharges: Subsea Control Fluid	✓	✓		✓	✓				✓	✓	
Marine Discharges: Hydrotest Fluid	✓	✓		✓					✓		
Physical Presence (unplanned): Vessel Interactions with Fauna	✓	✓	✓	✓	✓		✓		✓	✓	✓
Physical Presence (Unplanned): Invasive Marine Species	✓	✓	✓	✓			✓		✓	✓	✓
Production Activities: Seabed Subsidence					✓						
Unplanned Hydrocarbon Releases	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

6.2.2.2 Defining the Existing Environment

The existing environmental context of the proposed Browse to NWS Project was defined in order to identify environmental receptors that have the potential to interact with the proposed Browse to NWS Project, including:

- + physical characteristics of the environment (e.g. seabed and water quality)
- + ecological characteristics of the environment (e.g. benthic communities, fish, seabirds, marine reptiles and marine mammals)
- + socio-economic and cultural characteristics of the environment (e.g. heritage, fishing, shipping and tourism).

Definition of the existing environment includes environmental receptors in the Project Area and the broader EMBA by an unplanned event.

It should be noted that for the purpose of the environmental impact and risk assessment presented in this draft EIS/ERD, Scott Reef, which encompasses the reef system including all coral habitats and communities, is considered as the area “above the 75 m bathymetric contour within the 3 nm State waters boundary and the Scott Reef and Surrounds - Commonwealth Area National Heritage Place which comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef”. The deepwater benthic communities are defined as those communities below the 75 m bathymetric contour and make up the remainder of the Project Area.

Information on the existing environment has been primarily drawn from existing studies completed by Woodside and others. Over two decades, Woodside has commissioned approximately 60 studies within the proposed Browse Development Area, Scott Reef and the broader region. Studies have included baseline and monitoring programs for humpback whale, turtle, other marine megafauna and fish species in the region, as well as long-term monitoring of coral and fish communities at Scott Reef and the Rowley Shoals.

In addition, Woodside has undertaken an environmental survey of the proposed BTL route, including water and sediment sampling and characterisation of the deepwater seabed habitat and benthic communities.

These studies have enabled Woodside to build a comprehensive understanding of the environmental context of the proposed Browse to NWS Project, to enable identification of the potential environmental impacts and assessment and selection of the appropriate measures to manage and mitigate these.

A detailed description of the existing environment is provided in [Chapter 5](#).

6.2.2.3 Review of significance/sensitivity of receptors and levels of protection

This step is important for establishing the context of the environment, as it identifies the more significant or sensitive receptors and proposes the level of protection. This is achieved by assessing the receptor sensitivity (i.e. the susceptibility/vulnerability/importance of the receptor) as either high, medium or low value for each receptor in the Project Area and EMBA and the criteria for determining whether impacts and risks are acceptable.

The sensitivity of each of the receptors has been determined to be either low, medium or high. Key considerations for this determination included:

- + **Quality:** Is the receptor considered to be relatively high quality/in good condition, or is it damaged/degraded?
- + **Sensitivity to change:** Is the receptor highly sensitive to environmental change and less likely to be able to adapt?
- + **Importance:** Is the receptor considered to be of local, regional or international importance?

Sensitivity considerations take into account any relevant legal protection, government policy, stakeholder views and ecosystem service value.

6.2.2.4 Environmental legislation and other requirements

It is important to know what environment legislation or other requirements are applicable. These may include:

- + legislation that identifies the manner in which specific activities should be undertaken (such as vessel activities)
- + legislation or requirements for particular impacts and risks (e.g. biosecurity legislation)
- + management plans, guidelines, or advices that are issued by government departments to aid in the protection of significant receptors.

In preparing this draft EIS/ERD, Woodside has ensured that the proposed controls and impact and risk levels are consistent with national and international standards, law and policies (including applicable plans for management

and conservation advices and the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (Commonwealth of Australia, 2013).

This has included undertaking this impact and risk assessment in accordance with the applicable legislation identified in [Chapter 2](#) and incorporating relevant requirements of:

- + AMP management plans prepared under Section 370 of the EPBC Act. These outline the objectives for conserving marine habitats and the species that live and rely on these habitats within AMPs.
- + species recovery plans which are enacted under the EPBC Act and remain in force until the species is removed from the threatened list.
- + conservation advices which provide guidance on immediate recovery and threat abatement activities that can be undertaken to facilitate the conservation of a listed species or ecological communities.

This draft EIS/ERD has also considered the MNES Significant Impact Guidelines, Principles of Ecologically Sustainable Development as defined in Section 3A of the EPBC Act and the WA EPA Environmental Factors and Objectives as described in [Section 6.2.3.3](#).

6.2.2.5 External Requirements

In addition to legal or other requirements, to establish the context for the proposed Browse to NWS Project, there is a need to understand stakeholder expectations for the area in which the proposal/proposed action is to take place. These expectations may be based on previous experience and past stakeholder consultation or may be identified during current stakeholder consultation activities and, as such, need to be tracked and considered for the impact and risk assessment.

Woodside has a long history of operating in the north-west of Australia, has established strong stakeholder relationships and recognises the importance of understanding stakeholder views with respect to oil and gas activities in the region. When establishing acceptable levels for impacts and risks, Woodside considers the expectations of potentially impacted stakeholders and factors these expectations into decision-making processes for the level of potential impact and risk of activities.

Woodside continues to undertake consultation with identified relevant stakeholders (described in [Chapter 4](#)), incorporating outcomes into the draft EIS/ERD where applicable and will continue to consider the views of stakeholders who provide comment on the proposed Browse to NWS Project through the formal consultation process and other means of ongoing consultation.

Consideration of the stakeholder views received via the draft EIS/ERD public review process will be incorporated into the proposed Browse to NWS Project EIS/ERD Supplement that will be submitted to the DoEE and EPA for their assessment following the public comment period.

6.2.2.6 Internal Requirements

As well as legal and external requirements, there are also internal requirements within Woodside that must be implemented when undertaking activities. These may be focussed on the manner in which the particular activities are undertaken (e.g., mitigation measures to ensure minimal impact to cetaceans and turtles from VSP during development drilling), for particular impacts or risks (e.g., risk assessment of project vessels for Invasive Marine Species (IMS)) or in order to protect certain receptors.

The Woodside Management System (WMS) (described in [Chapter 8](#)) defines how Woodside delivers its business objectives and the boundaries within which all Woodside employees and contractors are expected to work. The objectives under the WMS define the mandatory performance requirements that apply to all Woodside activities and the performance of its employees and contractors within their areas of responsibility.

6.2.3 Impact and Risk Assessment

6.2.3.1 Identifying Impacts and Risks

Based upon the context of the proposed Browse to NWS Project, and known environmental aspects, relevant impacts and risks were identified in the scoping phase. During this phase, the relationships between the environmental aspects identified for the proposed activities and the associated potential impacts and risks for each receptor were established.

This set up the framework for the more detailed impact and risk analysis and evaluation and helped identify knowledge gaps, which may have triggered specific studies and surveys. The detailed impact and risk analysis and evaluation was undertaken by considering the identified receptors ([Chapter 5](#)) with the potential to be exposed to or interact with an aspect, then determining the subsequent outcomes of that interaction or exposure (impacts or risks).

These aspect–receptor relationships were first presented in the EISG/ESD and have been reviewed and refined during the preparation of the draft EIS/ERD and provided in [Table 6-2](#). This table shows all the identified impacts and risks which are discussed in [Section 6.3](#) and highlights those that have been carried through for a detailed assessment. Within [Table 6-2](#), aspects that present a potential impact from a planned activity are identified with an ‘I’. Where the aspect presents a risk from an unplanned event or incident they are identified with an ‘R’. Where both an impact and a risk apply, this identified by ‘I/R’.

Table 6-2 Aspect-Receptor Relationship

[illegible]

Aspect	Impact/Risk	Physical					Ecological										Socio-Economic												
		Sediment Quality	Water Quality	Air Quality	Ambient Light	Ambient Noise	Benthic communities and habitats	Fauna			Regional conservation values			Other Users							Heritage								
								Plankton Communities	Deepwater Benthic Communities and Habitats (>75 m depth)	Shallow Water Benthic Communities and Habitats (<75 m depth)	Coastal Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	Key Ecological Features	Australian Marine Parks	State Marine Parks & Nature Reserves	Commonwealth Managed Fisheries	State Managed Fisheries		Tourism and Recreation	Scientific Studies	Shipping	Industry	Settlements	Other Protected Places	Aboriginal and Indigenous heritage	Marine Archaeology
Physical Presence: Light	Change in ambient light				—					—	—	—																	
	Change in fauna behaviour																												
	Injury or mortality to fauna																												
	Changes to the functions, interests or activities of other users																												
Physical Presence: Electromagnetic Emissions	Change in fauna behaviour																												
Atmospheric Emissions: Offshore Activities	Change in air quality			—																									
	Injury or mortality to fauna										—																		
Atmospheric Emissions: Third Party Processing of Browse Gas	Change in air quality			—																								—	
	Change in ambient noise					—																							
Atmospheric Noise Emissions	Change in fauna behaviour																												
	Changes to the functions, interests or activities of other users																												

Aspect	Impact/Risk	Physical					Ecological								Socio-Economic											
		Sediment Quality	Water Quality	Air Quality	Ambient Light	Ambient Noise	Benthic communities and habitats			Fauna			Regional conservation values		Other Users							Heritage				
Plankton Communities	Deepwater Benthic Communities and Habitats (>75 m depth)						Shallow Water Benthic Communities and Habitats (<75 m depth)	Coastal Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	Key Ecological Features	Australian Marine Parks	State Marine Parks & Nature Reserves	Commonwealth Managed Fisheries	State Managed Fisheries	Tourism and Recreation	Scientific Studies	Shipping	Industry	Settlements	Other Protected Places	Aboriginal and Indigenous heritage	Marine Archaeology	
Underwater Noise Emissions	Change in ambient noise		I/R							I/R	I/R	I/R	I	I/R									I/R			
	Change in fauna behaviour									I/R	I/R	I/R		I/R									I/R			
	Injury or mortality to fauna									I/R	I/R	I/R		I/R									I/R			
	Changes to the functions, interests or activities of other users																I/R	I/R	I/R	I/R						
Marine Discharges: Sewage and Sullage	Change in water quality			I/R										I/R									I/R			
	Change in fauna behaviour																									
	Injury or mortality to fauna									I/R	I/R	I/R														
	Changes to the functions, interests or activities of other users																I/R	I/R	I/R	I/R						
Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	Change in water quality			I/R										I/R									I/R			
	Injury or mortality to fauna										I/R	I/R	I/R										I/R			
	Changes to the functions, interests or activities of other users																I/R	I/R	I/R	I/R			I/R			

Aspect	Impact/Risk	Physical					Ecological								Socio-Economic															
							Benthic communities and habitats		Fauna		Regional conservation values		Other Users						Heritage											
							Plankton Communities	Deepwater Benthic Communities and Habitats (>75 m depth)	Shallow Water Benthic Communities and Habitats (<75 m depth)	Coastal Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	Key Ecological Features	Australian Marine Parks	State Marine Parks & Nature Reserves	Commonwealth Managed Fisheries		State Managed Fisheries	Tourism and Recreation	Scientific Studies	Shipping	Industry	Settlements	Other Protected Places				
Marine Discharges: Drilling and completions discharges	Change in water quality		I/R												I/R											I/R		Marine Archaeology		
	Change in sediment quality		I/R												I/R											I/R		Aboriginal and Indigenous heritage		
	Injury or mortality to fauna							I/R	I/R	I/R	I/R	I/R																		
	Change in habitat								I/R																					
	Changes to the functions, interests or activities of other users																			I/R	I/R	I/R	I/R				I/R			
Marine Discharges: Subsea control fluids	Change in water quality		I/R												I/R	I/R														
	Change in sediment quality		I/R												I/R	I/R														
	Injury or mortality to fauna						I/R			I/R	I/R	I/R																		
	Changes to the functions, interests or activities of other users																			I/R	I/R									
Marine Discharges: Hydrotest Fluid	Change in water quality		I												I															
	Change in sediment quality		I												I															
	Injury or mortality to fauna							I	I	I	I	I	I													I				
	Changes to the functions, interests or activities of other users																			I	I	I	I							

Aspect	Impact/Risk	Physical				Ecological								Socio-Economic													
						Benthic communities and habitats		Fauna		Regional conservation values		Other Users								Heritage							
		Sediment Quality	Water Quality	Air Quality	Ambient Light	Ambient Noise	Plankton Communities	Deepwater Benthic Communities and Habitats (>75 m depth)	Shallow Water Benthic Communities and Habitats (<75 m depth)	Coastal Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	Key Ecological Features	Australian Marine Parks	State Marine Parks & Nature Reserves	Commonwealth Managed Fisheries	State Managed Fisheries	Tourism and Recreation	Scientific Studies	Shipping	Industry	Settlements	Other Protected Places	Aboriginal and Indigenous heritage	Marine Archaeology
Production Activities: Seabed Subsidence	Change in habitat							I	I		I							I			I						
	Changes to the functions, interests or activities of other users																				I						
	Change in heritage values																										I
	Change in water quality	R						R								R	R								R		
Marine Discharges: Hazardous and Non-Hazardous Inorganic Waste	Change in sediment quality	R													R	R											
	Injury or mortality to fauna						R				R	R	R	R	R	R	R										
	Changes to the functions, interests or activities of other users																		R	R	R	R					
Unplanned Vessel Interactions with Fauna	Injury or mortality to fauna											R	R	R					R	R	R						
Physical Presences (Unplanned): Invasive Marine Species	Change in ecosystem dynamics							R	R			R	R	R	R	R	R									R	
	Changes to the functions, interests or activities of other users							R				R							R	R	R	R			R		

IMPACTS AND RISK

6.2.3.2 Impacts and Risks Assessment

The assessment of impacts and risk was undertaken through a systematic process consistent with Woodside's Impact Assessment Procedure and Environment Impact Assessment Guideline. Each activity (either planned or unplanned) was considered with respect to its potential to affect an environmental receptor. The assessment was informed by a range of environmental studies that included the review of existing data and the modelling of discharges and emissions. Inherent controls, such as design features, legislative requirements, industry good practice and applicable Woodside corporate standards were considered when identifying the credible impact and risk scenarios.

This process provides the inputs to the assessment of the impact significance for impacts and the risk rating for risks. In this impact and risk assessment approach, in the event where an impact or risk (with inherent controls considered) is deemed to be unacceptable, further mitigation and management measures are identified and applied.

6.2.3.2.1 Impact Significance Level

The environmental impact assessment approach undertaken included the following steps:

1. Identification of project **aspects** (i.e. results of planned or unplanned project activities that have the potential to impact on the environment).

2. Identification of the **receptors** (i.e. physical, biological, socio economic (i.e. cultural or human elements) of the environment that may be impacted by project aspects).
3. Assessment of the **receptor sensitivity** (i.e. the sensitivity/vulnerability/importance of the receptor) as either high, medium or low value.
4. Assessment of the **magnitude** (i.e. no lasting effect, slight, minor, moderate, major or catastrophic) of the credible environmental impacts from each aspect based on the extent, duration, frequency and scale. Determination of magnitude considered the frequency and scale of the impact or risk and the sensitivity of the receptors.
5. Assigning an **impact significance level** to each environmental impact based on the receptor sensitivity and the magnitude of the impact.

Impacts have been classified in accordance with the significance levels outlined in Woodside's Environment Impact Assessment Guideline. Impact significance levels were determined based on the magnitude (extent, nature, scale) of the impact and the receptor sensitivity ([Figure 6-3](#)). The impact significance levels used for evaluating impacts align closely with the consequence levels used for evaluating risks ([Table 6-3](#)).

Magnitude	Sensitivity		
	Low	Medium	High
Catastrophic	B	A	A
Major	C	B	A
Moderate	D	C	B
Minor	E	D	C
Slight	F	E	D
No Lasting effect	F	F	E

Significance Level	
A	Catastrophic (A) - Applicable limits or standards are substantially exceeded and/or catastrophic or major magnitude impacts are expected to receptors of medium/ high or high sensitivity respectively.
B	Major (B) - Applicable limits or standards are exceeded and/ or moderate, major or catastrophic magnitude impacts are expected to occur to receptors of high, medium or low sensitivity respectively.
C	Moderate (C) - Impacts are close to applicable limits or standards, or within standards but with potential for occasional exceedance. Minor, moderate or major magnitude impacts are predicted to occur to receptors of high, medium or low sensitivity respectively.
D	Minor (D) - Impact magnitude is within applicable standards but is considered to have significance. Slight, minor or moderate impacts are predicted to occur to receptors of high, medium or low sensitivity respectively.
E	Slight (E) - The receptor will experience a noticeable effect, but the impact magnitude is sufficiently small and well within applicable standards, and/or the receptor is of low value.
F	Negligible (F) - The receptor will essentially not be affected.

Figure 6-3 Impact Significance Level

6.2.3.2.2 Environment Risk Rating

Environment risk ratings are determined separately to environmental impact significance as, along with consequence (aligned with impact significance), the risk ratings additionally consider the likelihood of an unplanned event or incident in accordance with the Woodside Risk Management Procedure and Risk Matrix.

The consequence is the worst-case credible consequence associated with the event, assuming all controls (preventative or mitigative) are absent or have

failed. Where more than one potential consequence applies, the highest severity consequence level is selected. Consequence levels are aligned with the impact significance levels and are determined in the same process as described in [Section 6.2.3.2.1](#). Consequences are defined in [Table 6-3](#).

The likelihood is determined based on the description that best fits the chance of the selected consequence occurring, assuming reasonable effectiveness of the prevention and mitigation controls in accordance with the descriptions in [Table 6-4](#).

The risk rating is then derived from the consequence and likelihood levels determined above in accordance with the Risk Matrix shown in [Figure 6-3](#).

Table 6-3 Consequence Description

Environment	Social & Cultural	Consequence Level
Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Catastrophic, long-term impact (>20 years) to a community, social infrastructure or highly valued areas/items of international cultural significance	A
Major, long term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Major, long-term impact (5–20 years) to a community, social infrastructure or highly valued areas/items of national cultural significance	B
Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes	Moderate, medium term Impact (2–5 years) to a community, social infrastructure or highly valued areas/items of national cultural significance	C
Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Minor, short-term impact (1–2 years) to a community or highly valued areas/items of cultural significance	D
Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Slight, short-term impact (<1 year) to a community or areas/items of cultural significance	E
No lasting effect (<1 month). Localised impact not significant to environmental receptors	No lasting effect (<1 month). Localised impact not significant to areas/items of cultural significance	F

Table 6-4 Likelihood Description

Likelihood Description						
Frequency	1 in 100,000–1,000,000 years	1 in 10,000–100,000 years	1 in 1000–10,000 years	1 in 100–1,000 years	1 in 10–100 years	>1 in 10 years
Experience	Remote: Unheard of in the industry	Highly Unlikely: Has occurred once or twice in the industry	Unlikely: Has occurred many times in the industry but not at Woodside	Possible: Has occurred once or twice in Woodside or may possibly occur	Likely: Has occurred frequently at Woodside or is likely to occur	Highly Likely: Has occurred frequently at the location or is expected to occur
Likelihood Level	0	1	2	3	4	5

Likelihood

Experience	Remote	Highly Unlikely	Unlikely	Possible	Likely	Highly Likely
Frequency	Unheard of in the industry	Has occurred once or twice in the industry	Has occurred many times in the industry but not at Woodside	Has occurred once or twice in Woodside or may possibly occur	Has occurred frequently at Woodside or is likely to occur	Has occurred frequently at the location or is expected to occur
Modelled distribution %* (Probability of event occurrence)	1 in 100,000 - 1,000,000 years	1 in 10,000 - 100,000 years	1 in 1,000 - 10,000 years	1 in 100 - 1,000 years	1 in 10 - 100 years	> 1 in 10 years
LEVEL	0	1	2	3	4	5
* Not to be used for operational Health & Safety or Environment risk assessments.						
LEVEL	0	1	2	3	4	5
A	A0	A1	A2	A3	A4	A5
B	B0	B1	B2	B3	B4	B5
C	C0	C1	C2	C3	C4	C5
D	D0	D1	D2	D3	D4	D5
E	E0	E1	E2	E3	E4	E5
F	F0	F1	F2	F3	F4	F5

Risk endorsement table

Current Risk

SEVERE	Risk at this level requires immediate (no more than 12 hours) communication to the CEO & divisional EVP / SVP via VP Risk & Compliance
VERY HIGH	Risk at this level requires immediate (no more than 12 hours) communication to divisional EVP / SVP with concurrent communication to VP Risk & Compliance
HIGH	Risk at this level requires timely communication to SVP / VP of business unit or function
MODERATE	Risk at this level requires timely communication to line manager (i.e. relevant Asset or Project Manager)
LOW	Risk at this level requires timely communication to the relevant line manager

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Consequence

Health & Safety	Environment	Financial	Reputation & Brand	Legal & Compliance	Social & Cultural
A	Catastrophic, long-term impact (> 50 years) on highly valued ecosystems, habitat or physical or biological attributes	> \$5B	Catastrophic, long-term impact (> 20 years) to reputation and brand. International concern and / or persistent national concern in significant area of operation. Company operations, major ventures, significant or multiple asset operations severely restricted or terminated, and may extend to company at stake	Loss of licence to operate. Potential jail terms for executives, directors or officers. Prolonged litigation / prosecution. Fines (> \$100M) and / or civil liability (> \$1B)	Catastrophic, long-term impact (> 20 years) to a community, social infrastructure or highly valued areas / items of international cultural significance
B	Major, long-term impact (10-50 years) on highly valued ecosystems, habitat or physical or biological attributes	> \$500M - \$5B	National concern and / or international interest. Medium to long-term impact (5-20 years) to reputation and brand. Venture and / or asset operations restricted	Significant restriction on licence to operate. Prolonged litigation / prosecution. Fines (< \$100M) and / or civil liability (< \$1B)	Major, long-term impact (5-20 years) to a community, social infrastructure or highly valued areas / items of national cultural significance
C	Moderate, medium-term impact (2-10 years) on ecosystems, habitat or physical or biological attributes	> \$50M - \$500M	National concern. Moderate, medium-term impact (2-5 years) to reputation and brand. Venture and / or asset operations restricted or curtailed	Material breach of legislation, regulation, contract or licence condition. Major litigation / prosecution. Fines (< \$15M) and / or civil liability (< \$150M)	Moderate, medium-term impact (2-5 years) to a community, social infrastructure or highly valued areas / items of national cultural significance
D	Minor, short-term impact (1-2 years) on species, habitat or ecosystems (but not affecting function), physical or biological attributes	> \$5M - \$50M	Minor, short-term impact (1-2 years) to reputation and brand. Close scrutiny of asset level operations or future proposals	Breach of legislation, regulation, contract or licence condition with investigation and / or report to authority. Litigation / prosecution. Fines (< \$5M) and / or civil liability (< \$50M)	Minor, short-term impact (1-2 years) to a community or highly valued areas / items of cultural significance
E	Slight, short-term impact (< 1 year) on species, habitat or ecosystems (but not affecting function), physical or biological attributes	> \$500K - \$5M	Slight, short-term local impact (< 1 year) to reputation and brand. Some impact on asset level non-production activities	Breach of legislation, regulation, contract or licence condition. Regulatory action and / or sanction	Slight, short-term impact (< 1 year) to a community or areas / items of cultural significance
F	Minor injury or occupational illness	≤ \$500K	No lasting effect (< 1 month). Isolated and short-term local concern	Breach of internal standard	No lasting effect (< 1 month). Localised and not significant to areas / items of cultural significance

Note: All currency stated in \$US. The consequence and likelihood categories are not necessarily equal to each other. For example, the financial column is not equal to the remediation costs or consequences described in other columns.

Figure 6-4 Environment Risk Rating Level

6.2.3.3 Impact and Risk Treatment

The overall objective of the proposed Browse to NWS Project in relation to the environmental outcomes is to conduct the activities associated with the proposed Browse to NWS Project in a manner that does not result in unacceptable impacts to MNES, does not affect ESD outcomes, is in accordance with the principles and objectives of the EPBC Act as defined in Section 3A of the EPBC Act and meets the EPA Environmental Objectives.

As part of the impact and risk assessment process, management and mitigation measures have been identified to reduce the level of impact and risk to an acceptable level and meet the environmental objectives for each aspect. The following framework tools were applied, as appropriate, to assist with identifying appropriate management and mitigation measures:

- + Good industry practice – identifies further engineering control standards and guidelines which may be applied by Woodside in addition to those required to meet the legislation, codes and standards.
- + Professional judgement – uses relevant personnel with the knowledge and experience to identify alternative controls.

The proposed management and mitigation measures have been developed using the following adaptive framework:

- + eliminate the risk by removing the hazard
- + substitute a hazard with a lesser one
- + prevent a credible impact from occurring through the implementation of additional engineering control measures
- + reduce the magnitude of a credible impact through the implementation of additional engineering control measures (e.g. solids control equipment onboard MODU to manage cuttings discharge)
- + mitigate the credible impact on the environment through the reduction in extent, scale, duration of impact (e.g. bunding, oil spill booms, relief well)
- + apply environmental offsets where justified
- + carry out emergency response and contingency planning to facilitate recovery from the credible impact of an event.

The proposed aspect specific mitigation and management measures are detailed in the relevant impact and assessment sections below. An overview of the proposed Browse to NWS Project environmental management framework is provided in [Chapter 8](#). This includes a description of the proposed management plans to be developed for the proposed Browse to NWS Project (noting that, where possible, the intent of the proposed management plans will be met through the

content of activity specific Environment Plans required under State and Commonwealth legislation).

6.2.3.4 Determining Acceptability

For the purpose of this impact and risk assessment, achievement of the environmental objectives ([Section 6.2.3.5](#)) and overall acceptability (i.e. whether an environment impact or risk is acceptable) is tied to the impact significance level and the risk rating and likelihood (for unplanned events and incidents).

An assessment of the acceptability of the impacts and risks is presented for each aspect and is provided in [Section 6.3](#). The assessment of acceptability considers the:

- + principles of ESD as defined in Section 3A of the EPBC Act
- + MNES Significant Impact Guidelines
- + WA EPA Environmental Factors and Objectives
- + other aspect or receptor requirements including State, Federal and international standards, laws, policies and guidelines, including Conservation and Recovery management plans and conservation advice for EPBC Act listed threatened and/or migratory species. Relevant guidelines, standards or plans are outlined each impact assessment section
- + external requirements ([Section 6.2.2.5](#))
- + internal requirements ([Section 6.2.2.6](#)).

Principles of Ecologically Sustainable Development

The promotion of ecologically sustainable development is a key objective of the EPBC Act. The principles of ESD must also be considered when deciding whether or not to approve actions under the Act. These principles set out a framework for thinking about and balancing the interaction between protection of the environment and social and economic matters.

The principles of ESD are found in section 3A of the EPBC Act and are:

- a. Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- b. 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.
- c. The principle of inter-generational equity applies – 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.

- d. The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
- e. Improved valuation, pricing and incentive mechanisms should be promoted.

Significant impact guidelines 1.1. outlines the significance criteria for MNES. The MNES relevant to the proposed Browse to NWS Project were detailed as the controlling provisions in the DoEE's decision notice on the referral of the proposed Browse to NWS Project under the EPBC Act (EPBC 2018/8319) for the purposes of the assessment of potential impacts. The relevant MNES and associated significance criteria are shown in [Table 6-5](#).

MNES Significant Impact Guidelines

The *Matters of National Environmental Significance* –

Table 6-5 MNES Significant Impact Criteria

Matter of National Environmental Significance	Significance Criteria
Listed Threatened Species and Ecological Communities	An action is likely to have a significant impact on a species listed in any of the following categories if there is a real chance or possibility that it will: Extinct in the wild + adversely affect a captive or propagated population or one recently introduced/reintroduced to the wild, or + interfere with the recovery of the species or its reintroduction into the wild. Critically Endangered and Endangered + lead to a long-term decrease in the size of a population + reduce the area of occupancy of the species + fragment an existing 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 critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat + introduce disease that may cause the species to decline + Interfere with the recovery of the species.

Matter of National Environmental Significance	Significance Criteria
Listed Threatened Species and Ecological Communities cont.	Vulnerable + lead to a long-term decrease in the size of an important population of a species + reduce the area of occupancy of an 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 an important population + modify, destroy, remove or 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 + interfere substantially with the recovery of the species. Threatened Ecological Communities + An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will: + reduce the extent of an ecological community + fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines + adversely affect habitat critical to the survival of an ecological community + modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns + cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting + cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: + assisting invasive species, that are harmful to the listed ecological community, to become established + causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community + interfere with the recovery of an ecological community.
Listed Migratory Species	An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: + substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), 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 + seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Matter of National Environmental Significance	Significance Criteria
The Commonwealth Marine Area	An action is likely to have a significant impact on the environment in a Commonwealth marine area if there is a real chance or possibility that the action 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 in a Commonwealth marine area results + have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution + result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity; social amenity or human health + result in 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 + have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck.
National Heritage Places	An action is likely to have a significant impact on the National Heritage values of a National Heritage place if there is a real chance or possibility that it will cause: + one or more of the National Heritage values to be lost + one or more of the National Heritage values to be degraded or damaged + one or more of the National Heritage values to be notably altered, modified, obscured or diminished.

WA EPA Environmental Factors and Objectives

The WA EPA has a series of key environmental factors that are considered when assessing the acceptability of a proposal. For each of these factors, an environmental objective has been identified. When considering significant impact or effect on an environmental factor, the EPA may have regard to various matters, including the following (EPA, 2016):

- + values, sensitivity and quality of the environment which is likely to be impacted
- + extent (intensity, duration, magnitude and geographic footprint) of the likely impacts
- + consequence of the likely impacts (or change)
- + resilience of the environment to cope with the impacts or change
- + cumulative impact with other projects
- + connections and interactions between parts of the environment to inform a holistic view of impacts to the whole environment
- + level of confidence in the prediction of impacts and the success of proposed mitigation

- + public interest about the likely effect of the proposal, if implemented, on the environment
- + public information that informs the EPA's assessment.

The EPA Environmental Factors relevant to the proposed Browse to NWS Project were identified in the EPA determination on the referral of the proposed Browse to NWS Project under the EP Act. The relevant Environmental Factors and associated Environmental Objectives are shown in [Table 6-6](#). While each of the EPA Environmental Factors and associated objectives are considered in the acceptability assessment presented in the Chapter, an assessment of the activities planned to be undertaken with the WA State jurisdiction is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Table 6-6 EPA Environmental Factors and Objectives

EPA Environmental Factor	Environmental Objective
Benthic Communities and Habitats	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.
Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected.
Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.
Air Quality	To maintain air quality and minimise emissions so that environmental values are protected.

Listed Threatened Species Management/Recovery Plans and Conservation Advices

The proposed Browse to NWS Project may trigger risks to or impacts on listed threatened species. The requirements of the species recovery plans and conservation advices have been considered to identify any requirements that may be applicable to the impact and risk assessment of the draft EIS/ERD.

[Table 5-19](#) outlines the management/recovery plans and conservation advices relevant to those species identified as potentially occurring or having habitat within the Project Area.

The management/recovery plans and conservation advices have been taken into consideration in assessing the impacts and risks associated with the proposed Browse to NWS Project and will be further incorporated into implementation planning in activity-specific EPs.

Australia Marine Parks

Under the EPBC Act, Australian Marine Parks (AMPs), are recognised for the purpose of conserving marine habitats and the species that live and rely on these habitats. The AMPs that occur within or near the Project Area are listed in [Table 5-29](#).

Activities in the AMPs must be undertaken in a manner that is not inconsistent with the objectives of the park zones and the values of the marine park (including natural, cultural, heritage and socio-economic values) (Director of National Parks, 2018):

- + The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.
- + The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats.

- + The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.

The values of the marine parks are described in [Section 5.3.3.2](#).

6.2.3.5 Environmental Objectives

Receptor specific environmental objectives have been established for the proposed Browse to NWS Project. These objectives have been established based on the considerations regarding acceptability as described above.

[Table 6-7](#) presents the environmental objectives.

Where relevant, Woodside has identified environmental objectives that are not inconsistent with the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (Commonwealth of Australia, 2013) except in relation to the Scott Reef shallow water benthic habitat (<75 m bathymetry) where the WA EPA Technical guidance - Protecting the Quality of Western Australia's Marine Environment (EPA, 2016b) has also been utilised

It should be noted that where qualitative terms (e.g. substantial, acceptable, serious) are used in objectives, they are supported by detailed impact and risk assessment in the sections that follow such that they can be interpreted as meaning “impact and risk greater than that predicted in this draft EIS/ERD”.

The term “marine ecosystem functioning or integrity” should be interpreted to mean “the structure (e.g. the variety and quantity of life forms) and functions (e.g. the food chains and nutrient cycles) of marine ecosystems”

Table 6-7 Receptor sensitivity, environmental objectives and relevant aspects

Receptor	Receptor Sensitivity Level	Environmental Objective	Environmental context (local and regional)	Relevant environmental aspects
Sediment quality ¹	Medium value (open waters) Ambient sediment quality is typical of the surrounding environment, with low sensitivity to change and no features of conservation value	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. ² Objective 2: To not result in 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. ²	Sediments in the Project Area are typical of an undisturbed tropical offshore environment, with low concentrations of metals and nutrients and no hydrocarbons detected from marine sediment quality seabed sampling (refer to Section 5.2.10).	+ Physical presence: seabed disturbance + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Hazardous and non-hazardous inorganic waste + Unplanned hydrocarbon releases.
Water quality	Medium value (open water) Ambient water quality is typical of an open water environment, with low sensitivity to change.	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. ²	Water quality in the Project Area near the location of the proposed subsea infrastructure and facilities is typical of an undisturbed tropical offshore environment. Much of the surface waters in this area is nutrient-poor, influenced by the Indonesian Throughflow, with low levels of primary productivity (Section 5.2.9).	+ Physical presence: seabed disturbance + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Marine discharges: hazardous and non-hazardous inorganic waste + Unplanned hydrocarbon releases

¹ Sediment quality associated with sediments that form part of the shallow water benthic communities and habitats (<75 m depth) are embedded with that receptor

² Source of environmental objective: Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the Matters of National Environmental Significance – Significant impact guidelines 1.1 (Commonwealth of Australia, 2013)

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Air quality	Medium value (open water) Ambient air quality is typical of an open water environment, with low sensitivity to change.	Objective 4: To not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. ²	Given the distance from any significant anthropogenic emissions sources, air quality within the Project Area is expected to be high (Section 5.2.6).	+ Atmospheric emissions: offshore activities + Atmospheric emissions: third party processing of Browse gas
Ambient light	Medium value (open water) Ambient light is typical of an open water environment, with low sensitivity to change.	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health. ²	The Project Area is located approximately 260 km from the shore where there are no existing significant sources of artificial light. The proposed BTL route is also distant from sources of light emissions, except where the proposed BTL route ties in near the existing NRC facilities (Section 5.2.7).	Physical presence: light
Ambient noise	Medium value (open water) Ambient noise is typical of an open water environment, with low sensitivity to change.	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health. ²	Atmospheric noise The existing anthropogenic noise environment within the vicinity of the Project Area is expected to be primarily associated with commercial shipping activities, as well as occasional petroleum exploration activities. Similar sources of anthropogenic underwater ambient noise may be expected along the proposed BTL route. Underwater noise Underwater noise in the Project Area is characterised by occasional general vessel traffic, seismic surveys, suspected illegal blast fishing at Scott Reef and marine fauna. Underwater noise from marine fauna recorded at the Browse Development Area included calls from humpback whales, minke and dwarf minke whales, pygmy blue whales, Bryde's whales, as well as calls from unidentified whales and fish chorus (Section 5.2.8).	+ Atmospheric noise emissions + Underwater noise emissions

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Plankton	Medium value (open water) Plankton populations are typical of an open water environment, with low sensitivity to change due to high turnover/recovery and no species of high importance or quality.	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.²	Plankton communities have a naturally variable distribution in both space and time in oceanic waters, noting that the NWMR is typically characterised by low planktonic productivity. Estimates of the phytoplankton biomass (measured as chlorophylla) close to Scott Reef are approximately twice that of open waters (sampled at distances greater than 50 km to the south-west of South Scott Reef). The open water location sampled is likely to be representative of the general outer shelf open water environment and so is representative of the oceanic waters of the Project Area (Section 5.3.1.1)	+ Physical presence: seabed disturbance + Physical presence: light + Underwater noise emissions + Marine discharges: sewage and sullage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Hazardous and non-hazardous inorganic waste + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Shallow water benthic communities and habitats (<75 m depth)	High value habitat Species of high importance with high sensitivity to change.	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.² Objective 8: To not result in the establishment of a known or potential invasive marine species (IMS) in the Scott Reef system. Objective 9: To avoid direct (i.e. physical footprint) disturbance to Scott Reef shallow water benthic habitat (<75 m bathymetry). Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).³	Shallow water benthic communities and habitats in the Project Area include those at Scott Reef. In addition, the proposed BTL route passes at a distance of a few kilometres from the Rowley Shoals shallow water benthic communities and habitats. Important species within these habitats include corals, seagrass and macroalgae. Coral Coral reefs and communities of the NWMR include: remote oceanic reefs systems (atolls) such as Scott Reef, Seringapatam etc.; fringing reefs around offshore islands such as Browse Island and along coastlines such as the Kimberley Region; and submerged shoals on the NWS such as Rankin Bank and Glomar Shoals. Within the deep waters of the Browse Development Area (i.e. the seabed excluding Scott Reef), no deepwater soft or hard corals were observed during environmental surveys. The scleractinian corals, are considered to be of high conservation and ecological value at Scott Reef. Recent studies have found 236 species of coral at Scott Reef, in comparison of a recorded 255 species at Ashmore Reef, 159 species at Seringapatam Reef and 211 species of corals at Mermaid Reef (Section 5.1.3).	+ Physical presence: seabed disturbance + Physical presence: light + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Production activities: seabed subsidence + Marine discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases

3 Source of environmental objective: Technical guidance - Protecting the Quality of Western Australia's Marine Environment (EPA, 2016b)

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Shallow water benthic communities and habitats (<75 m depth) cont.			Seagrass In the NWMR, seagrass habitats are generally found in shallow water environments near the mainland and offshore reefs and shoals. Water depths within the Browse Development Area are generally too deep to provide suitable conditions for seagrass growth other than shallower reef and lagoon habitats in the Scott Reef system. Scott Reef supports five species of seagrass. However, the highly energetic environment and significant tidal exposure of Scott Reef restricts the area of habitats potentially suitable for seagrass establishment to a small proportion of the total area, resulting in only low abundance (Section 5.3.1.3). Macroalgae A total of 351 species of marine benthic red algae and 171 species of marine benthic brown and green algae have been recorded in north-western Australia. The Indo-Pacific flora is highly diverse, with some subsets of the region regarded as 'biodiversity hotspots'. The growth of macroalgae in the deep waters of the Browse Development Area is restricted due to light availability and lack of hard substrate to support attachment in the predominantly soft sediment habitats of the area. A benthic habitat survey found no macroalgal beds during 11 drop camera surveys within the Browse Development Area. A total of 121 species of algae have been reported from Scott Reef. Studies found general algal cover to be approximately 5 to 10% in shallow and intertidal areas, but it was highly variable, with some areas approaching 100% cover (Section 5.3.1.3).	

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Deepwater benthic communities and habitats (>75 m depth)	Medium value No species of high importance	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. ²	The benthic communities inhabiting the predominantly soft, fine sediments of the deepwater benthic habitats are characterised by infauna such as polychaetes and sparsely distributed sessile and mobile epifauna. The density of benthic fauna is typically lower in deep-sea sediments (greater than 200 m) than in shallower coastal sediment habitats, but the diversity of communities may be similar. As confirmed by deepwater surveys (Section 5.3.1.2).	+ Physical presence: seabed disturbance + Underwater noise emissions + Marine discharges: sewage and sludge + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases
Coastal habitats	High value habitat Habitats with high sensitivity to change, such as mangroves.	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. ²	Given the offshore location, no coastal habitats occur in the Project Area. However, coastal habitats may occur within the EMBA. The shoreline within the northwest of Western Australia is varied, but predominantly includes tidal flats with smaller areas of rocky shores and sandy beaches. In addition, mangrove and saltmarsh environments also occur along the Pilbara coast and islands of the Dampier Archipelago.	+ Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental Objective	Environmental context (local and regional)	Relevant environmental aspects
Seabirds and migratory shorebirds	High value species MNES species known to be present.	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population.⁴ Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.⁴ Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.⁴	As the only emergent land mass within the immediate vicinity of the Browse Development Area, Scott Reef serves to provide nesting and/or roosting for seabirds, albeit in small numbers in comparison to other breeding and roosting sites in the region. This includes the little tern, which has a resting BIA at Scott Reef, associated with Sandy Islet. In addition, due to the large geographical range of seabirds, most species occurring within the wider NWMR have the potential to occur and transit through the Project Area. The islands of the Rowley Shoals (which the proposed BTL route passes at a distance of a few kilometres) are known to support a wide range of seabird species, including WA's second largest breeding colony of red-tailed tropicbird. The Rowley Shoals have also been identified as BIAs for the white-tailed tropicbird. Migratory shorebirds are occasionally observed in very low numbers at Scott Reef. Sandy Islet may be used as a staging site during the migrations between the Northern Hemisphere and Australia. Given its small size, however, Sandy Islet is unlikely to support large numbers of migratory shorebirds. Due to the large geographical ranges of migratory shorebirds, many of the species known to occur within the wider NWMR have the potential to transit through the Project Area, which overlaps with the migratory shorebird corridor. Shorebird presence in the Project Area is expected to be transitory and seasonal (Section 5.3.2.3).	+ Physical presence: light + Atmospheric emissions: offshore activities + Atmospheric noise emissions + Production activities: seabed subsidence + Marine discharges: putrescible waste + Marine discharges: hazardous and non-hazardous inorganic waste + Unplanned hydrocarbon releases

⁴ Source of environmental objective: Significant impact criteria for migratory species as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (Commonwealth of Australia, 2013)

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Fish	High value species MNES species known to be present.	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.⁴ Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.⁴ Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.²	Fish assemblages within the Browse Development Area occupy a diverse range of habitats and are typical of the fish communities and species representative of the Timor Province. These fish assemblages include: + shallow-water, site-attached coral reef fish communities with characteristically high diversity and abundance + open water pelagic fish + deepwater, demersal fish communities EPBC Act listed fish species that may occur within the Project Area include the whale shark, shortfin mako, longfin mako, green sawfish and largetooth sawfish. The whale shark foraging BIA extends north along the northern WA coastline (predominately inshore of the Project Area) from Ningaloo almost to the Northern Territory (NT) border (Section 5.3.2.2). Based on studies undertaken of the whale shark's migratory behaviours, this species may occur within the Project Area, albeit in low numbers (Section 5.3.2.7).	+ Physical presence: light + Physical presence: electromagnetic emissions + Atmospheric noise emissions + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Marine discharges: hazardous and non-hazardous inorganic waste + Unplanned vessel interactions with fauna + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental Objective	Environmental context (local and regional)	Relevant environmental aspects
Marine mammals	High value species MINES species known to be present.	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.⁴ Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.⁴ Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.²	The PMST identified 27 marine mammal species as potentially occurring within the Project Area. Of these, the pygmy blue whale (endangered and migratory), humpback whale, sei whale, fin whale (vulnerable and migratory) and Bryde's whale (migratory) are considered most likely to occur (albeit representing a low percentage of each species populations) within the Project Area and/or interact with the proposed Browse to NWS Project (Section 5.3.2.4). There are BIAs for migration and breeding and calving for the humpback whale along the WA coast and within the NWMR, but there are no known BIAs within the Project Area. A migratory BIA for the pygmy blue whale extends for most of the length of the NWMR within offshore waters and encompasses Scott Reef. The Conservation Plan for Blue Whales (Commonwealth of Australia, 2015) also documents a possible foraging area which encompasses the majority of Scott Reef and its surrounds. It is expected pygmy blue whales may occur within the Browse Development Area, albeit in low numbers, and it is acknowledged that pygmy blue whales have been recorded in the channel between North and South Scott Reef, and that they may forage opportunistically in and around Scott Reef (given it is a possible foraging BIA). Other marine mammal species identified as likely to occur in the Project Area (such as the sei whale, fin whale and Bryde's whales) are expected to be limited to infrequent transient individuals (Section 5.3.2.4.3).	+ Physical presence: electromagnetic emissions + Atmospheric noise emissions + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Marine discharges: hazardous and non-hazardous inorganic waste + Unplanned vessel interactions with fauna + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Marine reptiles	High value species MNES species known to be present.	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.⁴ Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.⁴ Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.²	The PMST identified six species of marine turtle species as potentially occurring within the Project Area: green turtle, hawksbill turtle, flatback turtle (vulnerable and migratory) and the leatherback turtle, loggerhead turtle, olive ridley turtle (endangered and migratory). The marine turtles documented to be present in the Browse Development Area include the vulnerable green turtle and loggerhead turtle. These species are described in Section 5.3.2.5. The Recovery Plan for Marine Turtles identifies Habitat Critical to the Survival of a Species and this has been identified for the Scott Reef – Browse Island green turtle genetic stock within the Project Area (Section 5.3.2.5.1). Habitat Critical for Survival is the nesting habitat of Sandy Islet and a 20 km internesting buffer at Scott Reef (Commonwealth of Australia, 2017a). There are also nesting and internesting BIAs at Scott Reef (associated with nesting at Sandy Islet) for both the green turtle and hawksbill turtle (Section 5.3.2.5.2).	+ Physical presence: light + Physical presence: electromagnetic emissions + Atmospheric noise emissions + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Production activities: seabed subsidence + Marine discharges: hazardous and non-hazardous inorganic waste + Unplanned vessel interactions with fauna + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Key ecological features	Medium value Designated sensitive Area. Values protected by legislation.	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a key Ecological Feature. ²	The Browse Development Area overlaps with the Continental slope demersal fish communities and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs. The proposed BTL route traverses the Mermaid Shoals KEF and the Ancient coastline surrounding Rowley Shoals KEF and the Ancient coastline at 125 m depth contour KEF (Section 5.3.3.1).	+ Physical presence: seabed disturbance + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: Subsea control fluids + Marine discharges: hydrotest fluid + Marine discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases
Australian marine parks	Medium value (multiple use zones) Designated sensitive area. Values protected by legislation.	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place. ²	The proposed BTL route traverses the Multiple Use Zones (IV) of the ArgoRowley Terrace and Kimberley Marine Parks. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park National Park Zone. Rationale for the route selection of the BTL is provided in Chapter 3 .	+ Physical presence: seabed disturbance + Physical presence: light + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: cooling water + Marine discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
State marine parks and nature reserves	High value Designated sensitive area. Values protected by legislation.	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place. ²	There are no State marine parks within the Project Area, however, the proposed BTL route passes approximately 3 km from the Rowley Shoals Marine Park (Section 5.3.3.2). The Scott Reef Nature Reserve which was designated in 1993 and encompasses South Scott Reef (including Sandy Islet) down to the low mean water mark (Atlas of Marine Protection, 2019). This Nature Reserve protects the physical and ecological features of Scott Reef which are described throughout Section 5, including important nesting and interesting habitat (Habitat Critical for Survival of a Species) for the green turtle.	+ Physical presence: light + Atmospheric noise emissions + Underwater noise emissions + Marine discharges: produced water + Marine discharges: cooling water + Production Activities: seabed subsidence + Marine Discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases
Other protected places	High value Designated sensitive area. Values protected by legislation.	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.² Objective 19: To not have a substantial adverse impact on heritage values²	There are no National Heritage Sites within the Project Area. The closest National Heritage Sites are the Dampier Archipelago (including the Burrup Peninsula) and the Ningaloo Coast (Section 5.4.3.2). There are no World Heritage Sites within the Project Area (Section 5.4.3.3). Commonwealth Heritage Places located within or within the vicinity of the Project Area include Scott Reef and Surrounds – Commonwealth Area, and Mermaid Reef – Rowley Shoals (Section 5.4.3.1).	+ Physical presence: seabed disturbance + Physical presence: light + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: hydrotest fluid + Marine discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
State and Commonwealth managed fisheries	High value marine user Key fishing area, with high importance to stakeholders.	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	State managed commercial fisheries in close proximity to the Project Area include Northern Demersal Scalefish, Mackerel, WA North Coast Shark, Onslow Prawn, Abalone, South West Coast Salmon, Pilbara Fish Trawl, Specimen Shell, Marine Aquarium Fish, West Coast Deep Sea Crustacean and Pearl Oyster Managed Fisheries. The Commonwealth managed fisheries located within the vicinity of the Project Area include the North West Slope Trawl Fishery, the Western Tuna and Billfish Fishery, the Southern Bluefin Tuna Fishery and the Skipjack Tuna Fishery (Western Skipjack Tuna Fishery). In 1974 the Australia-Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf – 1974 (MoU 74) was signed by the Governments of Australia and Indonesia, allowing allowed Indonesian fishers to continue to fish in designated areas using traditional methods only (Sections 5.4.2.1 and 5.4.2.2).	+ Physical presence: disturbance to other users + Physical presence: light + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: subsea control fluids + Marine discharges: hydrotest fluid + Marine Discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Tourism and recreation	High value users Project area has low to medium level of utilisation by stakeholders.	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	Recreation and tourism activities in the NWMR occur predominantly in WA State waters adjacent to coastal population centres (e.g. Broome), with a peak in activity during the winter months (dry season) (Section 5.4.2.6). Only one to two recreational fishing charter operators run trips to Scott Reef. The location has the potential to provide significant opportunities for pelagic sport fishing; however, given the distance from Broome and closest landfall and associated costs, only a limited number of charter operators are prepared to take recreational fishers out to Scott Reef. Those companies that do visit Scott Reef tend to make the trip only four to five times per year, spending around five days at the reef each time. Fishing is mainly focused on the south, west and north extremities of Scott Reef, generally only going into the South Scott Reef lagoon for snorkelling and for layover at night.	+ Physical presence: disturbance to other users + Physical presence: light + Atmospheric noise emissions + Underwater noise emissions + Marine discharges: sewage and sillage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: hydrotest fluid + Production activities: seabed subsidence + Marine Discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Scientific studies	High value users Project area has low to medium level of utilisation by stakeholders.	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	Within the Browse Development Area, scientific research is predominately undertaken at Scott Reef, Rowley Shoals and Ashmore Reef. Given no lasting effect on the Scott Reef system or fauna that may be present in the surrounding waters, the scientific and tourism values within the Project Area are not expected to be reduced (Section 5.4.2.7).	+ Physical presence: disturbance to other users + Physical presence: light + Atmospheric noise emissions + Underwater noise emissions + Marine discharges: sewage and sullage + Marine discharges: treated utility water, chemical and deck drainage + Marine discharges: putrescible waste + Marine discharges: produced water + Marine discharges: cooling water + Marine discharges: drilling or completions discharges + Marine discharges: hydrotest fluid + Production Activities: seabed subsidence + Marine discharges: hazardous and non-hazardous inorganic waste + Physical presences (unplanned): invasive marine species + Unplanned hydrocarbon releases
Shipping	Medium/high value users Busy shipping area is located outside of Project Area, but shipping traffic still likely to be high.	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	Shipping activity in and around the Browse Development Area is sparse, with the main commercial shipping routes located approximately 50 to 100 km west, intersecting the proposed BTL route at various locations, depending on the port. The main shipping activity in the NWMR relates to transits to and from Broome and transportation of goods between Australian and international ports. Major ports are adjacent to the Roebuck, Montebello and Dampier Commonwealth marine reserves (Section 5.4.2.4).	+ Physical presence: disturbance to other users + Unplanned hydrocarbon releases

Receptor	Receptor Sensitivity Level	Environmental objective	Environmental context (local and regional)	Relevant environmental aspects
Industry	Low value The Project Area is not of extensive use by other Industry.	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	The NWMR supports a number of industries including petroleum exploration and production, as well as minerals extraction. There are seven sedimentary petroleum basins in the NWMR: the Northern and Southern Carnarvon basins, Perth, Browse, Roebuck, Offshore Canning and Bonaparte basins. Of these, the Northern Carnarvon, Browse and Bonaparte basins hold large quantities of gas and comprise most of Australia's reserves of natural gas (Section 5.4.2.5).	+ Physical presence: disturbance to other users + Unplanned hydrocarbon releases
Settlements	Medium value users Regionally important, low sensitivity to change.	Objective 22: To protect social surroundings from significant harm.	The proposed Browse to NWS Project presents potential social benefits and impacts to communities within WA and particularly Broome and the Dampier Peninsula, with Broome being the potential primary supply chain and logistics support location (Section 5.4.4).	+ Atmospheric noise emissions + Unplanned hydrocarbon releases
Aboriginal and Indigenous heritage	High value users Browse Development Area is of high importance to stakeholders	Objective 19: To not have a substantial adverse impact on heritage values. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	No known sites of Aboriginal Heritage significance are located within the Development Area, according to the WA Department of Aboriginal Affairs' Aboriginal Sites Inquiry System. The existence of any unknown Aboriginal sites or artefacts of significance within the Browse Development Area, or the wider NWMR, is considered highly unlikely due to the site's remote location offshore (Section 5.4.3.1).	+ Physical presence: disturbance to other users + Atmospheric emissions: third party processing of Browse gas + Marine discharges: drilling or completions discharges + Marine discharges: produced water + Marine discharges: cooling water + Unplanned hydrocarbon releases
Marine archaeology	High value Maritime archaeology protected by legislation exists within the Browse Development Area	Objective 19: To not have a substantial adverse impact on heritage values.	The Australian National Shipwreck Database and the WA Maritime Museum Shipwreck Database list one protected historic wreck within the Browse Development Area. The historic shipwreck of the Yarra is located at South Scott Reef (Section 5.4.3.2).	+ Physical presence: seabed disturbance + Production activities: seabed subsidence + Unplanned hydrocarbon releases

6.3 Impact Assessment and Risk

6.3.1 Physical Presence: Seabed Disturbance

6.3.1.1 Impact and Risk Overview

Table 6-8 presents an overview of the potential impacts and risks from seabed disturbance associated with the physical presence of proposed Browse to NWS Project infrastructure.

Table 6-8 Physical presence: seabed disturbance - impact and risk overview

Aspect	Physical presence: seabed disturbance
Description	Seabed disturbance is associated with the temporary or permanent installation, placement and decommissioning of facilities, infrastructure and equipment, such as the: + FPSO facilities + BTL and inter-field spur line + subsea umbilicals + risers + flowlines + wells + manifolds + anchors + moorings. This includes other associated activities that may cause seabed disturbance such as seabed intervention, seabed preparation, trenching and secondary stabilisation for the BTL and inter-field spur line and wet storage of project infrastructure during construction. There is also a risk of additional unplanned disturbance to the seabed from dropped objects from the facilities and project vessels. The potential impacts associated with seabed disturbance specific to drilling discharges (e.g. drill cuttings and drilling fluids) during development drilling activities are covered in Section 6.3.15.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to seabed disturbance associated with the proposed Browse to NWS Project are Objectives 1, 2, 3, 6, 7, 9, 10, 17, 18 and 19. These objectives are detailed in Table 6-7 .
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect: + WA EPA Environmental Factor Guideline - Benthic Communities and Habitats (EPA, 2016b) + WA EPA Technical Guidance - Protection of Benthic Communities and Habitats (EPA, 2016c) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012) + North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Aspect	Physical presence: seabed disturbance		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. Physical + sediment quality (medium value (open waters)) + water quality (medium value (open waters)) Ecological + plankton (medium value (open water)) + benthic habitat and communities + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + KEFs (medium value) + AMPs (medium value (multiple use zones)) + other protected places (high value) Socio-economic + maritime archaeology (high value)		
Potential impacts	+ change in water quality + change in sediment quality + change in habitat + injury or mortality to fauna + change in heritage values		
Risks	+ turbidity generated during seabed disturbance significantly greater than expected. + dropped objects + damage to unidentified maritime archaeology		
Summary of impact evaluation for governing impact	Magnitude	Impact significance level	Confidence
	Minor	Minor (D)	High
Summary of risk evaluation for governing risk	Consequence	Likelihood	Risk rating
	Slight	Highly unlikely	Low (E0)

6.3.1.2 Source of Aspect

Seabed disturbance will be restricted to deep water within the Project Area and is expected to be approximately 50 km² (including approximately 10 km² allowed for contingency), including:

- + 11.34 km² (including 25% contingency) for wells, subsea infrastructure and moorings within the Browse Development Area (of which approximately 4.15 km² (including 25% contingency) of disturbance will be within the State Proposal Area)
- + 36.94 km² (including 25% contingency) for the BTL and inter-field spur line.
- + An indicative breakdown of the extent of seabed disturbance required for the proposed Browse to NWS Project is provided in [Table 6-9](#). The

largest impact to the seabed will result from the installation of the BTL, inter-field spur line and subsea infrastructure, including seabed intervention and preparation, trenching, secondary stabilisation operations and ongoing maintenance (i.e. IMR activities). The BTL and inter-field spur line route, which accounts for approximately three quarters of the proposed Browse to NWS Project physical footprint, has been selected to minimise seabed preparation, trenching and secondary stabilisation, by avoiding alternative routes with sand waves and shallow water (please refer [Section 3.8.3.2](#)). Seabed preparation, trenching and secondary stabilisation are required for the purpose of ensuring the stability of subsea infrastructure in its given geotechnical, bathymetric and metocean environment.

The scale of seabed disturbance from FPSO mooring (piles or anchors and mooring lines) is expected to be in the order of 1.58 km² (including 25% contingency), with the majority of installation and support vessels using DP systems to maintain position instead of anchoring (noting minor seabed disturbance will occur with the placement of DP transponders). Placement of anchors and/or piles for the MODU(s) and the pipelay vessel (if required during the initiation of pipelay) will be undertaken by support vessels, further reducing the area

of disturbance through the minimisation of anchor drag.

Disturbance from the development of the wells will be minor (in the order of 8.49 km² in total including 25% contingency). The estimated disturbance area includes drilling of the wells and disturbance related to discharge of drill cuttings and cement during development drilling activities (further described in [Section 6.3.15](#)). These values are subject to refinement during the detailed design process.

Table 6-9 Indicative Extent of Seabed Disturbance

Description		No.	Direct Disturbance (km ²)	Indirect Disturbance (km ²)	Total (km ²)
Drilling and Completions					
Wells (long term disturbance)	Calliance	19	0.15	2.24	2.39
	Torosa	29	0.23	3.42	3.64
	Brecknock	6	0.05	0.71	0.75
SURF Footprint					
Flowline network (long term disturbance)	Calliance	1	0.05	0.19	0.24
	Torosa	1	0.12	0.48	0.59
	Brecknock	1	0.04	0.15	0.19
FPSO Installation Footprint					
Pre-lay disturbance (temporary disturbance)	FPSO facilities	2	0.02	0.06	0.08
Facility mooring (long term)	Piles	36	0.07	0.21	0.28
	Mooring lines	36	0.18	0.72	0.90
BTL and Inter-Field Spur-Line Footprint					
Gas export pipelines	BTL	1	9	18	27
	Inter-field spur line	1	0.85	1.70	2.55
Total Expected			10.75	27.87	38.62
Contingency (25%)			2.69	6.97	9.66
Total (including contingency)			13.44	34.84	48.28

Basis:

- 1 Wells have a direct impact radius of 50 m and a total radius of 200 m.
- 2 Flowlines have a 2 m corridor direct impact and a 10 m corridor total impact.
- 3 FPSO piles have a direct impact radius of 25 m and a total radius of 50 m.
- 4 FPSO Mooring lines have a 2 m corridor direct impact for the entire length of chain and a 10 m corridor total impact.
- 5 BTL/Spur line has a 10 m corridor direct impact and a 30 m corridor total impact.

This estimate includes subsea disturbance from all major infrastructure sources. The contingency includes allowance for temporary wet storage during construction, pre lay and post lay of subsea infrastructure activities, allowance for a broader well radius for potential cementing and sedimentation, and other disturbance associated with piling/anchoring (if required).

6.3.1.3 Environmental Impact

Marine sediments

Change in sediment quality

The installation of the subsea infrastructure, BTL and inter-field spur line will result in temporary (in the order of minutes to a few hours) and localised (limited to the immediate disturbance area) displacement of surface sediments in the deepwater areas (125m - 600m deep) of the Project Area. This will result in very low levels of sediment deposition which is likely to be naturally reworked into surface sediment layers through bioturbation. The localised and temporary displacement of sediment and subsequent sediment deposition will not result in any lasting change to particle size distribution or the physio-chemical composition of sediment. As such, no change to sediment quality is expected to occur. Potential impacts associated with resultant sediment deposition on benthic habitats are discussed below.

Water quality

Change in water quality

The displacement of naturally occurring sediments is likely to result in low levels of highly localised (within tens of metres of the disturbance area) increases in turbidity levels at the seabed that will quickly disperse in the oceanic marine environment due to prevailing hydrodynamic conditions. As such, any reduction in water quality will be temporary (ranging in the order of minutes to a few hours) and will be limited to the waters close to the seabed immediately surrounding the disturbance area. No lasting change to the physical or chemical properties of water within the Project Area will occur as a result of seabed disturbance. As the temporary change in water quality will occur at the seabed in waters in excess of 400 m deep, no impacts to amenity will occur. Potential impacts of increased turbidity on benthic habitats are discussed below.

Plankton

Injury or mortality to fauna

Plankton are widely dispersed throughout the water column. Injury/mortality to plankton species may occur due to a change in water quality due to physical alterations to turbidity. Impacts to zooplankton from turbidity are associated with variations in predator prey dynamics which favours plankton feeders over visual feeders (Gophen, 2015), while impacts to phytoplankton occur due to decreases in available light, therefore reducing productivity (Dokulil, 1994).

Due to the temporary and localised nature of changes in water quality, impacts to plankton are not predicted.

Benthic communities and habitats

Change in water quality

Seabed disturbance has the potential to impact benthic habitats (including filter feeding communities) as a result of localised declines in water quality at the seabed due to temporary increases in turbidity. This can adversely affect marine biota by reducing light penetration, thereby reducing growth and productivity (Abdul Wahab, 2019). As described above, changes to water quality will be temporary, highly localised and restricted to near the seabed in the deep waters (125m - 600m deep) of the Project Area. Given that no light dependent biota (e.g. seagrass, corals, macroalgae) exist in these deep waters, no lasting effect to the deepwater benthic communities and habitats outside of the proposed disturbance area are expected to occur as a result of changes in water quality resulting from seabed disturbance.

Change in sediment quality

As described above, seabed disturbance is likely to result in very low levels of localised resuspension of natural sediments within the deep waters of the Project Area. This sediment resuspension and deposition is likely to be naturally reworked into surface sediment layers through bioturbation. The localised and temporary displacement of sediment and subsequent sediment deposition will not result in any change to sediment quality. As such, no lasting effect to benthic communities or habitats will occur.

Change in habitat

Seabed disturbance has the potential to permanently modify or remove the deepwater benthic communities and habitats within the Project Area. No temporary or permanent infrastructure will be placed on Scott Reef. As such, no direct disturbance to the Scott Reef shallow water benthic habitat (<75m bathymetry) will occur, with disturbance restricted to the deepwater habitats of the Project Area. Likewise, no disturbance to Rowley Shoals is expected to occur as a result of the installation of the BTL which at its closest point will be located approximately 2 km from the boundary of the Commonwealth Marine Park at Mermaid Reef. The estimated extent of seabed disturbance required for the proposed Browse to NWS Project is detailed in [Table 6-9](#).

A detailed description of the deepwater benthic habitat within the Browse Development Area and along the BTL and inter-field spur line route is included in [Section 5.3.1](#). Surveys indicate that the areas predicted to be impacted by the infrastructure are sparsely inhabited by benthic filter feeding invertebrate communities, which are well represented within the broader region.

The WA EPA Technical Guidance - Protection of Benthic Communities and Habitats provides the following definitions with respect to impacts to benthic communities and habitats (EPA, 2016c). These definitions have been adopted for the assessment of the proposed Browse to NWS Project as a whole:

- + 'Permanent loss' refers to direct removal or mortality of benthic communities and/or their habitats. Permanent loss of benthic communities and their associated habitats would commonly be associated with activities such as excavation or burial. In almost all cases, these activities directly modify the benthic community and its habitat so significantly that the impacted community would not recover to the pre-impact state.
- + 'Serious damage' means damage to benthic communities and/or their habitats that is effectively irreversible or where any recovery, if possible, would be unlikely to occur for at least 5 years. Serious damage is most often associated with indirect effects of development activities such as chronically elevated suspended sediment levels in the water column (e.g. leading to reduced benthic light and impacts on dependent seagrass or coral communities).
- + 'Reversible impacts or loss' refers to the situation where impacts or losses of benthic communities occur, but there is confidence that the community, and the ecological services it provides, will fully recover within five years.

As shown in [Table 6-9](#), an estimated 13.44 km² of direct seabed disturbance will occur as a result of the proposed Browse to NWS Project. This disturbance will result in the permanent loss of deepwater habitat associated with the development of the wells, installation of subsea infrastructure, FPSO moorings and the installation of the BTL and inter-field spur line, as well as other minor sources of permanent disturbance. This includes an allowance for any required seabed preparation and post lay stabilisation. It should be noted that this permanent loss may be partially compensated for by the creation of artificial hard substrate habitat (i.e. subsea infrastructure) which may be colonised by epifaunal organisms.

While the extent of seabed disturbance that will be required is considerable (primarily due to the significant length of the BTL), the area of permanent loss is considered insignificant due to the nature of the deepwater benthic habitat and the fact that it will be very small fraction of the widespread habitat available regionally.

Of the 13.44 km² direct disturbance, a small portion will be temporary disturbance resulting from activities such as wet storage and the installation of MODU transponders. This will result in reversible loss of deepwater benthic habitat, with benthic biota expected to recolonise the area once the temporary infrastructure

is removed. Studies indicate that benthic infauna and epifauna are likely to recover within three to ten years (Jones et al., 2012).

The deepwater sediment habitat composition and sparse benthic biota to be disturbed is widespread and representative of the region ([Section 5.3.1.2](#)). Given the small area of permanent disturbance, relative to the total area of similar habitat available regionally and expected recolonisation of the seabed with similar benthic biota after the removal of temporary infrastructure, seabed disturbance within the deep waters of the Project Area is not predicted to impact biological diversity or ecological integrity.

Injury or mortality to fauna

Seabed disturbance has the potential to impact epifauna as a result of clogging and damage to the feeding and breathing apparatus of filter feeding organisms (Parr et al., 1998) and smothering when the displaced sediments settle. Given the low level and highly localised nature of such deposition, smothering of biota will be limited to the disturbance footprint in the deep waters of the Project Area and is not predicted to impact biological diversity or ecological integrity.

Key Ecological Features

The Continental slope demersal fish communities and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs overlap with the Browse Development Area, while the BTL traverses the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF and the Ancient coastline at 125 m depth contour KEF.

Change in water quality

As described above, changes to water quality are expected to temporary and highly localised. As such, no adverse effect on the conservation values of KEFs within the Project Area are predicted.

Change in sediment quality

As described above, no lasting change to sediment quality are expected. As such, no adverse effect on the conservation values of KEFs within the Project Area are predicted.

Change in habitat

The Continental slope demersal fish communities KEF is regionally important due to the high levels of demersal fish species endemism and diversity found in this area relative to the region (Commonwealth of Australia, 2012). The Browse Development Area overlaps this KEF and the proposed BTL route will traverse the KEF for approximately 250 km ([Section 5.3.3.1; Figure 5-43](#)). Seabed disturbance will result in physical impacts to the seabed, which is likely to affect associated marine biota. The North-west Marine Plan identifies physical habitat modification as a pressure of 'potential concern' for this KEF (Commonwealth of Australia, 2012).

A survey of the proposed BTL route by Advisian (2019; [Chapter 10, Appendix D.1](#)) sampled six locations spread along this 250 km extent in order to inform this assessment against the ecological values associated with the Continental slope demersal fish communities KEF. The seabed at the sample locations within the KEF was dominated by bare sandy substrates with sparse epifaunal benthic invertebrates observed (Advisian, 2019). In addition, only a small portion of this KEF (< 0.08%) will be traversed by the proposed BTL route. Given this, it is considered that the identified conservation values of this KEF will not be adversely impacted by seabed disturbance associated with the proposed Browse to NWS Project.

The Seringapatam Reef and the Commonwealth waters in the Scott Reef complex KEF are regionally important as they support diverse aggregations of marine life, high primary productivity and high species richness (Commonwealth of Australia, 2012). The Browse Development Area overlaps the Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEF ([Section 5.3.3.1; Figure 5-43](#)). Seabed disturbance within this KEF will occur as a result of the development activities ([Section 6.3.1.2](#)). Seabed disturbance will result in the modification of the physical habitat of the disturbed area, which may affect marine biota utilising these habitats. The North-west Marine Plan identifies physical habitat modification as a pressure of ‘potential concern’ for the Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEF (Commonwealth of Australia, 2012).

As described above, seabed disturbance will only occur in deep waters (125 m - 600 m deep) with no predicted physical disturbance to shallow water habitats associated with coral, seagrass and macroalgae of Scott Reef. Surveys indicate that the areas predicted to be impacted by seabed disturbance are sparsely inhabited and well represented within the broader region. Habitat modification will occur to a very small fraction (approximately 0.1%) of the widespread available representative deepwater habitat within the KEF and, as such, are not expected to materially reduce primary production or effect species richness. Given this, it is considered that the identified conservation values of this KEF will not be adversely impacted by seabed disturbance associated with the proposed Browse to NWS Project.

Mermaid Reef and the Commonwealth waters surrounding the Rowley Shoals are recognised as areas of high species aggregation and high species richness associated with high productivity caused by wave action within the reef areas (Commonwealth of Australia, 2012). The proposed BTL route may traverse an inshore portion of the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF, although this is dependent on the final route selection ([Figure 5-43](#)). Should the proposed BTL route traverse the KEF, this would result in seabed disturbance and subsequent

modification of the physical habitat of the disturbed area, which could affect marine biota utilising these habitats. The North-West Marine Plan identifies physical habitat modification as a pressure of ‘potential concern’ for the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF (Commonwealth of Australia, 2012).

A benthic habitat survey along the proposed BTL route was completed, with four sites surveyed within this KEF (Advisian 2019; [Chapter 10, Appendix D.1](#)). Results from the sites surveyed did not identify any complex seabed features or increased species richness, or other values associated with this KEF. Habitat modification will occur in a very small fraction of the available representative deepwater habitat within the KEF and, as such, is not expected to materially reduce primary production or effect species richness. Given this, it is considered that the identified conservation values of this KEF will not be adversely impacted by seabed disturbance associated with the proposed Browse to NWS Project.

The Ancient coastline at 125 m depth contour is regionally significant as it is a unique seafloor feature with hard substrates and complex topography, which is thought to facilitate vertical mixing of the water column (promoting productivity) and provide benthic habitats in an area otherwise dominated by soft sediments (Commonwealth of Australia, 2012). The proposed BTL route traverses approximately 40 km of this KEF at the southern end of the proposed BTL route near the NRC tie in point ([Figure 5-43](#)). This represents a very small portion of this KEF, which extends along much of the WA coastline.

Advisian (2019) surveyed three locations along the proposed BTL route within this KEF. Survey results did not identify values associated with this KEF (as described in the North-west Marine Plan). Substrates consisted of sand with varying proportions of silt and clay, with no evidence of harder seabed substrates or rocky escarpment (Advisian, 2019). Only a small portion of this KEF (< 0.025%) will be traversed by the proposed BTL route. Given this, it is considered that the identified conservation values of this KEF will not be adversely impacted by seabed disturbance associated with the proposed Browse to NWS Project

Injury or mortality to fauna

As described above, impacts to fauna will be limited to epifauna in a very small fraction of the deep waters of the KEFs. Given this, it is considered that the identified conservation values of KEFs will not be adversely impacted by seabed disturbance associated with the proposed Browse to NWS Project.

Summary

[Table 6-10](#) provides an assessment of the proposed seabed disturbance in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-10 Assessment of proposed activities in relation to relevant pressures on KEFs - seabed disturbance

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the Northwest Marine Region (Commonwealth of Australia, 2012).	Physical habitat modification	Given that disturbance leading to physical modification of benthic communities and habitats will occur to a very small fraction of deepwater benthic habitats that are well represented both within each of the KEFs in the Project Area, and regionally, there is a high level of confidence that disturbance will not result in an adverse impact to marine ecosystem function or integrity with in the KEFs; or that any reduction in to the conservation values of the KEFs will occur.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals			
Ancient coastline at 125 m depth contour		None noted	

Australian Marine Parks

The proposed BTL route traverses the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley Marine Parks. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park National Park Zone. The rationale for selection of the BTL route is provided in [Chapter 3](#). The North-west Marine Parks Network Management Plan (Director of National Parks, 2018) outlines the objectives of the Multiple Use Zone (VI) multi use zones traverse by the BTL as “to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species”.

Change in water quality

As described above, changes to water quality are expected to temporary and highly localised. As such, the objectives of the AMPs within the Project Area will be achieved.

Change in sediment quality

As described above, no lasting change to sediment quality are expected. As such, the objectives of the AMPs within the Project Area will be achieved.

Change in habitat

Installation of the BTL and associated activities will result in seabed disturbance and permanent habitat modification in the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley Marine Parks. No seabed disturbance is planned in the Mermaid Reef Marine Park National Park Zone.

The Argo-Rowley Terrace Marine Park provides protection for the ecological communities and habitats of the deeper offshore waters of the region, in water depths ranging from 220 to 6,000m. This includes protection for many bathymetric features, including aprons and fans, canyons, continental rise, knolls/abyssal hills and the terrace and continental slope (Director of National Parks, 2018). The proposed BTL route traverses Multiple Use Zones of the Argo-Rowley Terrace AMP for approximately 97 km ([Figure 5-44](#)).

The Kimberley Marine Park provides protection for habitats and ecological communities in waters offshore of the Kimberley coastline, ranging in water depths from less than 15 to 800m. The Kimberley Marine Park supports a range of protected species and BIAs. The proposed BTL route traverses through the Multiple Use Zones of the Kimberley AMP for approximately 68 km ([Figure 5-44](#)).

The North-West Marine Region is vulnerable to physical habitat modification due to pressure from increasing large-scale projects associated with the resources sector, therefore, physical habitat modification is a priority for conservation effort in this region (Commonwealth of Australia, 2012).

The area traversed by the proposed BTL represents a small proportion of the total area of the AMPs. The majority of the proposed BTL route traverses depths of between 280 and 440m which are too deep for the establishment of seagrass, macroalgae or light-dependent coral communities. A benthic habitat survey along the proposed BTL route sampled six locations within the AMPs (two in the Kimberley Marine Park and four within the Argo-Rowley Terrace Marine Park). Analysis of the benthic imagery found that the seabed along the BTL route within the AMPs was predominantly composed of unconsolidated soft sand, largely devoid of epibenthic communities, with occasional solitary non-coral benthic invertebrates (Advisian, 2019). The modification of a small fraction of the available representative deepwater habitat within the AMPs is not expected to materially reduce primary production or effect species richness. Given this, the proposed activities are considered to be not inconsistent with the objective of the Multiple Use Zone (VI) to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.

Injury or mortality to fauna

As described above, impacts to fauna will be limited to a very small fraction of deepwater epifaunal communities within the AMPs. Given this, it is considered that seabed

disturbance will not adversely affect marine fauna within the AMPs and the proposed activities are considered to be not inconsistent with the objective of the Multiple Use Zone (VI) to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.

Summary

Table 6-11 provides an assessment of the proposed seabed disturbance in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Table 6-11 Alignment with the North-west Marine Parks Network Management Plan – physical presence: seabed disturbance

Australian Marine Park	Relevant plan(s)	Australian Marine Park Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	The BTL survey did not identify any sensitive biota or species of conservation significance within AMPs along the proposed BTL route. Given that seabed disturbance will occur in a very small fraction of deepwater benthic habitat that is well represented both within each of the AMPs in the Project Area, and regionally, there is a high level of confidence that seabed disturbance will not result in an adverse impact to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
Kimberley Marine Park Multi Use Zone (VI)			
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, no direct or indirect impacts from seabed disturbance are predicted to occur in this AMP with no effects on ecosystems, habitats or native species in the AMP predicted. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other protected places

Change in sediment quality, change in water quality, change in habitat, injury or mortality to fauna

No seabed disturbance will occur within the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places, with planned disturbance only occurring in deep water benthic communities and habitat. As such, it is considered that the conservation values of these protected places will be maintained.

Maritime archaeology

Change in heritage values

Known maritime archaeological sites in the vicinity of the Project Area (including ship wrecks on Scott Reef) are described in [Chapter 5](#). Due to the distance of these sites from the proposed infrastructure, impacts to these sites are not expected to occur.

6.3.1.4 Environmental Risk

Risk event: Turbidity generated during seabed disturbance significantly greater than expected

Turbidity generated during seabed disturbance significantly greater than expected would potentially result in:

- + increased spatial extent of impacts to deepwater benthic communities and habitats (including within KEFs and AMPs) as a result of increased suspended sediment concentrations and sediment deposition rates
- + sediment deposition on the shallow water benthic communities and habitats.

Given the sparse nature of the deepwater habitats and the small fraction of the KEFs and AMPs that would be impacted, the likelihood that increased spatial extent of impacts to deepwater benthic communities and habitats

would result in adverse impacts to biological diversity or ecological integrity, or the conservation values of the KEFs or AMPs, is considered remote, with a subsequent risk rating determined to be low.

The displacement of sediments is likely to result in localised (within tens of metres of the disturbance area) and temporary increases in turbidity at the seabed. This turbidity will quickly disperse in the oceanic marine environment due to prevailing hydrodynamic conditions and, therefore, the likelihood of any resultant ecological impacts to Scott Reef, the Rowley Shoals, or nearby protected places (i.e. Mermaid Reef Marine Park, Scott Reef and Surrounds Commonwealth Heritage Place or Mermaid Reef - Rowley Shoals Commonwealth Heritage Place) occurring has been assessed as remote, with the subsequent risk rating determined to be low.

Risk event: Dropped objects

Objects such as tools and equipment may be lost as a result of being accidentally dropped from the MODU, FPSOs and vessels during the proposed Browse to NWS Project. Operator error, bad weather events or failure of equipment may lead to such loss. Depending on the size and nature of the dropped object, impacts could include temporary or permanent modification of habitat (depending on whether the object can be re-located and retrieved), localised and temporary sedimentation, temporary reduction in water quality or injury or mortality to marine fauna. Dropped objects which have the potential to cause significant seabed disturbance are limited, with the chance of this occurring restricted mainly to the construction and decommissioning phases of the proposed Browse to NWS Project.

Given the Project Area encompasses four KEFs and the BTL crosses two AMPs, there is a potential for dropped objects to occur within these areas. The likelihood of a dropped object causing significant disturbance to the seabed in the deep waters of the Project Area has been assessed as highly unlikely, with the subsequent risk rating determined to be low. Given that no activities are planned within the Scott Reef system (defined as the area above the 75 m bathymetric contour), the likelihood of a dropped object event occurring resulting in impact to Scott Reef shallow water benthic habitat (<75 m bathymetry) has been assessed as remote, with the subsequent risk rating determined to be low.

Risk event: Damage to unidentified maritime archaeology

Change in heritage values

During installation of temporary and permanent infrastructure, there is a potential for unidentified historic ship wrecks and plane wrecks to be impacted. Benthic habitat and geophysical surveys along the proposed BTL route have not identified any potential cultural heritage sites. Therefore, the likelihood of damage occurring to maritime archaeology as a result of a dropped object is considered remote, with the subsequent risk rating determined to be low.

6.3.1.5 Cumulative Impacts

Cumulative impacts resulting from seabed disturbance (both from multiple project activities and other developments in the area) are highly unlikely given the relatively small physical footprint of the proposed activities within the context of the sparsely distributed deepwater benthic communities and habitats of the Project Area, the distance to other developments in the region and the location of the proposed Browse to NWS Project in offshore waters. Given this likelihood, the magnitude of the impact (slight) and the nature of the receptors (deepwater benthic habitat), cumulative impacts from the physical presence of infrastructure, wet storage, FPSOs, MODUs and project vessels are not expected to result in reductions in biological diversity or ecological integrity in the Project Area.

6.3.1.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact and risk assessments and the adopted controls for physical presence: seabed disturbance is provided in [Table 6-12](#) and [Table 6-13](#). The final acceptability assessment is provided in [Table 6-14](#).

Table 6-12 Impact assessment summary and adopted controls – physical presence: seabed disturbance

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Sediment quality (medium value (open waters))	+ Change in sediment quality	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.	<u>Development drilling</u> + No infrastructure will be placed on Scott Reef shallow water benthic communities and habitat (<75 m bathymetry). + No moorings for the MODUs will be installed in the Scott Reef shallow water benthic communities and habitat (<75 m bathymetry). <u>Installation of subsea infrastructure</u> + Moorings for the FPSO facilities will be located outside of the State waters 3 nm boundary. + No moorings will be installed within the lagoon at North and South Scott Reef. + Secondary stabilisation of subsea infrastructure will be limited to the level necessary to ensure pipeline integrity. + Vessels will be required to comply with an anchoring management plan which will include mooring analysis, with the requirement to avoid placing anchors on sensitive receptors.	No lasting effect	Negligible (F)
Water quality (medium value (open waters))	+ Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.		No lasting effect	Negligible (F)
Plankton (medium value (open water))	+ Injury or mortality to fauna	Objective 7: To not have a substantial adverse effect on a population of plankton, including its lifecycle and spatial distribution.		No lasting effect	Negligible (F)

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Deepwater benthic communities and habitats (>75 m depth) – (medium value)	+ Change in water quality + Change in sediment quality + Change in habitat + Injury or mortality to fauna	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.	<u>Installation of the BTL and inter-field spur line</u> + The BTL and inter-field spur line will be located in Commonwealth waters at least 3 nm from Scott Reef shallow water benthic communities and habitat (<75 m bathymetry).	Minor	Minor (D)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	+ Change in water quality + Change in sediment quality + Change in habitat + Injury or mortality to fauna	Objective 9: To avoid direct (i.e. physical footprint) disturbance to Scott Reef shallow water benthic habitat (<75 m bathymetry). Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry)	+ DP pipeline vessels will be used during BTL and inter-field spur line installation (except for initial anchoring to commence the pipeline activity). + Activities will be conducted in a manner not inconsistent with the objectives, values and principles of the multi-use zones of the AMPs which are traversed by the BTL route.	No impact predicted	No impact predicted
KEFs (medium value)	+ Change in water quality + Change in sediment quality + Change in habitat + Injury or mortality to fauna	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
Australian marine parks (medium value (multiple use zones))	+ Change in water quality + Change in sediment quality + Change in habitat + Injury or mortality to fauna	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Negligible (F)
Other protected places				No impacted predicted	No impacted predicted

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Maritime archaeology (high value)	+ Change in heritage values	Objective 19: To not have a substantial adverse impact on heritage values.	Shipwrecks, plane wrecks or other underwater cultural heritage sites identified during surveys or installation activities will be avoided and reported in accordance with the Underwater Cultural Heritage Act 2018	No impact predicted	

Table 6-13 Risk assessment summary and adopted controls – physical presence: seabed disturbance

Receptor	Risk Events	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Sediment quality (medium value (open waters))	+ Turbidity generated during seabed disturbance significantly greater than expected.	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.	Lifting procedures and measures to avoid impact resulting from dropped objects will be implemented.	No increase to significance/consequence		
Water quality (medium value (open waters))		Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.		No increase to significance/consequence		
Plankton (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No increase to significance/consequence		

Receptor	Risk Events	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Deepwater benthic communities and habitats (>75 m depth) – (medium value)	+ Turbidity generated during seabed disturbance significantly greater than expected.	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results		No increase to significance/consequence		
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	+ Dropped objects	Objective 9: To avoid physical footprint disturbance to Scott Reef shallow water benthic habitat (<75 m bathymetry) Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		Slight	Remote	Low (EO)
KEFs (medium value)		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No increase to significance/consequence		
Australian marine parks (medium value (multiple use zones))		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
Other protected places (high value)	+ Turbidity generated during seabed disturbance significantly greater than expected.	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
Maritime archaeology (high value)	+ Damage to unidentified maritime archaeology.	Objective 19: To not have a substantial adverse impact on heritage value.		Slight	Remote	Low (EO)

Table 6-14 Acceptability assessment – physical presence: seabed disturbance

Acceptability Assessment
Confidence in assessment Woodside has a high level of certainty with respect to the assessment of the potential impacts and risks associated with seabed disturbance, as: + Surveys have characterised the deepwater benthic communities and habitats that may be impacted by seabed disturbance. + The deepwater benthic biota that may be impacted are sparse and well represented both in the Project Area and regionally. + No seabed disturbance will occur to shallow water benthic habitats (e.g. at Scott Reef and Rowley Shoals). + The proposed controls are standard controls widely employed in industry and proven to mitigate the potential impacts and risks effectively. + Suitable contingency has been allowed in seabed disturbance estimates appropriate for the current design stage of the proposed Browse to NWS Project.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objectives for each potentially impacted receptor will be achieved. As such, it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines Listed threatened species and ecological communities/listed migratory species + No adverse impacts to listed threatened or migratory species are predicted. + No threatened ecological communities exist in the Project Area. Commonwealth marine environment As described in Table 6-12, the potential impact from physical presence: seabed disturbance to sediment quality, water quality, plankton, KEFs and AMPs has been assessed as Negligible (F). Minor (D) impacts may occur to deepwater benthic communities and habitats (>75 m depth), while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth), other protected places or maritime archaeology. As described in Table 6-13, potential risk events present a Low risk to shallow water benthic communities and habitats (<75 m depth) and maritime archaeology. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each potentially impacted receptor will be achieved. As such, no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted National heritage places No impacts to national heritage places are predicted within the Project area. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of physical presence: seabed disturbance against the WA EPA Objectives is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)). This includes State Proposal Area specific disturbance area estimates.

Marine environmental quality

As described in [Table 6-12](#), the potential impact from physical presence: seabed disturbance to sediment quality, water quality and plankton has been assessed as Negligible (F). Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors and the WA EPA environmental objective “*To maintain the quality of water, sediment and biota so that environmental values are protected*” will be achieved.

Benthic communities and habitats

As described in [Table 6-12](#), Minor (D) impacts may occur to deepwater benthic communities and habitats (>75 m depth), while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth). As described in [Table 6-13](#), potential risk events present a Low risk to shallow water benthic communities and habitats (<75 m depth). Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors and the WA EPA environmental objective “*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*” will be achieved.

Marine fauna

Impacts to epifauna and infauna are included in the above assessment of impacts to benthic communities and habitats. No other impacts to marine fauna are predicted as a result of seabed disturbance.

Conclusion: Acceptable

External context

To date, there have been no specific matters raised by stakeholders regarding physical presence: seabed disturbance in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Conclusion: Acceptable

Other requirements

EPBC Act recovery and conservation plans and advices

Impacts to listed threatened species from seabed disturbance are not predicted. As such, no relevant EPBC Act recovery and conservation plans and advices apply in relation to seabed disturbance.

KEFs

As detailed in [Table 6-10](#), the proposed seabed disturbance will not materially increase existing relevant pressures on the conservation values of KEFs.

AMPs

As detailed in [Table 6-11](#), the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other Protected Places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.2 Physical Presence: Disturbance to Other Users

6.3.2.1 Impact and Risk Overview

Table 6-15 presents an overview of the potential impacts and risks from disturbance to other users associated with the physical presence of proposed Browse to NWS Project infrastructure.

Table 6-15 Physical presence: disturbance to other users impact and risk overview

Aspect	Physical presence: disturbance to other users		
Description	Disturbance or displacement of other users from the Project Area may occur due to the physical presence of infrastructure and associated exclusion zones and activities including: + surveys + vessel operations + MODU operations + helicopter operations + installation and operations of the subsea infrastructure, BTL and inter field spur line + installation and operations of the FPSO, including condensate offtake tankers + removal of infrastructure.		
Area	Project Area, Browse Development Area, State Proposal Area		
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning		
Environmental objectives	The environmental objectives in relation to disturbance to other users associated with the proposed Browse to NWS Project are Objectives 19, 20 and 21. These objectives are detailed in Table 6-7 .		
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect: + Commonwealth Navigation Act 2012.		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5 . Socio-economic + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value users) + scientific studies (high value users) + shipping (medium/high value users) + industry (low value) + Aboriginal and indigenous heritage (high value users)		
Potential impacts	Changes to the functions, interests or activities of other users		
Risks	There are no anticipated environmental risks in relation to this aspect associated with unplanned incidents or events.		
Summary of impact evaluation for governing impact	Magnitude	Impact significance level	Confidence
	Slight	Minor (D)	High
Summary of risk evaluation for governing risk	Consequence	Likelihood	Risk rating
	n/a	n/a	n/a

6.3.2.2 Source of Aspect

Disturbance or displacement of other users from the Project Area may occur due to the physical presence of infrastructure and associated exclusion zones and activities, including:

- + surveys
- + vessel operations
- + MODU operations
- + helicopter operations
- + installation and operations of the subsea infrastructure, BTL and inter field spur line
- + installation and operations of the FPSO, including condensate offtake tankers
- + removal of infrastructure.

During development drilling, construction and operations, non-project vessel movements will be restricted in proximity to the MODU(s) and FPSO facilities via the implementation of a 500 m petroleum safety zone. The pipelay vessels will move along the BTL and inter-field spur line route at a rate of up to approximately 5 km/day (depending on the pipelay vessel and operational conditions such as sea state). A petroleum safety zone will be established around the pipelay vessel during installation of the BTL and inter-field spur line.

6.3.2.3 Environmental Impact

Physical presence of vessels, MODU, BTL and inter-field spur line, and FPSO facilities and the use of helicopters are likely to result in localised changes to the functions, interests or activities of other users. The duration of change will depend upon the activity or duration for which the vessel and/or MODU is required. In the case of the FPSO, BTL and inter field spur line, and subsea infrastructure presence, the change will be permanent for the duration of the field life.

State and Commonwealth managed fisheries

Changes to the functions, interests or activities of other users

Four Commonwealth and 11 WA State fisheries overlap the Project Area, in particular the BTL ([Figures 5-47 to Figure 5-50](#)). Of these, six fisheries have been assessed as having the potential to operate within the Project Area, with two of these fisheries being of particular importance given the use of trawl fishing methods. Potential impacts to commercial fisheries include damage to fishing gear and a reduction of commercial catch due to displacement from fishing grounds. Subsea infrastructure such as flowlines, wellhead and manifolds present the greatest snag hazard risk.

During installation of the subsea infrastructure and during survey and drilling activities, the presence of vessels (and MODU) within the Browse Development

Area will present a surface hazard to fishing vessels. During drilling activities, a 500 m safety exclusion zone will be designated around the MODU and, once operational, the FPSO facilities will also have a 500 m radius safety exclusion zone. This will result in short term exclusion during drilling and installation and longer-term exclusion during the operational phase.

Given the distance offshore, the Project Area is not an area of high commercial fishing activity. Furthermore, the 500 m safety exclusion zone around the MODU and FPSO comprises a relatively small area when compared to the extent of the fisheries. As such, displacement of commercial fisheries due to the proposed project activities is not expected to impact commercial fishing activities or the economic viability of the fisheries.

Following construction and development drilling, infrastructure on the seabed will present a potential snagging risk to commercial fishers. The Commonwealth North West Slope Trawl Fishery (NWSTF) and the State Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF) overlap the Project Area and the proposed BTL, where snagging is likely to be the greatest risk. However, given the low fishing effort expected within the Project Area and that the BTL, inter-field spur line and development wells will be marked on navigational charts, the risk of snagging is considered low. As the FPSO facilities and well locations are in water depths greater than 350 m, with no known subsea features of significance for fish populations in the area, it is not considered that the loss of access to fishing grounds within the petroleum safety zones (representing a fraction of the area of the fisheries) will affect current fishing levels in the region.

Recreation and tourism

Changes to the functions, interests or activities of other users

Scott Reef is used for tourism and recreation (primarily diving and fishing charters) at low levels. Given the proposed locations of the FPSO facilities, MODU and subsea infrastructure within deep waters off the reef, it is not considered that the physical presence of infrastructure will reduce the recreation and tourism value of Scott Reef.

Scientific research

Changes to the functions, interests or activities of other users

Scientific research is occasionally undertaken at Scott Reef within the Browse Development Area. A number of marine research and monitoring programs have been ongoing, particularly those conducted by AIMS and the WA Museum. WA DoF also conducts monitoring and research programs within the region. Given that no direct disturbance is planned to Scott Reef (the feature of interest for ongoing research activities), the frequency of the monitoring programs, the small

area of exclusions resulting from the establishment of the 500 m petroleum safety zones and the planned ongoing consultation with relevant stakeholders, it is not anticipated that the proposed Browse to NWS Project will result in the reduction of the scientific research values of the Scott Reef system.

Shipping

Changes to the functions, interests or activities of other users

Although no main commercial shipping fairways cross the Browse Development Area, the proposed BTL route in the broader Project Area traverses a number of shipping fairways and areas of higher shipping density ([Section 5.4.2.4](#)). Given this, impacts to shipping traffic are expected to be limited to temporary disruptions to shipping during BTL installation activities and intermittent IMR activities along the proposed BTL route. Impacts from this disruption will be limited to vessels taking an alternate route around the exclusion areas. No impacts to shipping are expected during the operations of the BTL.

Industry

Changes to the functions, interests or activities of other users

There are several approved and prospective petroleum developments in the vicinity of the Browse Development Area, including the operating Shell Prelude FLNG and INPEX Ichthys projects located 140 km and 105 km away, respectively. In addition, the BTL passes through several exploration and production permits with a variety of titleholders, crossing existing trunklines. Displacement of, or interference with, other oil and gas activities is not expected within the Browse Development Area. However, activities associated with the trunkline, such as trunkline installation, may result in short term interference, particularly at the NRC location (5-10 km away). Once installed, the presence and operation of the trunkline will not result in significant interference with other petroleum activities e.g. seismic activities. Such facilities will be regularly serviced by offshore support vessels; however, through the implementation of a 500m petroleum safety zone, it is considered highly unlikely that the operation of these facilities to be affected.

Aboriginal and indigenous heritage

Changes to the functions, interests or activities of other users

Indonesian fishers (permitted in accordance with MoU 74) generally visit Scott Reef between July and October, fishing using traditional methods such as reef gleaning, free-diving and hand lining ([Section 5.4.2.3](#)). Fishing is generally limited to the shallow waters around the reef and traditional fishing vessels are only present in deep waters during transit to and from reef locations.

The presence of a MODU, FPSOs and vessels may have the potential to slightly disrupt their transit within the area. Drilling and installation activities, however, will only restrict passage through a relatively small, deepwater area of the broader Scott Reef system.

6.3.2.4 Environmental Risk

There are no anticipated environmental risks in relation to disturbance to other users associated with unplanned events or incidents.

6.3.2.5 Cumulative Impacts

Cumulative impacts resulting from the physical presence of infrastructure (both from multiple project activities and other developments in the area) are highly unlikely given the large distances between developments in the area.

6.3.2.6 Impact Assessment Summary and Acceptability Assessment

A summary of the impact assessment and the adopted controls for physical presence: disturbance to other users is provided in [Table 6-16](#). The final acceptability assessment is provided in [Table 6-17](#).

Table 6-16 Impact assessment summary and adopted controls – physical presence: disturbance to other users

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
State and Commonwealth managed fisheries (high value marine user)	+ Changes to the functions, interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	Physical presence of infrastructure + A 500m petroleum safety zone around the FPSO facilities, MODUs and installation vessels will be gazetted under Section 616 of the OPGGS Act. + FPSO facilities and the BTL will be gazetted and included on navigational charts, with a notice to mariners issued through the Australian Hydrographic Service to alert other users of their location. + Operational radar and vessel tracking equipment will be in place on the FPSO facilities in accordance with Marine Order 30 (Prevention of Collisions) and Marine Order 21 (Safety and Emergency Arrangements). + Ongoing consultation with commercial fishers, recreational fishing groups and other relevant stakeholders that operate in the Project Area will be undertaken. + FPSO facilities will be located away from shipping lanes and approach and exit paths to Scott Reef that traditional Indonesian fishers would be likely to take. + Activities will not be conducted in a manner inconsistent with the Objectives of the respective zones of the AMPs, the Principles of the IUCN Area Categories of the Values of the AMPs.	Slight	Minor (D)
Other users including tourism and recreation, scientific studies (high value users),	+ Changes to the functions, interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Slight	Minor (D)
Shipping (medium/high value user)	+ Changes to the functions, interests or activities of other users			Slight	Minor (D)
Industry (low value user)	+ Changes to the functions, interests or activities of other users			Slight	Negligible (F)
Aboriginal and indigenous heritage (high value users)	+ Changes to the functions, interests or activities of other users	Objective 19: To not have a substantial adverse impact on heritage values. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Slight	Minor (D)

Table 6-17 Acceptability assessment – physical presence: disturbance to other users

Acceptability Assessment
Confidence in assessment Woodside has a high level of certainty with respect to the assessment of the potential impacts associated with disturbance to other users as: + there is a good understanding of the users operating within the Project Area + the area across which other users operate is large in relation to the Project Area + FPSO facilities will not block shipping lanes or access to Scott Reef for traditional fishers.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such, it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines Disturbance to other users is not relevant to any of the controlling provisions identified in the DoEE's decision notice on the referral of the proposed Browse to NWS Project under the EPBC Act. Conclusion: Acceptable
WA EPA Environmental Objectives Disturbance to other users is not relevant to any of the EPA Environmental Factors identified in the EPA determination on the referral of the proposed Browse to NWS Project under the EP Act. Conclusion: Acceptable
External context As part of previous stakeholder consultation undertaken for previous development concepts, stakeholders raised concerns about the potential exclusion from some areas of the NWSTF, with subsequent commercial impacts to users. Impacts on commercial fisheries are not expected to be significant and, with the proposed management measures to be implemented, significant impacts on key target species of the NWSTF and their habitats are not expected. However, Woodside appreciates that the proposed Browse to NWS Project has the potential to impact the NWSTF in areas where the fishery overlaps with the subsea infrastructure and activities associated with the Calliance reservoir and BTL. Consultation with affected and interested fisheries continue as part of broader stakeholder engagement and will be ongoing throughout the life of the proposed Browse to NWS Project. Woodside seeks to minimise the impacts of development activities through two-way communication. If there is a potential for a material ongoing impact on existing marine activities, Woodside will consult with specific individuals or groups of marine users who may be affected on a case-by-case basis. Conclusion: Acceptable
Internal context This impact assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline (Section 6.2) The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System. Conclusion: Acceptable
Other requirements None identified. Conclusion: Acceptable

6.3.3 Physical Presence: Light

6.3.3.1 Impact and Risk Overview

Table 6-18 presents an overview of the potential impacts and risks from light emissions associated with the physical presence of offshore facilities, MODU and vessels during all phases of the proposed Browse to NWS Project.

Table 6-18 Physical presence: light impact and risk overview

Aspect	Physical presence: light
Description	Light emissions will occur from the offshore facilities, MODU and project vessels during all phases of the proposed Browse to NWS Project. This will include light emission for: + navigation + operational + safety reasons + intermittent flaring and pilot gas (fuel gas supplied to keep the flare alight). The amount of light that will be emitted will vary based on a number of factors, including flaring frequency and duration, the number of activities being undertaken in the field, the location and/or placement of light fittings and the intensity and wavelength of the light source.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to light emissions associated with the proposed Browse to NWS Project are Objectives 5, 6, 7, 10, 11, 12, 13, 14, 16, 18, 20 and 21. These objectives are detailed in Table 6-7 .
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-23). + WA Biodiversity Conservation Act 2016 (Wildlife Conservation (Specially Protected Fauna) Notice 2018) + WA Environment Protection Authority – Environmental Factor Guideline – Marine Fauna + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a) + Draft National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia 2019) + North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Aspect	Physical presence: light		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. Physical + ambient light (medium value (open water)) Ecological + plankton communities (medium value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + fauna + seabirds and migratory shorebirds (high value species) + fish (high value species) + marine reptiles (high value species) + Australian marine parks (medium value (multiple use zones)) + State marine parks and nature reserves (high value) + other protected places (high value) Socio-economic + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value users) + scientific studies (high value users)		
Potential impacts	+ change in ambient light + change in fauna behaviour + injury or mortality to fauna + changes to the functions, interests or activities of other users		
Risks	There are no anticipated environmental risks in relation to this aspect associated with unplanned incidents or events.		
Summary of impact evaluation for governing impact	Magnitude	Impact significance level	Confidence
	Slight	Minor (D)	High
Summary of risk evaluation for governing risk	Consequence	Likelihood	Risk rating
	n/a	n/a	n/a

6.3.3.2 Source of Aspect

Lighting from the proposed project activities will be long term, that is, over the life of the project. Artificial light emissions will be generated from two main sources:

- + Navigational and operational lighting – these functional lighting sources are required on vessels, MODU and FPSO facilities at levels that provide a safe working environment for personnel and ensure maritime shipping safety. This lighting typically consists of bright white (i.e. metal halide, halogen, fluorescent) lights and is not dissimilar to lighting used for other offshore activities, including fishing

and shipping. Typical FPSO lighting is from LED lights, with only a small number of high-pressure sodium floodlights. On average, illumination levels of approximately 200 Lux will be used in outdoor operational areas, with the exception of lighting for navigation and collision prevention. Lighting is considered standard and is restricted to the amount required for safe operations and navigational requirements.

- + Flaring - During hydrocarbon processing, flare stacks are used for burning off flammable gas released by pressure release valves (referred to as flaring). Light emissions are associated with intermittent flaring from the FPSOs and MODU. These will vary in duration and intensity. There will be no continuous flaring during normal operations, with the exception of pilot gas and compressor seal gas. Flaring most often takes place during start-ups and shutdowns or in emergency events.

Light emissions in State waters will occur only during the construction phases (i.e. drilling and installation activities) and during infrequent IMR activities during routine operations.

Light sources and, therefore, light emissions within the Browse Development Area will vary depending on the phase of the proposed Browse to NWS Project. It is likely that the footprint from light emissions will be highest during the construction phase (i.e. drilling and installation) due to the presence of multiple vessels and MODUs. Light sources are likely to be reduced during routine operations as primary light sources will be from the FPSOs. Lighting from MODU operations will be transient at each drill centre (typically in the order of two to three months per well), with flaring associated with well unloading only in the order of 1-2 days per well.

Light emissions will also be generated as part of the proposed BTL and inter-field spur installation activities, however, these emissions are likely to be temporary and minor. This is because the pipelay vessels will move along the proposed BTL route and inter-field spur line route at a rate of up to approximately 5 km/day (depending on the pipelay vessel and operational conditions such as sea state) meaning light emissions in any one area will be short term. Once the BTL and inter-field spur lines are operational, there will be no ongoing light emissions except occasional vessel lights during IMR activities.

6.3.3.3 Light Modelling Studies

To further understand the effects of light emissions on sensitive receptors (particularly green turtles), a line of sight assessment and a light density (luminous flux density) modelling study were conducted as part of the approved Browse FLNG Development EIS developed in 2014. A comparison between the proposed Browse to NWS Project and the previously proposed Browse FLNG Development is presented in [Section 3](#). Given the similarities between the concepts, these previous studies adequately defined the potential impacts from artificial light emissions associated with the proposed Browse to NWS Project.

The studies of the proposed Browse FLNG Development assessed light emission impacts from:

- + lighting on a drill rig during drilling activities at the TRE drill centre (ERM, 2010)⁵, refer to [Figure 6-5](#) for location
- + lighting on the proposed FLNG facilities at Torosa, Brecknock and Calliance (Jacobs and SKM, 2014)⁶, refer to [Figure 6-6](#) for location.

The overall artificial light spill area from the proposed Browse to NWS Project is likely to be smaller than the previously proposed Browse FLNG Development due to the reduced number of facilities and the significantly reduced size, and as such presents conservative representation of the permanent infrastructure light sources.

The TRE drill centre was the closest to the most sensitive receptor location (Sandy Islet) and light emissions from the MODU are expected to exceed those of other project vessels at TRE. A MODU at TRE is therefore the governing scenario for light emissions associated with temporary activities.

Given these facilities in proximity to the sensitive receptors of Scott Reef have been identified as the governing scenarios, modelling of other light sources, which either have less light emissions or are further away from sensitive receptors, are not deemed a requirement of the impact assessment. Further, emergency flaring will be intermittent and of a short-term duration and, therefore, not assessed further.

Line of sight assessment

A line of sight assessment was undertaken to determine the maximum distance that light associated with the above activities may be visible (irrespective of the light source intensity). The maximum line of sight is based on the following:

- + the location and height above sea level of the light source
- + the height above sea level of the viewing location
- + the distance between the light source and the viewing location
- + the curvature of the earth's surface.

The line of sight assessment was undertaken using a Line of Sight Calculator (Kagstrom, 2005) based on the predicted illumination characteristics of a drill rig within the channel (TRE drill centre) at Scott Reef (ERM, 2010) and using ESRI ArcMap viewshed analysis for the proposed offshore facilities (Jacobs and SKM, 2014).

5 ERM (2010) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

6 Jacobs-SKM (2014) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

The line of sight assessment for a drill rig at the TRE drill centre (ERM, 2010), [Figure 6-5](#), showed that the maximum distance that direct light may be visible extended up to:

- + 16.6 km for main deck lights
- + 21 km for drill floor lights
- + 26.6 km for derrick lights
- + 45.2 km for a continuous 2 m high purge flare
- + 52.4 km for an intermittent emergency flare (indicative initial flame length of 50 m).

Note that the initial emergency flaring flame length of 50m is broadly representative of the flaring flame length during well unloading, which is a temporary activity not lasting more than 1-2 days.

It should be noted that line of sight calculations did not take into account the diminishing size of the light source with distance or the decrease in light density and wavelengths as distance from the light source increased.

Due to the proximity of the TRE drill centre from Scott Reef, it was predicted that direct light emitted from a MODU at this location would be visible to some extent from all areas of Scott Reef ([Figure 6-5](#)).

The maximum distance at which direct light may be visible from any of the FPSO facilities under routine operational conditions, based on modelling of the

previously proposed FLNG facilities (Jacobs and SKM, 2014) ([Figure 6-6](#)), was predicted to be:

- + 18.8 km for deck lighting
- + 33.5 km for topside modules/cranes lighting
- + 47.7 km for the flare (noting that no continuous flaring is planned for the proposed Browse to NWS Project, with the exception of pilot gas and compressor seal gas).

At these distances the light sources would be visible as small points on the horizon. The line of sight assessment indicated that direct lights from an offshore processing facility at the previously proposed Torosa locations would be visible to some extent from all of Scott Reef, depending on the location of the facility ([Figure 6-6](#)). Deck lights were predicted to be visible from most of North Scott Reef and from a small portion to the east of South Scott Reef, but not from Sandy Islet. Direct light emitted from the topside modules/cranes would be visible from most of North and South Scott Reef, including Sandy Islet, while light emitted by flaring was predicted to be directly visible from any location at Scott Reef (ERM, 2010⁷). The FPSO flare at the Brecknock location was estimated to be visible from a portion of south Scott Reef, but not from Sandy Islet ([Figure 6-6](#)). Operational light emissions from the Brecknock and Calliance facilities were, therefore, not considered for further assessment.

⁷ ERM 2010; <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

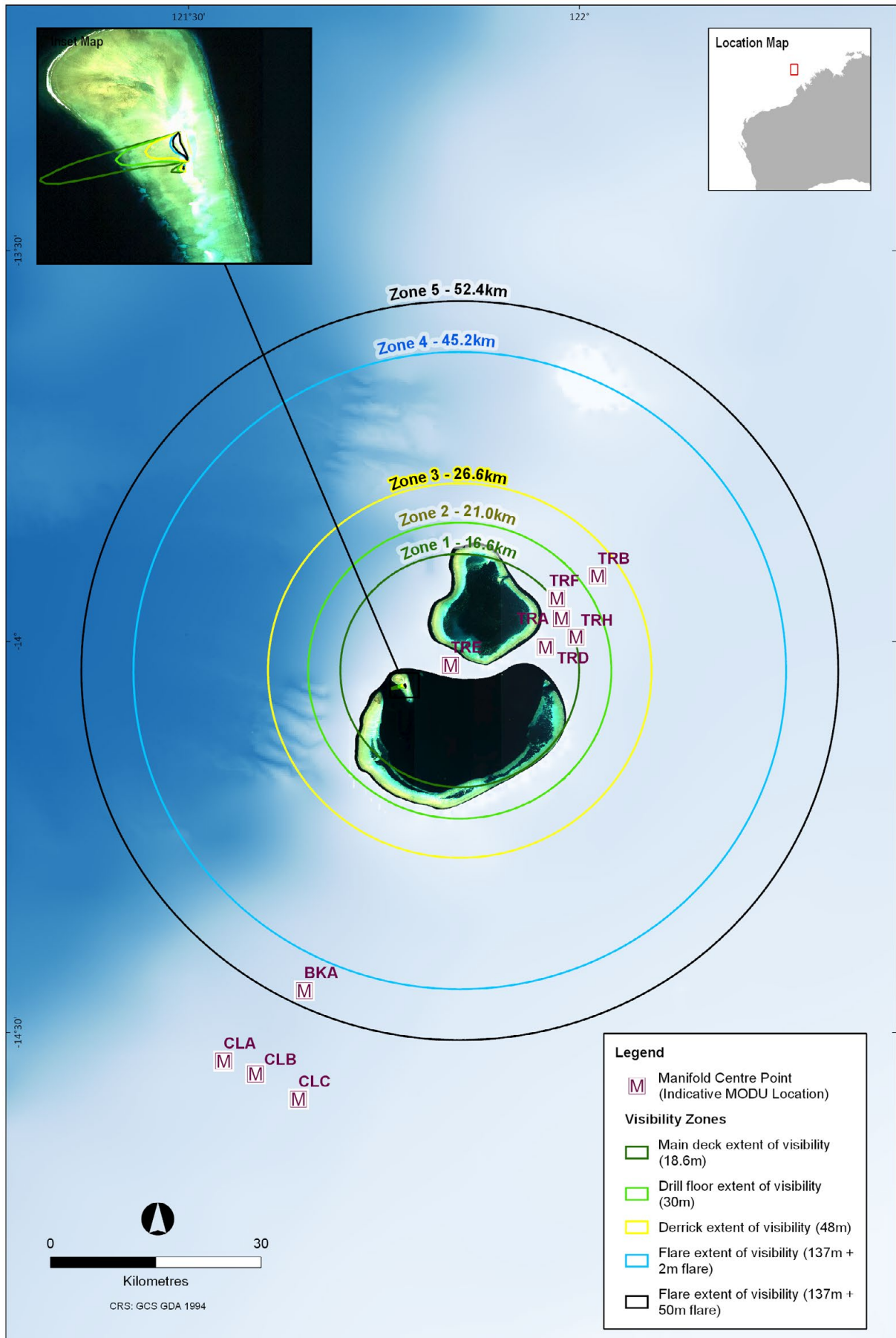


Figure 6-5 Line of sight assessment for a drill rig at TRE drill centre (ERM, 2010)



Figure 6-6 Line of sight assessment for previously proposed FLNG facilities locations at Torosa (refer to proposed Torosa FPSO), Brecknock and Calliance FPSO (Jacobs and SKM, 2014)

Light density modelling

Light density represents the intensity of light that arrives at or leaves a surface, as perceived by the human eye. Light density is measured in Lux (the unit of illuminance and luminous emittance of visible light for humans). The total amount of light as it arrives at a surface is referred to as illuminance and is the parameter that was modelled in the light density modelling study

undertaken for the previously proposed Browse FLNG Development EIS (Jacobs and SKM, 2014)⁸.

Light density decreases as distance increases from the source of light. Typical ambient light density levels range from 0.0001 Lux on a moonless overcast night to 130,000 Lux for direct sunlight. Typical light density levels are shown in [Table 6-19](#).

Table 6-19 Typical light density levels (Micron Technology 2007)

Light Type	Light Density (Lux)
Direct sunlight	100,000 to 130,000
Full daylight, indirect sunlight	10,000 to 20,000
Overcast day	1,000
Very dark day	100
Twilight	10
Deep twilight	1
Full moon	0.1
Quarter moon	0.01
Moonless clear night sky	0.001
Moonless overcast night sky	0.0001

These levels are consistent with the results of a baseline survey of light density undertaken at Scott Reef in 2008. This baseline survey was undertaken during a 'new moon' to determine the darkest natural conditions, with light density observed to range between 0.00 and 0.01 Lux (ERM and SKM, 2008)⁹. These levels were used to represent the range of background light density levels under variable natural conditions for this assessment.

It is acknowledged that the application of modelled photometric measures (i.e. lux levels) for the purposes of this impact assessment on marine fauna (specifically marine turtles) needs to take into consideration the wavelengths of light (i.e. blue and red) to which turtles are most sensitive. The following sections discuss the predicted light levels for sensitive receptors in the context of their visible wavelength ranges ([Figure 6-8](#)).

MODU

Light density levels representing a drill rig were predicted by using light density data measured during the drilling of the Torosa 6 (T-6) appraisal well (previously referred to as Torosa South-1 (TS-1) pilot appraisal well), located on the edge of the South Scott Reef lagoon (ERM, 2010; ERM and SKM, 2008). Although the MODUs for the proposed Browse to NWS Project early phase development drilling is yet to be confirmed and different MODUs are likely to be used throughout the Browse field life, light levels associated with drill rig

lighting are expected to be comparable to that observed during the drilling of the T-6 appraisal well.

The light density from the drill rig at Scott Reef (northern edge of the southern lagoon) was highest (8.9 Lux) at 100 m from the rig, further reducing to below 1.0 Lux at 300 m from the rig and lowest (0 to 0.03 Lux) at the extremities of the survey area, approximately 1.4 km from the drill rig ([Figure 6-7](#)) (ERM and SKM, 2008). Light density attenuated to below 0.1 Lux between 1 km and 1.4 km from the drill rig located >12 km from Sandy Islet.

Measurements on the light emitted from the drill rig used for the T-6 appraisal well indicated that peak wavelengths emitted from the drill rig ranged from 530 to 620 nm, which is within the range that is visible to marine turtles and seabirds ([Figure 6-8](#)) (ERM and SKM, 2008). These wavelengths are expected to be comparable to routine light emissions from the proposed Browse to NWS Project MODU and the FPSO facilities. Light intensity and wavelength measurements of the T-6 appraisal well drilling activities did not measure flaring, as this did not occur during the activity. Natural gas flares have previously been measured to have a peak spectral signature in the invisible infrared range (750 to 900 nm), with lower levels of light emitted in the range visible to turtles (Pendoley, 2000). As the peak light wavelength from natural gas flares is not in the UV-blue region of the visible spectrum which is the

⁸ Jacobs and SKM, 2014 <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

⁹ ERM and SKM (2008) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

most disruptive to wildlife in general (Commonwealth of Australia, 2019) including marine turtles, the absence of an assessment of flaring impacts (as part of the ERM 2010 study) does not impact on the overall assessment.

Results of the light density modelling for a MODU at the TRE drill centre are presented in [Table 6-20](#) and

Figure 6-9. Based on these modelling results, the maximum predicted light density levels from a MODU at the TRE drill centre (closest drill centre to Scott Reef) reaching Sandy Islet are lower than 0.01 Lux, which is comparable to light levels between a moonless clear night sky and a quarter moon.

Table 6-20 Predicted light density from a MODU at the TRE drill centre (ERM, 2010)

Distance from Drill Rig	Light Density (Lux)	Ambient Level Light Comparison
Up to 800m	0.1	Full moon to twilight
800m to 1.2 km	0.01 to 0.1	Quarter moon to full moon night sky
1.2 km to 12.6 km	Lower than 0.01	Between a moonless clear night sky and a quarter moon
Beyond 12.6 km	No measurable change	n/a

FPSO facilities

Light density modelling for the previously proposed FLNG facilities at Torosa was based on a surface area of 20,500m² being illuminated to an average level of 200 Lux. Light sources included deck lighting, topside and crane lighting; however, light emissions from the flare of pilot flame were not included in this assessment. In the modelled scenario, the broad side of the FLNG facilities was assumed to face Scott Reef at an angle of 90 degrees, which represents a worst-case scenario for exposure to light. It should be noted that the proposed FPSO facilities will weathervane around the turret mooring system and, therefore, their actual orientation will depend on prevailing wind and current conditions.

Results of the light density modelling for an FLNG operating at Torosa are presented in [Table 6-21](#). For a single FLNG facility operating at Torosa, light emissions were expected to attenuate to less than 0.1 Lux (comparable to a full moon) within approximately 3-7 km of the facility. Light emissions from the proposed Browse to NWS Project FPSO facilities are expected to be less than those predicted for FLNG facilities (due to the significantly smaller size of the facilities). Therefore, for the proposed operating FPSO facilities, brightness levels above the brightest natural source at night (i.e. a full moon) are not expected to reach Scott Reef or Sandy Islet.

Table 6-21 Predicted light density from the previously proposed FLNG facility operating at Torosa (Jacobs and SKM, 2014)

Distance from Facility (km)	Light Density (Lux)	Ambient Level Light Comparison
Up to 1 km	5 – 25	Between twilight and a very dark day
1 to 1.5 km	2.5 to 5	Between deep twilight and twilight
1.5 to 2 km	0.5 to 2.5	Between full moon and twilight
2 to 3 km	0.25 to 0.5	Between full moon and deep twilight
3 to 7 km	0.05 to 0.25	Between quarter moon and full moon
7 to 10 km	0.002 to 0.05	Between quarter moon and a moonless clear night sky
Beyond 33 km	Less than 0.002	Moonless clear night sky to overcast night sky

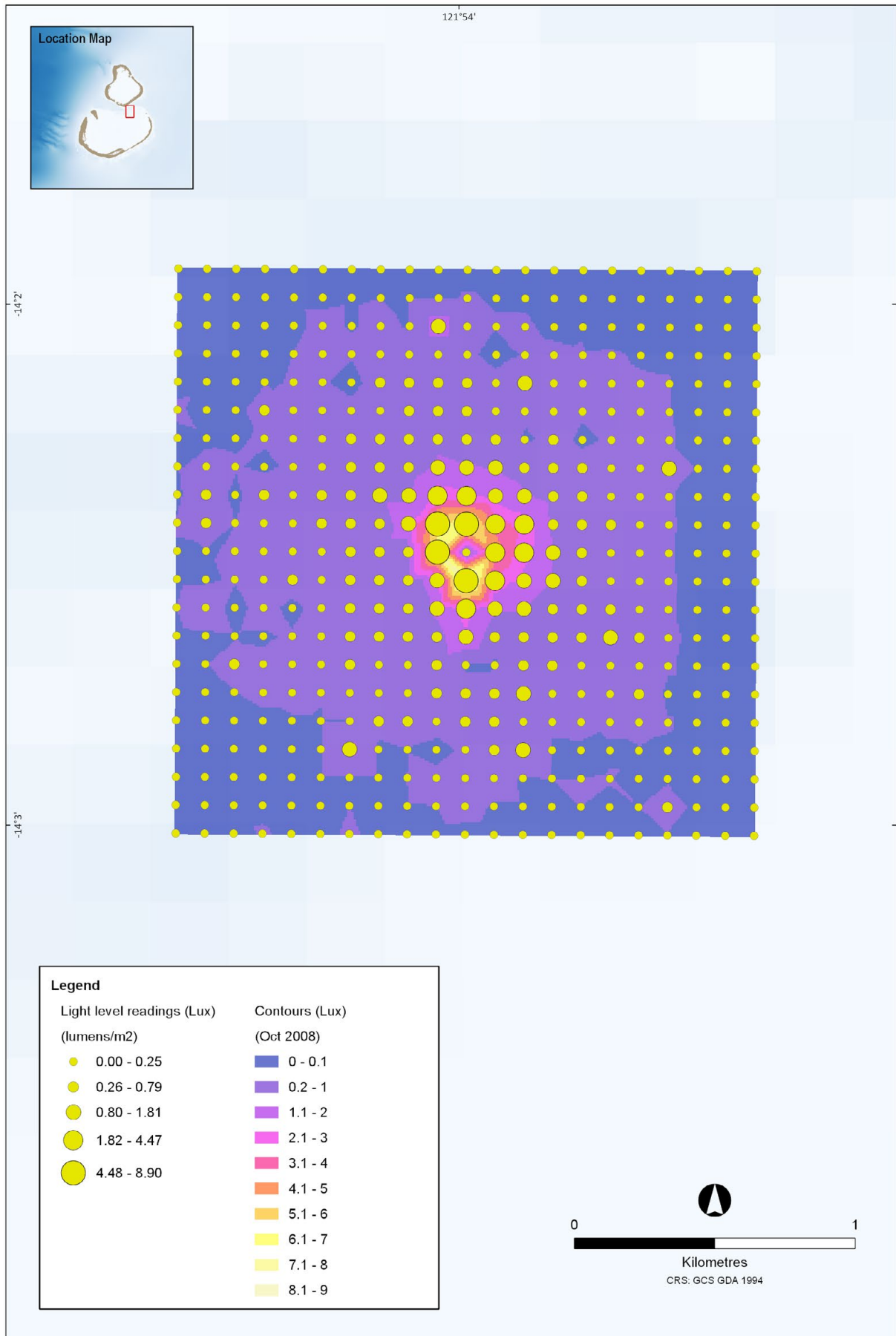


Figure 6-7 Lux Levels measured around the Torosa 6 Appraisal Well (previously referred to as Torosa South-1 pilot appraisal well) Drill Rig at South Lagoon, Scott Reef (ERM and SKM, 2008)

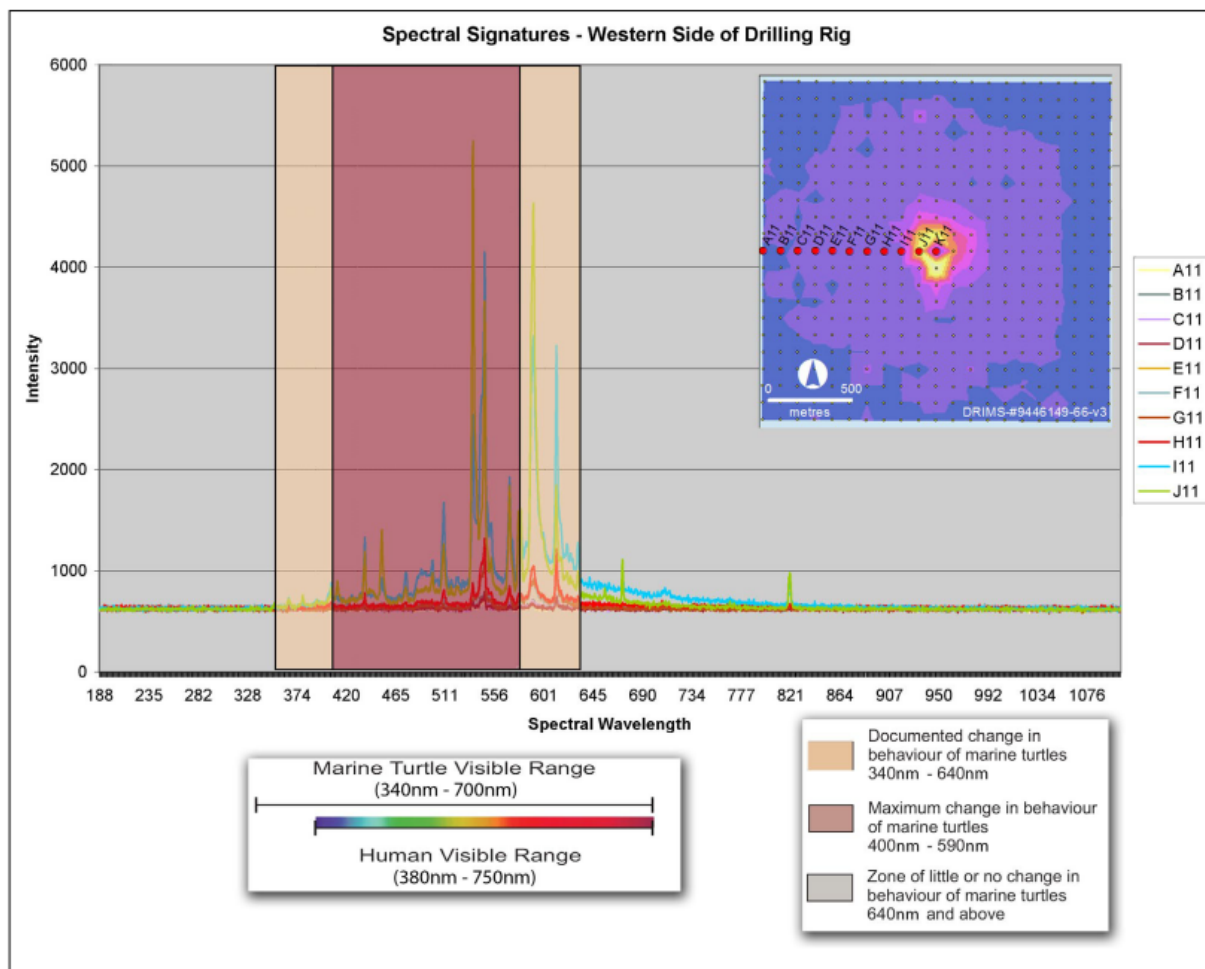


Figure 6-8 Spectral signature of the Torosa 6 Appraisal Well (previously referred to as Torosa South-1 pilot appraisal well) Drill Rig located at Scott Reef in 2008, as measured for the western direction from the drill rig towards Sandy Islet. The insert shows the modelled light density (Lux) levels (refer to Figure 6-7)

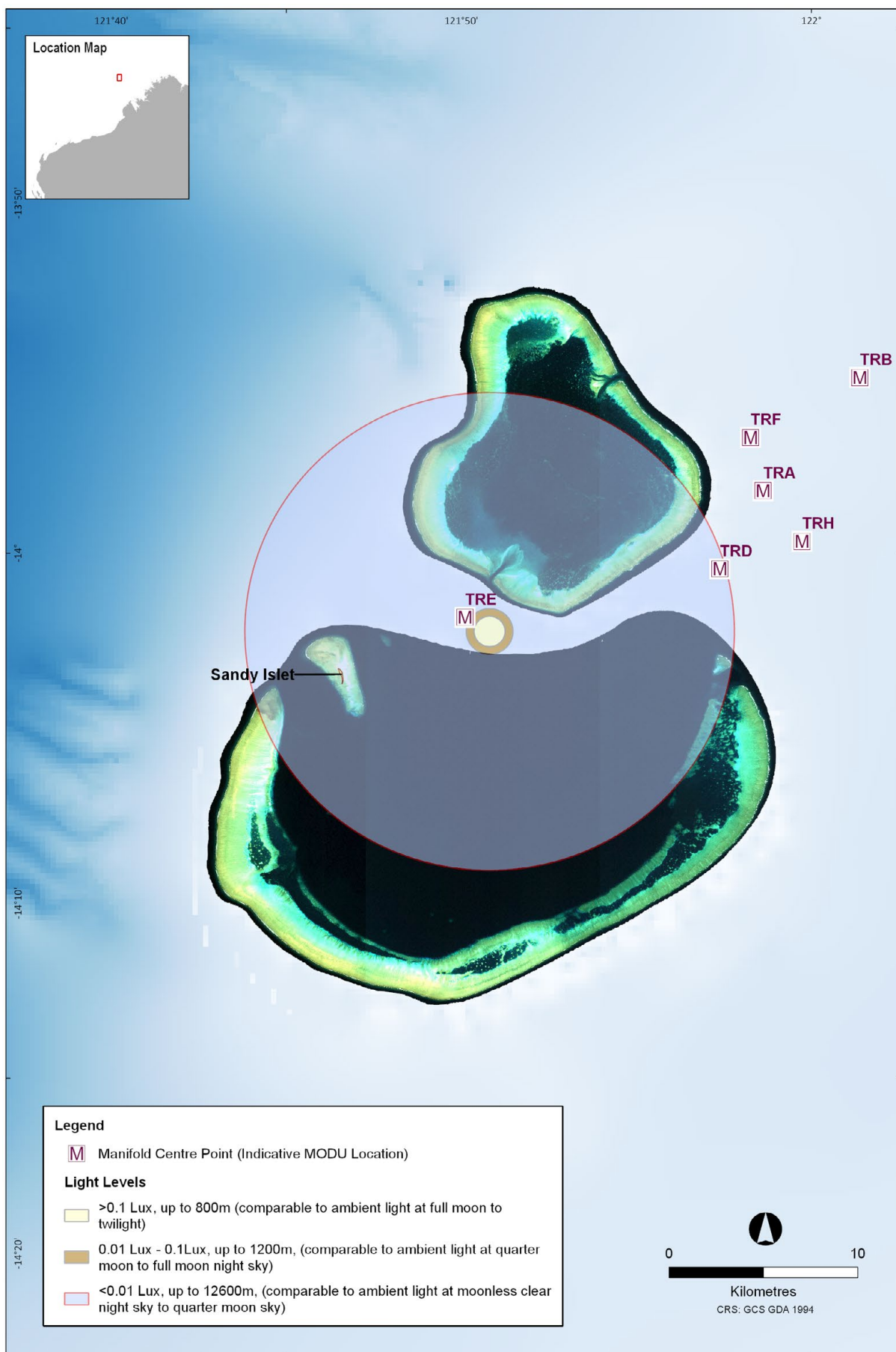


Figure 6-9 Modelled Lux Levels from a drill rig at the previously proposed TRE Drill Centre, Scott Reef (ERM, 2010)

6.3.3.4 Environmental Impact

Ambient light

Change in ambient light

The Project Area is a significant distance from coastal sources of light emissions, with no permanent sources of artificial light at the present time, except for the existing NRC facilities near the BTL tie in point. There are other existing facilities in the broader Browse Basin (i.e. Shell's Prelude FLNG and INPEX's Ichthys Development) which represent permanent light sources from their offshore facilities and supporting activities. General shipping traffic also influences the ambient light conditions within the region however, these light emissions are temporary and spatially variable.

The proposed Browse to NWS Project will contribute to localised light emissions and change the ambient light levels, particularly during drilling and completions, installation, commissioning and decommissioning when project vessel number and activity is highest, but also during operations primarily from the FPSO facilities at Torosa, Brecknock and Calliance fields. Based on the outcomes of the light emission prediction modelling, the change in ambient light will be localised around the FPSO facilities, MODU and project vessels with light levels expected to reach ambient levels comparable to a quarter moon to full moon night sky within 1200m (refer to [Figure 6-9](#) and [Table 6-19](#)) of the MODU and less than 7 km from the FPSO facilities ([Table 6-20](#)). Light emissions from the FPSO facilities, MODU and vessels associated with the proposed Browse to NWS Project are not expected to markedly impact ambient light.

Plankton

Change in fauna behaviour

Zooplankton often display diurnal vertical movements (Leach and Johnsen, 2003) within the ocean, migrating to surface waters at night to feed. Artificial light has, therefore the potential to reduce the amplitude of their migration if lighting levels are sufficiently high at night (Moore et al., 2000). Artificial light emissions can influence the migration of zooplankton from deep water to the surface, thereby affecting the food supply of nocturnal plankton-feeders. Alternatively, as most studies have demonstrated, the illumination of marine waters at night has the effect of increasing feeding opportunities for predators due to better visualisation of prey rather than resulting in potential plankton density reduction, however, these effects are expected to be highly localised and given the high turnover rate of plankton populations (ITOF, 2011) in open oceanic water there will be no lasting impact.

It is likely that plankton in the immediate vicinity of the FPSO facilities, MODU and project vessels that are within the light spill area (within hundreds of metres) will be impacted by light, based on the light emissions

modelling. Given the highly localised effects of light emissions from the FPSO facilities, MODU and vessels associated with the proposed Browse to NWS Project, the proportion of the plankton population affected and the high turnover and recovery of plankton populations, no discernible impact on plankton communities at a population level is expected.

Benthic habitats - coral

Change in fauna behaviour

The nearest coral habitat to the proposed location of the FPSO facilities is at Scott Reef (~8 km from Torosa FPSO), where extensive shallow and deeper water coral habitat and communities are present. Coral colonies are particularly sensitive to changes in ambient environmental conditions, with natural factors (e.g. temperature, nocturnal moonlight cycles and daily light/dark cycles) providing cues for reproduction (i.e. spawning) (Harrison and Wallace, 1990)1990.

Broadcast spawning corals at Scott Reef undergo two short and distinct periods of mass spawning which occur in spring and autumn, with autumn being the dominant spawning period (Gilmour et al., 2010, 2009b, 2009a). The nights of coral spawning at Scott Reef typically occur following a full moon and during neap tides (Gilmour et al., 2013). Most coral species synchronise their spawning through detection of low light intensity (Aubrecht et al., 2008). Therefore, as corals are able to detect natural illumination at night (i.e. moonlight), increases in nocturnal illumination from artificial sources, particularly in shorter wavelengths (Gorbunov and Falkowski, 2002), may impact reproductive cycles or other natural processes (i.e. feeding).

As indicated by the light modelling, Scott Reef is expected to receive light emission levels of less than 0.1 and 0.01 Lux, respectively, from the FPSO facilities and the MODU operating in the channel between North Scott Reef and South Scott Reef. Such light levels are less than a full moon ([Table 6-20](#) and [Table 6-21](#)), therefore it is not considered that light emissions from the FPSO facilities, MODU and vessels associated with the proposed Browse to NWS Project will be of sufficient intensity to affect coral reproduction or spawning events.

Fauna

Change in fauna behaviour - seabirds and migratory shorebirds

Seabirds and migratory shorebirds at Scott Reef may be affected by light emissions associated with the proposed Browse to NWS Project, although the area does not represent a significant aggregation, nesting or roosting area. Anthropogenic disturbance is identified in the Wildlife Conservation Plan for Migratory Shorebirds as a threat to the conservation of migratory shorebirds (Commonwealth of Australia, 2015a).

The exact mechanism for navigation of migratory birds is not clear, however, it is widely thought that they use a mixture of natural cues, including the earth's magnetic field, solar and celestial orientation and polarised light patterns to determine their migratory pathway (Weindler and Liepa, 1999; Wiltchko and Wiltchko, 2001). Therefore, there is a risk that artificial light sources along migratory pathways may alter natural patterns, specifically in the absence of terrestrial landmarks (i.e. offshore).

Studies have demonstrated that light from offshore facilities has been shown to attract migrating birds, with species that migrate during the night more likely to be affected (Marquenie et al., 2008; Verheijen, 1985). Birds may either be attracted by the light source itself or indirectly as lighted structures in marine environments tend to attract marine life at all trophic levels, creating food sources and shelter for seabirds. In some cases, sources of artificial light may provide enhanced capability for seabirds to forage at night (Verheijen, 1985). Studies in the North Sea indicate that migratory birds may be attracted to lights on offshore platforms when travelling within a radius of 3 to 5 km from the light source. Outside this area their migratory paths are likely to be unaffected (Marquenie et al., 2008).

Additionally, artificial lighting may interfere with a bird's internal magnetic compass. It is thought that migratory birds require light from the blue-green part of the spectrum for magnetic compass orientation (Muheim et al., 2002; Wiltchko and Wiltchko, 2001, 1995) whereas red light, the long-wavelength component of light, is more likely to disrupt magnetic compass orientation.

Artificial light emissions from offshore facilities have the potential to impact seabirds through collisions with infrastructure due to visual disorientation, particularly during periods of low visibility (e.g. cloudy, overcast or foggy conditions) (Wiese et al., 2001). Newly fledged juvenile birds leaving breeding colonies for the first time are the most prone to disorientation by artificial light (Commonwealth of Australia, 2019). In addition, some studies have indicated the potential impact of artificial lighting on the diversion of migratory pathways of seabirds (Verheijen, 1985), particularly those dependent on visual cues.

Migratory birds that use the East Asian Australasian Flyway (EAAF) flight paths may include overlap over or near the proposed Browse to NWS Project infrastructure (Figure 5-32). However, light from the MODU and FPSO facilities are unlikely to attract a significant number of seabirds or shorebirds as activities are proposed to be located a considerable distance from known key aggregation areas, such as Ashmore Reef (230 km), Roebuck Bay (370 km) and Eighty Mile Beach (500 km). Seabirds and migratory shorebirds have been occasionally observed in very low numbers at Scott Reef and Sandy Islet may be used as a resting point during

migrations. Given its small size, Sandy Islet does not support large numbers of visiting birds at any one time. Sandy Islet is recognised as part of a resting BIA that encompasses the whole of south Scott Reef and part of North Scott Reef for the little tern (*Sternula albifrons*).

Red light (the long-wavelength component of light) is more likely to disrupt the magnetic compass orientation of migratory birds. The expected spectral signature of light emissions from the MODU is 530 to 620 nm (based on measurements of the drill rig during drilling of the T-6 pilot appraisal well (ERM and SKM, 2008), with the red part of the spectrum outside of these ranges. Therefore, it is not expected that bird species magnetic compass orientation will be disrupted.

Given that a relatively small number of transiting birds are expected to pass in the vicinity of the Browse Development Area, behavioural effects such as disorientation and/or attraction are expected to be slight. Similarly, birds roosting at night on Sandy Islet are unlikely to be disturbed given the low level of artificial light (less than 0.01 Lux) that would be received at Sandy Islet from any permanent or temporary infrastructure within the Browse Development Area.

BIAs exist for the white-tailed tropic bird (breeding BIA) and wedge-tailed shearwater (breeding and foraging BIA) along the proposed BTL route near Rowley Shoals, however, as noted above, temporary light associated with the installation of the BTL and occasional IMR activities are not considered to be a credible source of light intensity to induce discernible impacts and, as such, are not considered further.

Change in fauna behaviour – fish

The Browse Development Area hosts a rich diversity of fish species, including demersal (seabed dwelling), pelagic (open water) and site-attached (coral habitat) fish. The attraction of fish to artificial light is a well known phenomenon and is likely associated with the increased availability of plankton prey on the surface at night (due to vertical migration of zooplankton over a 24 hr period) and the increased prey detection abilities provided by the light (Marchesan et al., 2005). The response of fish to artificial light has been shown to differ depending on species and changes in behaviour due to increased light intensity acting as an attractant to fish species and potentially pose an increased risk of predation through changes to natural night time distribution (Marchesan et al., 2005; Nightingale and Simenstad, 2001). Credible light emissions from the FPSO facilities, MODU and vessels associated with the proposed Browse to NWS Project are expected to be restricted to localised fish attraction within the light spill area (several hundred metres).

The whale shark (*Rhincodon typus*) is the only migratory and threatened fish species that has the potential to occur within the Browse Development Area. Impacts from light emissions are not documented for this species, although this has been identified as an area for further research within the latest conservation advice for this species (Threatened Species Scientific Committee, 2015a). Given the low numbers and infrequent nature of whale shark presence in the Project Area, it is considered highly unlikely that adverse impacts will occur to the small number of individual whale sharks that may encounter elevated, localised light emissions around facilities, MODUs and vessels. Occasional and temporary behavioural changes such as opportunistic feeding utilising attractant aggregations of food sources (such as zooplankton) is known to occur around offshore facilities and may occur for the proposed Browse to NWS Project.

Change in fauna behaviour – marine turtles

Specific behavioural response to artificial light emissions by marine turtles relates to altered nocturnal behaviours (as described by Witherington and Martin (1996) and include:

- + Disorientation: loss of orientation, being unable to maintain constant directional movement
- + Misorientation: orientation in the wrong direction, for hatchling marine turtles on the beach, travel in any direction other than the general vicinity of the ocean.

There are many variables that influence the range and severity of potential impacts of light emissions on the behaviour of marine turtles including:

- + Turtle vision
- + Life stage (adult and hatchling).

Exposure of marine turtles to artificial light can result in changes to their natural behaviour, in particular with regards to nesting (Commonwealth of Australia, 2019). Sandy Islet (nesting habitat) and a 20 km internesting buffer of the surrounding waters are recognised as habitat critical to the survival of green turtles for the Scott Reef-Browse Island genetic stock in the Recovery Plan for Australian Marine Turtles 2017-2027 (Commonwealth of Australia, 2017a) (**Figure 5-29**). In addition, a BIA exists for internesting green and hawksbill turtles around Sandy Islet (Commonwealth of Australia, 2017a). Green turtles predominately nest at Sandy Islet between November and February and internesting turtles have been observed to aggregate primarily in an area to the south west of Sandy Islet. Only one hawksbill turtle has been recorded nesting at Sandy Islet (**Section 5.3.2.5.2**).

The Recovery Plan for Marine Turtles in Australia (2017-2027) identifies light pollution as a moderate risk to the Scott Reef-Browse Island green turtle genetic stock and a high risk to the WA hawksbill turtle population. Actions

in the recovery plan (Commonwealth of Australia, 2017a) relevant to the proposed Browse to NWS Project in relation to light emissions are:

- + manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival
- + manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue
- + 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.

The National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia, 2019) further discuss impacts and management of artificial light in relation to marine turtles.

Female adult marine turtles spend most of their lives in open ocean environments, however, female turtles return to natal beaches to nest and lay eggs, predominantly at night. There is significant evidence that indicates artificial lighting on or near nesting beaches may disrupt adult female turtle nesting behaviour (Commonwealth of Australia, 2019; Salmon, 2005; Salmon et al., 1992). Artificial lighting may affect the location that turtles emerge on the beach, the success of nest construction, whether nesting is abandoned and even the seaward return of adults (Salmon, 2005 and Salmon et al., 1992). It was found that turtles deterred from typical nesting beaches due to artificial lighting re-emerged onto alternate beaches outside of their typical range at increasingly distant and inappropriate nesting locations (Witherington and Martin, 2000, 1996). The selection of suboptimal nesting habitat may contribute to a reduction in the success of egg deposition and hatchling production (Witherington and Martin, 2000). There is no indication whether, under natural conditions, the full moon affects rates of female adults landing on a beach to nest. Nor is there any information available in the published literature that suggests adult turtles are affected by light during foraging activity (Pendoley, 2000).

Hatchlings have a strong tendency to orient themselves to the brightest light source, which under natural conditions is the seaward horizon (in natural circumstances derived from the moon for most of the month) rather than the darker silhouetted landward horizon (Limpus, 2006). The light glow created by artificial lighting may, therefore, cause hatchlings to be attracted to this light source rather than to the water (Witherington and Martin, 2000, 1996). Hatchlings which are disoriented or mis-oriented by artificial lights often do not find the sea promptly, this may lead to predation or exhaustion. Once in the ocean, little is known of the extent to which hatchlings still use vision over wave direction and the earth's magnetic field for orientation

(Lohmann, 1992). Hatchlings swimming out to sea from the beach, however, may be attracted to light emissions from offshore structures or vessels, making them more susceptible to predation or vessel strike after they enter the water (Thums et al., 2016). Wilson et al. (2018) found that light emissions disrupted the dispersal of hatchlings and hatchlings become disoriented in nearshore environments.

The wavelength at which adult and hatchling turtles can sense light is important in determining their corresponding attraction and sensitivity to light emissions. Studies suggest that marine turtles are most sensitive to short-wavelength light in the near-ultraviolet to yellow region of the visible spectrum, from approximately 340 to 700 nm (Witherington and Martin, 2000). Studies on hatchling orientation, relative to spectrally controlled light sources, indicate that although the wavelength at which hatchlings can sense light varies between species, all turtle species are more sensitive to light in the blue and ultraviolet (UV) end of the spectrum. The most disruptive wavelengths to hatchlings are in the 300 to 500 nm range (Witherington, 1997). Light spill effects are not known to vary for different turtle species, however, green turtles are known to be attracted to light of lower wavelengths (<600 nm), with a preference for blue light (400 – 450 nm). The light intensity measurements and modelling predictions accounted for the full wavelength spectrum detected by marine turtles (340 to 700 nm) (ERM and SKM, 2008).

The actual light intensity measurements and modelled predicted light intensity for the main light sources associated with the proposed Browse to NWS Project on the green turtle population at Scott Reef is presented below and summarised in [Table 6-22](#).

Based on the spectral signature of light emissions measured from the drill rig during drilling of the T-6 appraisal well detectable levels of artificial lighting associated with the proposed Browse to NWS Project is expected to be within the visible range for marine turtles. Peak wavelengths emitted from the drill rig ranged between 530 to 620 nm ([Figure 6-8](#)).

Based on lighting data from the drill rig, approximately 60% of the total light wavelength transmission is within the sensitive wavelength range for turtle hatchlings (300 to 500 nm) (ERM, 2010), with most common artificial light sources, such as fluorescent, generating light within these wavelengths (Witherington and Martin, 2000; Witherington, 1997). Given light intensity attenuated to 0.1 Lux at distances of 1.2 km from the studied drilling rig, the distance of the TRE drill centre location from Sandy Islet it is only in the nearfield light spill that adult breeding turtles may be impacted.

Based on the measured attenuation of light density and wavelengths from a drill rig at Scott Reef (ERM and SKM, 2008) and the predicted light levels modelled (ERM and

SKM, 2008; Jacobs and SKM, 2014), light levels expected are below detection levels or so low (0.1 Lux) that no disturbance to nesting behaviour of adult female marine turtles is predicted at Sandy Islet. It should also be noted that drilling at TRE (the closet light source to Sandy Islet) is a temporary activity, with the MODU only likely to be in that location during the development drilling activities. Flaring from the MODU is not predicted to lead to impacts given its temporary nature (will only occur during well unloading activities and be of 1-2 days duration per well). The light emissions from the Torosa FPSO facility (a distance of 27 km from Sandy Islet) will not be detectable at Sandy Islet with light intensity detectable at extremely low levels <0.01 Lux.

There will be no continuous flaring from the FPSO facilities (with the exception of pilot gas and compressor seal gas). During normal operations, infrequent, non-routine flaring may be required during shut down and restart. Given the frequency and duration of such flaring and the distance of the closet FPSO facility to Sandy Islet (approximately 27 km and outside the habitat critical to survival for green turtles) no disturbance to hatchlings or nesting turtles from potential light emissions is expected.

Impact of light spill around MODU and FPSO facilities on marine turtles

Historical studies have reported that due to turtle hatchlings' vision being limited in water, other more dominant navigational cues take over (Amos, 2014; Lohmann and Lohmann, 1992) such as surface currents (Frick, 1976; Liew and Heng Chan, 1992; Okuyama et al., 2009; Salmon and Wyneken, 1987; Witherington, 1995). However, more recent studies (Limpus et al., 2003; Thums et al., 2016) have demonstrated that offshore lights have the ability to attract in-water dispersing hatchlings, causing them to linger around the light source at sea. Additionally, Whelan and Wyneken (2007) and Harewood and Horrocks (2008) reported that artificial lights onshore, can slow down hatchlings' in-water dispersal. Harewood and Horrocks (2008) also demonstrated in this study, that hatchling turtles released from dark beaches, were attracted by artificial lights from neighbouring beaches that were only visible after the hatchlings were a substantial distance from shore. Perhaps more importantly, this study reported that a number of the unsuccessful hatchlings (unsuccessful, meaning hatchlings which did not correctly orientate themselves in a seaward position from the beach) stayed within 10 m of shore and travelled parallel to the shoreline, orientating towards the lighted headlands. Harewood and Horrocks (2008) concluded that artificial lights may override the effects of wave cues in low wave energy environments.

Similarly, Truscott et al. (2017) reported that artificial light sources can attract hatchlings back to shore. More recently, Wilson et al. (2018) confirmed that in the presence of artificial light, surface currents had little effect on the bearing of hatchling swimming, with 88% of individuals' trajectories tracked, orientated towards the experimental artificial lighting. Additionally, this study showed that under ambient conditions, ocean currents affected the bearing of hatchlings as they left the shore; however, when light was present, this effect was diminished, showing that the turtles actively swam against currents in their attempts to move towards light. Hatchling behaviour onshore is not expected to be impacted given the distance of Sandy Islet to TRE and the islet's height above sea level (maximum on west side of 5 m). Hatchling emergence and sea entry were assessed for potential impact from MODU lighting. It was concluded that hatchlings being drawn to MODU lighting thereby increasing vulnerability to predation were considered unlikely, given the distance of Sandy Islet from all drill centre locations.

As surface currents within the Scott Reef channel are known to be strong (averaging approximately 0.5 knots with speeds up to and exceeding two knots), it is unlikely that hatchlings will have the ability to linger and come within the light spill area in the vicinity of a MODU operating in the channel as a result of the artificial light acting as an attractant.

Therefore, artificial lighting associated with the MODU and proposed facilities, may theoretically have the potential to override and disorientate natural hatchling cues, potentially attracting individuals towards the structure. However, the results from the line of sight assessment undertaken as part of the previously proposed FLNG Development concept (ERM, 2010; Jacobs and SKM, 2014), demonstrate that the maximum predicted direct light levels reaching Sandy Islet from a MODU at the TRE drill centre (approximately 7 km away, [Figure 6-5](#)) or the Torosa FPSO Facility (approximately 27 km away, [Figure 6-6](#)) are less than 0.1 and 0.01 Lux, respectively ([Figure 6-5](#) and [Figure 6-6](#)).

For context, the predicted light intensity at this level of light is comparable to the light level between a moonless clear night sky and a quarter moon. Therefore, this level of light is not expected to be of an intensity (and associated wavelength frequency) to alter hatchling behaviour (attraction or mis-orientation of hatchlings leaving nesting sites on Sandy Islet). In addition, spectral analysis of light emissions from a flare at Thevenard Island (Pendoley 2000) determined that this light source does not contain a high proportion of light wavelengths within the range that is most disruptive to turtle hatchlings (300 to 500 nm). Therefore, no adverse impacts to hatchlings from artificial light are anticipated, despite the fact that some studies have demonstrated the theoretical potential for misorientation to some individuals.

Adult turtles passing through the Project Area may temporarily alter their normal behaviour whilst attracted to the light spill from the offshore facilities. Light spill of at least 0.1 Lux (i.e. at least quarter moon light intensity levels) is likely to extend 1.2 km radially from the MODU and 15 km radially from FPSO facilities. While the light spill area overlaps with the internesting habitat for green turtles, it is not anticipated that large number of individuals will be present within this area given the preference to internest to the southwest of Sandy Islet and, therefore will not be subject to behavioural impacts.

In addition, given the wide migratory distribution of adult turtles outside of nesting season (i.e. several hundred kilometres) and their low-density presence within the Project Area, the zone of influence and subsequent attraction from direct lighting is expected to be relatively minor in comparison to their migratory area, resulting in only a temporary disruption to a small portion of the adult turtle population. In addition, due to the limited range of any lighting impacts, it is not deemed that the predicted lighting impacts will adversely affect habitat critical to the survival of green turtles and is, therefore not inconsistent with the recovery objectives outlined within the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Table 6-22 Summary of light intensity values at Sandy Islet and predicted impact significance to marine turtles

Source of Light Emissions	Light intensity – Sandy Islet	Potential impact to female adult nesting green turtles	Potential impact to green turtle hatchlings
Torosa FPSO	<0.01 Lux	Minor (D)	Minor (D)
TRE MODU	0.1 Lux	Minor (D)	Minor (D)

Injury of mortality to fauna – marine turtles

Attraction to the FPSO facilities and MODU may present a physical risk as a result of activities such as FPSO offloading and the facilities intakes and thrusters (i.e. DP). However, given the low number for turtles expected to be affected, the depth of the intakes and thrusters; and the fact that the turtles are expected to display avoidance behaviour from the noise generated by the thrusters this is considered highly unlikely to occur.

Assessment against EPBC Act recovery and conservation plans and advices

Table 6-23 provides an assessment of the light emissions for the proposed activities in relation to objective and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-23 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – light

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Migratory shorebirds	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)	Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated.	Potential impacts to migratory shorebirds are predicted to be limited to slight localised and temporary behavioural impacts to a small number of individuals. Therefore, it is considered that the proposed activities are not inconsistent with the Wildlife Conservation Plan for Migratory Shorebirds.
Whale shark (<i>Rhincodon typus</i>)	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The potential impact of light emissions resulting from the proposed Browse to NWS Project have been assessed and mitigation measures proposed. Given the low numbers and infrequent nature of whale shark presence in the Project Area, there is a high level of confidence that light will not result in adverse impact to whale sharks.

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Green turtle (Chelonia mydas) Hawksbill turtle (Eretmochelys imbricata)	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management measures: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Light emissions are not predicted to impact nesting adult turtles or emerging hatchlings on Sandy Islet or internesting female adult turtles based on knowledge of their primary habitat utilisation. Light spill from the MODU and FPSO may result in behavioural impacts to adults and hatchlings in the unlikely circumstance that they are within the immediate light spill areas, however, this will only result in a temporary disruption to a small portion of the breeding population. There is a high level of confidence that light emissions will not result in displacement or disturbance of the Scott Reef – Browse Island green turtle genetic stock from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the defined BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Australian Marine Parks

The proposed BTL route traverses the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley Marine Parks. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park National Park Zone. Rationale for the route selection of the BTL is provided in [Chapter 3](#).

Change in fauna behaviour

Artificial light emissions will occur within the Argo-Rowley Marine Park, Kimberley Marine Park and the Mermaid Marine Park during installation of the proposed BTL and infrequent IMR activities. The values of the Argo-Rowley Marine Park that are potentially sensitive to light emissions are the BIAs for seabird resting and breeding habitat (Director of National Parks, 2018). The values potentially sensitive to light in the Kimberley Marine Park are turtles which use the marine park habitats for internesting and nesting and seabirds which use it for breeding and foraging (Director of National Parks, 2018). The Mermaid Marine Park boundary is approximately 2 km at its closest point from the

proposed BTL route and contains the islands of the Rowley Shoals which support a wide range of seabird species, including WA's second largest breeding colony of red-tailed tropicbird (Department of Environment and Conservation, 2007). The Rowley Shoals have also been identified as BIAs for white-tailed tropicbirds and little terns; as well as being breeding grounds of red-tailed tropicbirds.

The North-West Marine Parks Network Management Plan recognises that the modification of natural light through the installation of lighting associated with infrastructure can cause changes in animal behaviour (Director of National Parks, 2018). Marine turtles are particularly sensitive to artificial light and the sources of onshore and offshore sources need to be managed to ensure that biologically important behaviour of nesting adults and dispersing hatchlings can continue (Commonwealth of Australia, 2017a).

Light emissions from vessels operating within the AMPs will be temporary and transient in nature (e.g. the slowest moving Project vessel will be the pipelay vessel, which will move at a rate of up to 5 km/day). Based on the predicted light levels, vessel lights are unlikely to disturb adult nesting and internesting turtles which are known to occur in the easterly portion of the Kimberley Marine Park. Similarly, for seabirds that occur in these AMPs, the temporary and short duration of artificial light associated with vessel activity for the installation of the BTL and occasional IMR activities is not considered to be a credible source of significant impact due to

the highly localised light spill area and attenuation of emissions including spectral wavelengths away from the vessel light sources. Given this, it is considered that the identified conservation values of these AMPs will not be detrimentally impacted by artificial light associated with the proposed Browse to NWS Project.

Summary

Table 6-24 provides an assessment of the proposed seabed disturbance in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Table 6-24 Alignment with the North-west Marine Parks Network Management Plan – physical presence: light

AMP	Relevant plan(s)	AMP Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	The light emissions from vessels operating within these AMPs will be temporary and transient in nature as well as sufficient distance for attenuation of the light spill being unlikely to disturb marine turtles or seabirds in these AMPs. There is a high level of confidence that ambient light will not result in an adverse impact to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).
Kimberley Marine Park Multi Use Zone (VI)			
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, the temporary light associated with the installation of the BTL and occasional IMR activities will not be detected at light intensity levels to be considered a credible source of significant impact and no effect on ecosystems, habitats or native species in the AMP will occur. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

State marine parks and nature reserves

Change in fauna behaviour

The Rowley Shoals Marine Park is located approximately 3 km from the BTL route at its closest point. Given this distance and that light emissions from vessels operating along the BTL route will be temporary and transient in nature (e.g. the slowest moving project vessel will be the pipelay vessel, which will move at a rate of up to 5 km/day); and light intensity within the marine park will be barely detectable (given the distance from the light source), no impacts to the conservation values of the State marine parks are predicted.

The Scott Reef Nature Reserve protects the physical and ecological features of Scott Reef, including important nesting habitat (designated as a BIA and Habitat Critical for Survival of a Species) for the green turtle Scott Reef-Browse Island genetic stock. As discussed above, the proposed activities are considered to be not inconsistent with the requirements of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) and, as such, no adverse impacts to the conservation values of the Scott Reef Nature Reserve are predicted.

Other protected places

Change in fauna behaviour

The Scott Reef and Surrounds Commonwealth Heritage Place is utilised by fauna including turtles, whales, dolphins and birds. Sandy Islet in particular is used by nesting green turtles (*Chelonia mydas*), roosting seabirds and migratory shorebirds. Light emissions from the infrastructure within the Project Area is unlikely to impact on fauna on Sandy Islet due to the low level of artificial light (less than 0.01 Lux) that would be received at Sandy Islet from any permanent or temporary infrastructure in the Browse Development Area. As such, it is considered that the conservation values of these protected places will not be detrimentally impacted by the artificial light generated from the infrastructure and project vessels within the Project Area. The same applies with respect to the potential for artificial light impacts on the Mermaid Reef - Rowley Shoals Commonwealth Heritage Place.

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that the impacts from light emissions to marine fauna including fish have been evaluated to be negligible, no significant subsequent impact to fisheries is expected.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

Scott Reef is used for tourism and recreation (primarily diving and fishing charters) and scientific studies at low levels. Given the light modelling predictions that light

emissions from the FPSO, MODU and vessels reaching Scott Reef are not expected to be above natural sources of light, adverse impacts to tourism/recreation and scientific studies are not predicted.

6.3.3.5 Environmental Risk

There are no anticipated environmental risks in relation to light emissions associated with unplanned events or incidents.

6.3.3.6 Cumulative Impacts

At times (particularly during the construction phase), multiple light sources will occur from Project activities. The period where this will be most prominent will be during the drilling of the post RFSU wells where both a MODU and the FPSOs will be operating. Given the light emission from the Torosa FPSO facility will not be detectable at Sandy Islet, cumulative impacts to receptors at Sandy Islet as a result of the MODU and FPSO operating concurrently are not predicted. However, receptors such as marine turtles that may temporarily alter their normal behaviour as a result of attraction, may be exposed to light emissions from both the MODU and FPSO operating currently. However, given the distance from the post RFSU wells to the FPSO facility at Torosa, while a larger number of turtles may experience temporary behavioural impacts during these times, cumulative impacts are not expected to increase the magnitude of the individual impacts.

Light emissions associated with vessels (including for offloading) and helicopters are transient and relatively minor in nature, resulting in temporary and localised effects to sensitive receptors. These light emissions will be significantly less than the primary sources of light emissions (MODU and FPSO facilities).

As such, no significant cumulative impacts from multiple activities associated with the proposed Browse to NWS Project are expected to occur.

The main commercial shipping routes are approximately 50 to 100 km west of the Browse Development Area, intersecting the proposed BTL route at various locations depending on the port. Cumulative impacts from commercial shipping lights and proposed activity lights are not expected as shipping routes are too far from the Browse Development Area for cumulative lighting impacts to occur. In areas where commercial ships intersect the proposed BTL route it is highly unlikely that cumulative impacts will occur because commercial ships are not expected to stop (i.e. they will be continuously travelling) and the ships will need to avoid the 500 m petroleum safety zone around the pipelay vessel.

Other than normal shipping operations, the closest additional significant sources of light emissions within the Browse Basin are the current operating assets at the Prelude and Ichthys projects located over 120 km north-east of the proposed Torosa FPSO. As the distance between the nearest facility within the Project Area and the Prelude and Ichthys developments is over 120 km, no cumulative impacts are anticipated due to artificial light emissions from developments within the Browse Basin.

6.3.3.7 Impact Assessment Summary and Acceptability Assessment

A summary of the impact assessment and the adopted controls for physical presence: light is provided in [Table 6-25](#). The final acceptability assessment is provided in [Table 6-26](#).

Table 6-25 Impact assessment summary and adopted controls – light emissions

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Ambient light (medium value (open water)).	Change in ambient light	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	+ The design of the FPSO facilities will consider the Principles for Best Lighting Design. This includes the minimisation of light spill, selective use of long wavelength light sources and lighting in each operational area will be kept to the minimum required for safe passage when personnel are not required to be working in the area.	Slight	Slight (E)
Plankton communities (medium value (open water))	Change in fauna behaviour	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	+ Navigation beacons and lighting will be designed in line with the safety requirements of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and the Navigation Act 2012 (Cth) + The FPSO facilities will be designed such that continuous flaring will be limited to pilot gas and compressor seal gas + Light monitoring will occur during drilling and completion of a well at TRE drill centre to verify modelling predictions.	No lasting effect	Negligible (F)

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in fauna behaviour	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		No impact predicted	
Seabirds and migratory shorebirds (high value species)	Change in fauna behaviour	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population.		Slight	Minor (D)
Fish (high value species)	Change in fauna behaviour	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No lasting effect	Slight (E)
Marine turtles (high value species)	Change in fauna behaviour Fauna injury or mortality	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population		Slight	Minor (D)
AMPs (medium value (multiple use zones)	Change in fauna behaviour	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Negligible (F)
State marine parks and nature reserves (high value)	Change in fauna behaviour	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Slight (E)

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Other protected places (high value).	Change in fauna behaviour	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Slight (E)
State and Commonwealth managed fisheries (high value marine user)	Changes to the functions, interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies, (high value users)	Changes to the functions, interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Table 6-26 Acceptability assessment – light emissions

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts associated with light emissions as: + Light modelling studies based on light outputs from the Project infrastructure and vessels indicated that there would be minimal impact to sensitive receptors. Light level measurements taken during the T-6 pilot appraisal well drilling provide further confidence in the assessment. + The proposed controls are standard controls widely employed in industry and proven to mitigate the potential impacts and risks effectively. This includes elements of the best practice lighting design principles within the National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia, 2019). The available green turtle data, 2002 to 2010, were determined to be adequate for the purposes of impact assessment and management planning purposes based on the lack of significantly altered regional cumulative impacts since collection (Chapter 9), ability to extrapolate population trends using existing literature, and conservative interpretation of available data where applied. The existing data will be updated by targeted monitoring programs to verify impact predictions at relevant times throughout the project life cycle.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such, it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-25, the potential impact from physical presence: light to listed threatened and migratory species has been assessed as Minor (D) for marine turtles, seabirds and migratory shorebirds, with no lasting effect predicted on fish. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>Commonwealth marine environment</u> As described in Table 6-25, the potential impact from physical presence: light to ambient light has been assessed as Slight (E). No lasting effect is predicted to other receptors within the Commonwealth marine environment (with the exception of threatened or migratory species discussed above). Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each potentially impacted receptor will be achieved. As such, no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>National heritage places</u> No impacts to national heritage places are predicted within the Project Area. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of physical presence: light against the WA EPA Objective is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Marine environmental quality

As described in [Table 6-25](#), the potential impact from physical presence: light to plankton has been assessed as Negligible (F). Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for this receptor and the WA EPA environmental objective *“To maintain the quality of water, sediment and biota so that environmental values are protected”* will be achieved for the State Proposal.

Benthic communities and habitats

As described in [Table 6-25](#), no impacts are predicted to corals associated with shallow water benthic communities and habitats (<75 m depth) of Scott Reef. Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for this receptor will be achieved and the WA EPA environmental objective *“to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained”* will be achieved.

Marine fauna

As described in [Table 6-25](#), the potential impact from physical presence: light to fauna has been assessed as Minor (D) for marine turtles, seabirds and migratory shorebirds, with no lasting effect predicted on fish.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors and the WA EPA environmental objective *“to protect marine fauna so that biological diversity and ecological integrity are maintained”* will be achieved.

Conclusion: Acceptable

External context

Aspects of petroleum developments such as the potential for light emissions to impact on listed species has been raised as part of stakeholder consultations as part of previous development concepts. As described above, impacts from light emissions are not expected to result in impacts to listed species beyond temporary behavioural impacts.

Conclusion: Acceptable

Internal context

This impact assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Conclusion: Acceptable

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-23](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)
- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

AMPs

As detailed in [Table 6-24](#), the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Conclusion: Acceptable

6.3.4 Physical Presence: Electromagnetic Emissions

6.3.4.1 Impact and Risk Overview

[Table 6-27](#) presents an overview of the potential impacts and risks from electromagnetic emissions associated with the physical presence of proposed Browse to NWS Project Infrastructure.

Table 6-27 Physical Presence: electromagnetic emissions

Aspect	Physical presence: Electromagnetic emissions		
Description	EMF will be generated as a result of: + active heating of the subsea flowlines + the subsea power cables that distribute power generated at the FPSO to subsea infrastructure.		
Area	Project Area, Browse Development Area, State Proposal Area		
Project stage	Operations		
Environmental objectives	The environmental objectives in relation to electromagnetic emissions associated with the proposed Browse to NWS Project are Objectives 12, 13, 15 and 16. These objectives are detailed in Table 6-7 .		
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-28). + WA <i>Biodiversity Conservation Act 2016</i> (Wildlife Conservation (Specially Protected Fauna) Notice 2018) + WA Environment Protection Authority – Environmental Factor Guideline – Marine Fauna + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b).		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5 . <i>Ecological</i> + fauna + marine mammals (high value species) + fish (high value species) + marine reptiles (high value species)		
Potential impacts	+ change in fauna behaviour		
Risks	+ There are no anticipated environmental risks in relation to this aspect associated with unplanned incidents or events.		
Summary of impact evaluation for governing impact	Magnitude	Impact significance level	Confidence
	No lasting effect	Slight (E)	High
Summary of risk evaluation for governing risk	Consequence	Likelihood	Risk rating
	n/a	n/a	n/a

6.3.4.2 Source of Aspect

Electromagnetic fields (EMF) originate from both natural and anthropogenic sources. Natural sources include the earth's magnetic field that is derived primarily from heat convection within the Earth's core (Woodruff et al., 2013) and sea currents travelling through the geomagnetic field (Fisher and Slater, 2010). Electric fields normally range 0.005–0.5 $\mu\text{V}/\text{cm}$ in marine waters; however, naturally occurring electric fields as strong 500 $\mu\text{V}/\text{cm}$ have been reported, particularly during storms and solar flares events (Walker, 2001). Magnetic fields are created by the flow of electrical current and are measured in microtesla (μT). The greater the current, the stronger the magnetic field. The strength of the magnetic field produced by the earth ranges from 31 μT at 0° latitude (on the equator) to 58 μT at 50° latitude. Magnetic fields penetrate most materials and therefore only attenuate via distance.

EMFs emitted from underwater power transmission cables consist of the electric field (E-field), an induced magnetic field (B-field), and induced electrical field (iE-field) created by movement of water or an organism through the magnetic field (Cada et al., 2011; Normandeau et al., 2011). An electric field will exist even when there is no current flowing, while a magnetic field is only produced once a device is switched on and current flows. However, an induced electric field (iE field) is produced whenever a magnetic field changes in time. Electric field strength is typically measured in micro volts per centimetre ($\mu\text{V}/\text{cm}$). The higher the voltage, the stronger the resultant electric field.

EMF will be generated within the Browse Development Area as a result of active heating of the subsea flowlines and power cables. The use of active heating technology in the design of the subsea system minimises the volume of Mono-ethylene Glycol (MEG) required to prevent hydrate formation. Active heating occurs using electricity and will be used in the infield flowlines and risers carrying the reservoir fluids from the subsea

manifolds to the FPSOs. Active heating will prevent blockages in the flowlines which can occur when fluids cool causing hydrates and waxes to solidify. Active heating is not expected to be required continuously. While the flowlines are producing, active heating is not required, instead only being turned on for hydrate management when the flowline is not producing after a short period. Active heating remains on until the flowline recommences production and warms up. The other source of EMF will be the subsea power cables that distribute power generated at the FPSO to subsea infrastructure.

Estimates for the active heating power demand required per cable are approximately 2.2 MW with the corresponding supply voltage for such a system ranging from 1.9 kV to 6.8kV. These parameters, along with the pipe length and diameter, U-value of pipe (measure of the rate of heat loss through a material), strength of electrical current and conductance of seawater, determine the extent and range of EMFs from the source. Due to the proposed open current system and unshielded 'piggyback' power cable, electric fields will be present in the water surrounding the power cable. Typically, 50% of the current returns via the pipe and 50% via the seawater (Woodside, 2011).

The predicted electromagnetic field strength from a DEH system when activated was modelled as part of the environmental approvals for a previous Browse development concept (Woodside, 2011). The results of the study demonstrated the rapid dissipation of both electric and magnetic fields from the source (Table 6-28). Within 0.5 m, the magnetic field decreases from 506 μT to 41 μT , further dissipating to below the earth's magnetic field strength within 1 m (Woodside, 2011). The electric field is also predicted to dissipate with distance, albeit more gradually than the magnetic field (Table 6-28). The results demonstrated that within 10 m the electric field dissipates to less than half (489 $\mu\text{V}/\text{cm}$) of the source.

Table 6-28 Predicted electromagnetic field strengths at distance from pipeline (Source: Woodside, 2011)

Electromagnetic Field	Distance from Source (m)	Strength
Electric	0	1100 $\mu\text{V}/\text{cm}$
	0.5	1080 $\mu\text{V}/\text{cm}$
	1	1010 $\mu\text{V}/\text{cm}$
	5	701 $\mu\text{V}/\text{cm}$
	10	489 $\mu\text{V}/\text{cm}$
	75	46 $\mu\text{V}/\text{cm}$
Magnetic	0	506 μT
	0.5	41 μT
	1	23 μT
	5	16 μT
	10	9 μT
	75	0.07 μT

6.3.4.3 Environmental Impact

Fish

Change in fauna behaviour

It is well established that many organisms including elasmobranchs and some bony fish, can detect both natural and anthropogenic EMFs, which many species use for directional movement, foraging and migration. However, the mechanism or mechanisms by which animals can exploit these fields is not fully understood. Some species may sense magnetic fields directly through biogenic magnetite crystals that reorient as the animal moves to maintain alignment with geomagnetic field lines (e.g., (Kirschvink et al., 2001)). Alternatively, the movement of seawater through magnetic fields (e.g. via current or tidal flow) induces localized electric fields that, although small (0.05-0.5 uV/cm), may be detectable by certain species (Kalmijn, 1982).

A wide range of studies have quantified the effects of EMFs on the behaviour and physiology of fish species (Gill et al., 2005; Normandeau et al., 2011; Walker, 2001). EMF produced from anthropogenic sources within the range of detection by electroreceptors have the potential to impact these species through alteration of their behaviour (attraction or repulsion) or disorientation, leading to interference in migration and movement patterns (Gill et al., 2005; Gill and Taylor, 2005). As electric fields diminish in strength with increasing distance from the source, elasmobranchs are likely to be initially attracted to the electric field, but as the individual approaches and the electric field strength increases there will be a point where the animal will turn and swim away. Gill and Taylor (2005) observed the repulsion of elasmobranchs from electric fields >10 µV/cm (Gill and Taylor, 2005). Therefore, when considering the result of the modelling presented above (Table 6-28), it is likely that fish may be repulsed by the electric field from the DEH system within a least 75 m of the source. However, such impacts are predicted to be behavioural only with no physical impacts likely as a result of the likely avoidance of the source (Walker, 2001).

Marine turtles

Change in fauna behaviour

Marine turtles are able to detect magnetic fields rather than electric fields; however, they do not appear to be as sensitive to magnetic fields as elasmobranchs (Courtyllo et al., 1997; Normandeau et al., 2011; Walker, 2001) and furthermore the potential for behavioural disturbance or displacement is considered low as they are unlikely to be in proximity to the sources of EMF given the depth of water (>400 m) that the subsea infrastructure will be installed in.

Marine mammals

Change in fauna behaviour

Marine mammals have been observed to be affected to varying degrees by magnetic fields but not electric fields (Fisher and Slater, 2010). Whales and dolphins appear to rely on geomagnetic contours for navigation, and magnetic fields generated by cables may result in disorientation and disruption to navigation and therefore negatively affect migratory behaviour (Meißner et al., 2006). However, the magnetic field strength emitted from the active heating of the flowlines will be indistinguishable from the earth's field beyond 1 m from the source (Table 6-28). In addition, given the depth of water (>400 m) that the majority of the EMF will be in, the significance level is predicted to be slight as it is not anticipated that marine mammals will be in close enough proximity to the source to elicit any lasting effects.

Summary

In summary, EMF can be detected at various levels of sensitivity by a number of marine fauna, with some behaviour responses evident from studies outlined above. However, EMF associated with DEH of the flowlines and risers are predicted to attenuate rapidly from the source, with the magnetic field predicted to be below the earth's natural geomagnetic level within 1 m and the electric field predicted to dissipate to 46 µV/cm within 75 m (Table 6-28). Given the depth of water (>400 m) that the majority of the EMF will be in and the predicted attenuation distances of the electric and magnetic fields, impacts on marine fauna are not predicted to be significant. If marine fauna are temporarily within the area of influence of EMF, effects are expected to be limited to short-term behavioural impacts.

Assessment against EPBC Act recovery and conservation plans and advices

Table 6-29 provides an assessment of the electromagnetic emissions from the proposed activities in relation to objective and actions of the relevant EPBC Act recovery and conservation plans and advices.

6.3.4.4 Environmental Risk

There are no anticipated environmental risks in relation to electromagnetic emissions associated with unplanned events or incidents.

6.3.4.5 Cumulative Impacts

Given the geographic spread of the project subsea infrastructure as well as subsea infrastructure from other developments within the Browse Basin, cumulative impacts resulting from electromagnetic emission from the proposed Browse to NWS Project are not expected to occur.

Table 6-29 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna: Electromagnetic emissions

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts	The potential impact of electromagnetic emissions resulting from the proposed Browse to NWS Project have been assessed and given the low numbers and infrequent nature of whale shark presence in the Project Area, there is a high level of confidence that electromagnetic emissions will not result in adverse impact to whale sharks.
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival.	Behavioural disturbance or displacement is not predicted given the predicted attenuation distances of the electric and magnetic fields and the depth of water (>400 m) that the majority of the subsea infrastructure will be installed in. Therefore, there is a high level of confidence that electromagnetic emissions will not result in displacement of the Scott Reef – Browse Island green turtle genetic stock from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the defined BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).
Pygmy Blue Whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Electromagnetic emissions have not been identified as a threat to pygmy blue whales.	Given the predicted attenuation distances of the electric and magnetic fields and the depth of water (>400 m) that the majority of the subsea infrastructure will be installed in, no lasting effect to cetaceans is predicted as it is not anticipated that marine mammals will be in close enough proximity to the source to elicit any impacts. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback Whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Electromagnetic emissions have not been identified as a threat to these whale species.	
Sei Whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale		
Fin Whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale		

6.3.4.6 Impact Assessment Summary and Acceptability Assessment

A summary of the impact assessment for the physical presence: electromagnetic emissions is provided in [Table 6-30](#). The final acceptability assessment is provided in [Table 6-31](#).

Table 6-30 Impact assessment summary and adopted controls – electromagnetic emissions

Receptor (sensitivity)	Potential Impacts	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Fish (high value species)	Change in fauna behaviour	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.	As the impact from EMFs will be within a localised area (<70 m) and not impact on MNES, management measures, other than normal practices such as shielding of the subsea power cables, are not proposed.	No lasting effect	Slight (E)
Marine turtles (high value species)	Change in fauna behaviour	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No lasting effect	Slight (E)
Marine mammals (high value species)	Change in fauna behaviour	Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No lasting effect	Slight (E)

Table 6-31 Acceptability assessment – electromagnetic emissions

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts associated with electromagnetic emissions as: + modelling studies (Woodside 2011) have indicated that there will be minimal impact to the surrounding environment as a result of EMF, with the emissions field strength decreasing rapidly with increasing distance from the source.
Principles of ESD Given the predicted lack of significant impacts, the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met.
Conclusion: Acceptable Significant Impacts as defined by the MNES Significant Impact Guidelines Listed threatened species and ecological communities / listed migratory species As described in Table 6-30, no lasting effect is predicted to occur from physical presence: electromagnetic emissions to listed threatened and migratory species with the impact significance level determined to be Slight (E). Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted Conclusion: Acceptable
WA EPA Environmental Objectives An assessment of the impacts of electromagnetic emissions against the WA EPA Objective is presented in the State Proposal ERD (Chapter 10, Appendix B). Marine fauna As described in Table 6-30, no lasting effect is predicted to occur from physical presence: electromagnetic emissions to listed threatened and migratory species with the impact significance level determined to be Slight (E). Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such the WA EPA Environmental Objective “to protect marine fauna so that biological diversity and ecological integrity are maintained” will be achieved. Conclusion: Acceptable
External context To date there have been no specific matters raised by stakeholders, regarding electromagnetic emissions in relation to the proposed Browse to NWS Project. Conclusion: Acceptable
Internal context This impact assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline (Section 6.2). The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System. Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-29](#) the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d).

Conclusion: Acceptable

6.3.5 Atmospheric Emissions: Offshore Activities

6.3.5.1 Impact and Risk Overview

This section details the impact assessment of atmospheric emissions from the offshore activities on air quality and sensitive receptors. It does not address the emission of GHGs, which is addressed in [Chapter 7](#). It also does not address atmospheric emissions from third party processing of the Browse gas which is addressed in [Section 6.3.6](#).

[Table 6-32](#) presents an overview of the potential impacts and risks from atmospheric emissions: associated with the offshore activities of the proposed Browse to NWS Project.

Table 6-32 Atmospheric emissions: offshore activities

Aspect	Atmospheric emissions: offshore activities
Description	Atmospheric emissions will occur throughout all phases of the proposed Browse to NWS Project. During drilling and completion, installation and commissioning, the main contributor to atmospheric emissions will be power generation on the: + vessels + FPSO facilities + MODU. The main fuel source for power generation during these phases will be diesel. During routine operations, the main contributor to atmospheric emissions will be associated with the: + AGRU vents + fuel gas in gas turbines used for providing power to the facilities and the export gas compressors on the FPSOs.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to atmospheric emissions associated with the proposed Browse to NWS Project are Objectives 4, 11, 12 and 13. These objectives are detailed in Table 6-7 .

Aspect	Atmospheric emissions: offshore activities		
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, EPBC Act conservation advice has been considered (Table 6-33). + MARPOL 73/78 Annex VI (Prevention of Air Pollution from Ships) requirements as defined in the Marine Order 97 (Marine Pollution Prevention, Air Pollution) (pursuant to the Commonwealth Navigation (Consequential Amendments) Act 2012) + WA EPA Environmental Factor Guideline - Air Quality + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a).		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <i><u>Physical</u></i> + air quality (medium value (open water)) <i><u>Ecological</u></i> + fauna - seabirds and migratory shorebirds (high value species)		
Potential impacts	+ change in air quality + injury or mortality to fauna		
Risks	There are no anticipated environmental risks in relation to this aspect associated with unplanned incidents or events.		
Summary of impact evaluation for governing impact	<i>Magnitude</i>	<i>Impact significance level</i>	<i>Confidence</i>
	Slight	Slight (E)	High
Summary of risk evaluation for governing risk	<i>Consequence</i>	<i>Likelihood</i>	<i>Risk rating</i>
	n/a	n/a	n/a

6.3.5.2 Source of aspect

Atmospheric emissions refer to the discharges to the atmosphere of gases and particulates from an activity or from a facility (e.g. MODU, project vessel, FPSO facilities) which have a recognised adverse effect on human health and/or an environmental receptor. The main emissions responsible for these effects include carbon monoxide (CO), oxides of nitrogen (NO_x), sulphur dioxide (SO₂), particulate matter less than 10 microns (PM10), mercury and non-methane volatile organic compounds (VOCs), such as BTEX (benzene, toluene, ethylbenzene and xylenes). Atmospheric emissions will occur throughout all phases of the proposed Browse to NWS Project.

Sources of atmospheric emissions include:

- + Power generation on the project vessels and MODU. The fuel source for power generation on project vessels and MODU will be diesel.
- + Power generation associated with the combustion of fuel gas in gas turbines used for providing power to the facilities and the export gas compressors on the FPSOs (as well as power general using diesel during installation and commissioning).

- + Flaring - while there is no continuous flaring planned from the FPSO facilities (other than pilot gas and compressor seal gas), intermittent non-routine flaring will occur from the FPSO and the MODU during well unloading activities, resulting in atmospheric emissions.
- + Venting - reservoir CO₂ that is separated from the natural gas and directed to atmosphere by a vent line. While the vent location has not been finalised, it is most likely to be located on the turbine exhaust stack. GHG emissions are addressed in [Chapter 7](#).

SO_x and particulate matter emissions are heavily influenced by the fuel used and its relative sulphur content, Marine Gas Oil (MGO) having a lower sulphite content than marine diesel oil (MDO) or heavy fuel oil (HFO).

NO_x and SO_x

Nitrogen oxides (NO_x) emissions will be produced from gas turbines and flaring operations. The generation of sulphur dioxide (SO_x) emissions results from the combustion of diesel and from conversion of small amounts of hydrogen sulphide (H₂S) from the fuel gas.

NO₂ emissions from routine MODU and production platform power generation for an offshore project were modelled previously by another operator (BP, 2013). NO₂ was the focus of the modelling, on account of the larger predicted emission volumes compared to the other pollutants, and the potential for NO₂ to impact on human health (as a proxy for environmental receptors). The model demonstrated that atmospheric emissions generated by MODU operations may increase ambient NO₂ concentrations by 1 µg/m³ (0.001 ppm) within 10 km of the source and 0.1 µg/m³ (0.0001 ppm) within 40 km of the source. While NO₂ emissions from the proposed Browse to NWS Project are likely to be higher (due to the use of two FPSO facilities) the study shows that air quality will remain well below the World Health Organisation air quality guideline for NO₂ of 40 µg/m³ annual mean. As NO₂ is the main emission that poses a threat to receptor health, it is considered conservative to use the above studies to justify potential impacts to receptors. As such, studies into the attenuation of other gasses emitted are not evaluated.

Mercury

Emissions from diesel generators may include small amounts of elemental mercury. It should be noted that a gas-phase mercury removal unit has been incorporated in the design, upstream of the AGRU. The positioning of the removal unit in the design ensures no atmospheric emissions of mercury in either AGRU vent or gas turbines above trace quantities during steady state operations.

Although elemental mercury occurs as a liquid, it is highly insoluble in marine waters. Elemental mercury readily volatilises and escapes from the ocean as a gas into the atmosphere. This form of mercury has a long residency time in the atmosphere (approximately one year) which means it can be widely distributed through the atmosphere. During this time, elemental mercury slowly oxidises to inorganic mercury. It is this inorganic mercury that settles out or is washed out in precipitation (e.g. in rain) back to the Earth's surface. Most (approximately 90%) mercury inputs into the world oceans, including areas remote from human activities, are in the form of inorganic mercury from the atmosphere (J. M. Neff, 2002). In the oceans, a complex set of chemical and biologically-mediated transformations convert inorganic mercury back into elemental mercury, such that much of the mercury deposited into the ocean is cycled back into the atmosphere to begin the cycle again (J. M. Neff, 2002). Therefore, impacts from the release of elemental

mercury associated with the development are expected to have no significant effects on the environment as a whole.

VOCs including BTEX

A proportion of methane and VOCs, including BTEX, are entrained within the AGRU vent stream, however during steady state operations these entrained hydrocarbons will be incinerated by thermal oxidisers (or equivalent) and converted to CO₂. In the event that thermal oxidisers are not available, for example due to temporary failure or maintenance, the methane and volatile organic compounds are vented to atmosphere unincinerated.

Small quantities of BTEX released as part of the AGRU vent stream (when the thermal oxidiser is not available (i.e. due to temporary failure or maintenance)) will predominantly end up in the atmosphere although a portion may return to earth after reacting with other air pollutants. Low levels of BTEX are unlikely to damage the environment, bio-accumulation is considered unlikely to occur and does not pose a risk to people on the FPSOs or nearby vessels due to the vent location and rapid dispersion in the atmosphere. As such no significant impacts are expected to occur as a result of the release of BTEX to the atmosphere (Scottish EPA, 2019).

6.3.5.3 Environmental Impact

Ambient air quality

Change in air quality

Atmospheric emissions from the proposed Browse to NWS Project have the potential to result in a localised reduction in air quality in the immediate vicinity of the release point. While a slight reduction in air quality on a local scale will occur for the duration of the activities, given the low emissions levels, very low background levels of pollutants and distance from the emissions sources to the nearest environmental sensitive receptors, it is not anticipated that emissions from the proposed Browse to NWS Project will result in lasting effect on air quality locally or regionally.

Fauna - seabirds and migratory shorebirds

Injury or mortality to fauna

Atmospheric emissions can cause direct impacts to fauna such as seabirds and migratory shorebirds, if they are present in the immediate vicinity of significant releases. Anthropogenic disturbance is identified in the Wildlife Conservation Plan for Migratory Shorebirds as a threat to the conservation of migratory shorebirds (Commonwealth of Australia, 2015a).

The nearest roosting site for seabirds and migratory shorebird is Scott Reef (>8 km away from the Torosa FPSO) so large numbers of seabirds or migratory shorebirds are not expected to occur in close proximity to the FPSO facilities. Likewise, while the proposed BTL route intersects a number of BIAs for seabirds, atmospheric emissions from the pipelay vessel and IMR vessels will be temporary and highly localised.

Given that atmospheric emissions will be typical of other operating facilities and equipment, and that seabird and migratory shorebird numbers will be low at the point of discharge, no lasting impact to seabirds and migratory shorebirds as a result of atmospheric emissions is expected.

[Table 6-33](#) provides an assessment of the light emissions for the proposed activities in relation to objective and actions of the relevant EPBC Act recovery and conservation plans and advices.

6.3.5.4 Environmental Risk

It is not considered that the unplanned release of atmospheric emission resulting in significant impacts to the sensitive receptors is a credible scenario. As such it is not considered that an environmental risk in relation to this aspect associated with the proposed Browse to NWS Project exists.

6.3.5.5 Cumulative Impacts

Given the geographic spread of the project vessels and facilities, cumulative impacts resulting from atmospheric emission from the proposed Browse to NWS Project are not expected to occur.

6.3.5.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact assessment and the adopted controls for the discharge of atmospheric emissions is provided in [Table 6-34](#). The final acceptability assessment is provided in [Table 6-35](#).

Table 6-33 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – offshore atmospheric emissions

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Migratory shorebirds	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)	Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated.	No lasting impacts to migratory shorebirds are predicted as a result of offshore atmospheric emissions related to the proposed Browse to NWS Project. Therefore, it is considered that the proposed activities are not inconsistent with the Wildlife Conservation Plan for Migratory Shorebirds.

Table 6-34 Impact assessment summary and adopted controls – offshore atmospheric emissions

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Air quality (medium value (open water))	Localised reduction in air quality	Objective 4: To not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	Operations + Entrained hydrocarbons will be incinerated in the acid gas vent stream (when available) via a thermal oxidizer, with routing to a safe location for dispersion as a contingency when thermal oxidizers are offline. + A gas-phase mercury removal unit upstream of the AGRU will be used to ensure no atmospheric emissions of mercury in either AGRU vent or gas turbines above trace quantities during steady state operations. + Use of a vapour recovery system on the cargo tanks to minimize VOCs vented to atmosphere from the tanks. Project vessel, MODU and FPSO operations + Fuel usage will be recorded for FPSO facilities, MODU and vessels associated with the proposed Browse to NWS Project and emissions will be derived from fuel usage. + Project vessels will not use heavy fuel oil or intermediate fuel oil. Project vessel operations + Vessels will comply with MARPOL 73/78 Annex VI (Prevention of Air Pollution from Ships), where required, as defined in the Marine Order 97 (Marine Pollution Prevention, Air Pollution) (pursuant to the Commonwealth Navigation Act 2012). This includes requirements for use of low sulphur fuel.	Slight	Slight (E)
Seabirds and migratory shorebirds (high value species)	Injury or mortality to marine fauna	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population. Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No lasting effect	Slight (E)

Table 6-35 Acceptability assessment – offshore atmospheric emissions

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the offshore atmospheric discharges as: + there is a good understanding of the current air quality in the Project Area. + there is a good understanding of the expected atmospheric emissions from the proposed Browse to NWS Project. + the proposed controls are standard controls widely employed in industry and proven to mitigate the potential impacts and risks effectively.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines Listed threatened species and ecological communities / listed migratory species As described in Table 6-34, no lasting effect to seabirds or migratory shorebirds is predicted to occur as a result of offshore atmospheric emissions. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for seabirds and migratory shorebirds will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Commonwealth marine environment As described in Table 6-34, the potential impact from offshore atmospheric emissions to air quality has been assessed as Slight (E). No lasting effect is predicted to other receptors within the Commonwealth marine environment (including threatened or migratory species discussed above). Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each potentially impacted receptor will be achieved. As such, no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. National heritage places No impacts to national heritage places in the Project Area are predicted as a result of offshore atmospheric emissions. Conclusion: Acceptable
WA EPA Environmental Objectives An assessment of the impacts of offshore atmospheric emissions against the WA EPA Objectives is presented in the State Proposal ERD (Chapter 10, Appendix B). Marine fauna As described in Table 6-34, no lasting effect to seabirds or migratory shorebirds is predicted to occur as a result of offshore atmospheric emissions. Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to protect marine fauna so that biological diversity and ecological integrity are maintained” will be achieved. Air Quality Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for air quality, and the WA EPA environmental objective “To maintain air quality and minimise emissions so that environmental values are protected” will be achieved. Conclusion: Acceptable

Acceptability Assessment

External context

To date there have been no specific matters raised by stakeholders, regarding the offshore discharge of atmospheric emissions in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System.

Conclusion: Acceptable

Other requirements

As detailed in [Table 6-33](#), the proposed activities are considered to be not inconsistent with the actions and objectives of the Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)

Conclusion: Acceptable

6.3.6 Atmospheric Emissions: Third Party Processing of Browse Gas

The assessment of any potential impacts on the national heritage values of the listed National Heritage Place on the Dampier Archipelago that may be associated with the onshore processing of the Browse gas by the NWS JV, is addressed within the ERD associated with the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335).

6.3.7 Atmospheric Noise

6.3.7.1 Impact and Risk Overview

[Table 6-34](#) presents an overview of the potential impacts and risks from atmospheric noise associated with the proposed Browse to NWS Project.

Table 6-34 Atmospheric noise impact and risk overview

Aspect	Atmospheric noise
Description	Atmospheric noise emissions will occur during all phases of the proposed Browse to NWS Project. Noise emission sources included: + helicopters between the offshore facilities and the mainland + project vessel, MODU and FPSO facilities operations + flaring from the MODU during well unloading + Intermittent flaring from the FPSO facilities + piling.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning.
Environmental objectives	The environmental objectives in relation to atmospheric noise associated with the proposed Browse to NWS Project are Objectives 5, 6, 11, 12, 13, 14, 15, 16, 18, 21 and 23. These objectives are detailed in Table 6-7 .

Aspect	Atmospheric noise						
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-36). + Commonwealth Airspace Act 2007 + Commonwealth Air Navigation (Aircraft Noise) Regulations 2018 + International Civil Aviation Organization’s (ICAO) document Annex 16, Environmental Protection - Volume I + EPBC Regulations 2000 Part 8 Division 8.3 (Regulation 8.07) + WA EPA Environmental Factor Guideline - Marine Fauna + Recovery Plan for Marine Turtles in Australia (2017-2027)(Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b) + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a).						
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. Physical + ambient noise (medium value (open water)). Ecological + marine fauna + seabirds and migratory shorebirds (high value species) + fish (high value species) + marine mammals (high value species) + marine reptiles (high value species) + state marine parks and nature reserves (high value). Socio-economic + other users + tourism and recreations (high value users) + scientific studies (high value users) + settlements (Broome) (medium value users).						
Potential impacts	+ change in ambient noise + change in fauna behaviour + changes to the functions, interests or activities of other users.						
Risk	+ There are no anticipated environmental risks in relation to this aspect associated with unplanned project activities.						
Summary of governing impact evaluation	<table><tr><th>Magnitude</th><th>Impact significance level</th><th>Confidence</th></tr><tr><td>No lasting effect</td><td>Slight (E)</td><td>High</td></tr></table>	Magnitude	Impact significance level	Confidence	No lasting effect	Slight (E)	High
Magnitude	Impact significance level	Confidence					
No lasting effect	Slight (E)	High					
Summary of governing risk evaluation	<table><tr><th>Consequence</th><th>Likelihood</th><th>Risk rating</th></tr><tr><td>n/a</td><td>n/a</td><td>n/a</td></tr></table>	Consequence	Likelihood	Risk rating	n/a	n/a	n/a
Consequence	Likelihood	Risk rating					
n/a	n/a	n/a					

6.3.7.2 Source of aspect

The following activities and infrastructure may cause disruption to other users due to atmospheric noise in the Project Area:

- + Helicopter personnel transfer to the offshore facilities and MODU from onshore logistics bases Broome. Approximately five personnel transfers a week per FPSO facility will be required during normal operations.

Atmospheric noise will be created as a result of helicopter flights, with sound levels typically below 162 dB at 1m (Richardson et al., 1995 and Simmonds et al., 2004). Richardson et al. (1995) reported that helicopter sound was audible in air for four 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. Noise levels for a Bell 212 helicopter during fly-over were reported at 162 dB re 1 μ Pa and for a Sikorsky-61 helicopter were recorded at 108 dB re 1 μ Pa at 305 m (Simmonds et al., 2004). Atmospheric noise will be created as a result of helicopter flights, with sound levels typically below 162 dB at 1m (Richardson et al., 1995 and Simmonds et al., 2004) (Richardson et al., 1995; Simmonds et al., 2004). As noise loses energy as it travels through the atmosphere, peak-received level diminishes with increasing helicopter distance from a receptor; however, the duration of audibility often increases with increasing altitude. Richardson et al. (1995) reported that helicopter sound was audible in air for four 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. Noise levels for a Bell 212 helicopter during fly-over were reported at 162 dB re 1 μ Pa and for a Sikorsky-61 helicopter were recorded at 108 dB re 1 μ Pa at 305 m (Simmonds et al., 2004).

Noise levels for typical helicopters used in offshore operations (Eurocopter Super Puma AS332) at 150 m separation distance has been measured at up to a maximum of 90.6 dB (BMT Asia Pacific, 2005). Water has a very high acoustic impedance contrast compared to air, and the sea surface is a strong reflector of noise energy (i.e. very little noise energy generated above the sea surface crosses into and propagates below the sea surface). The angle at which the sound path meets the surface influences the transmission of noise energy from the atmosphere through the sea surface; angles $\pm > 13^\circ$ from vertical being almost entirely reflected (Richardson et al., 1995).

- + Vessel personnel transfer to the offshore facilities and MODU from onshore logistic bases. Seven transfers per week would occur during normal operations with additional transfers during shut downs and major maintenance. Atmospheric

emissions from vessels are expected to be relatively minor in comparison with underwater noise emissions from vessels and are not expected to result in significant impacts to sensitive receptors. As such, atmospheric noise emissions from vessels are not considered further.

- + Normal operations on the FPSO facilities (e.g. flaring). Atmospheric noise emissions from FPSO flaring will be intermittent, of short duration and will occur a significant distance from sensitive receptors. It is not considered credible that these emissions will result in significant impacts to sensitive receptors. As such, atmospheric noise emissions from FPSO flaring are not considered further.
- + Flaring from the MODU during well unloading. Atmospheric noise emissions from MODU flaring will be of a short duration (1-2 days per well) and will occur a significant distance from sensitive receptors. It is not considered credible that these emissions will result in significant impacts to sensitive receptors. As such, atmospheric noise emissions from FPSO flaring are not considered further.
- + Pile driving for mooring installation (if required). Some atmospheric noise emissions will occur during pile driving. If the pile driving is required for the FPSO foundations or MODU mooring, this will only occur during the construction phase. These atmospheric noise emissions are expected to be relatively minor in comparison with underwater noise emissions from the pile driving activities and are not expected to result in significant impacts. As such atmospheric noise from pile driving is not considered further.

Other noise sources

Other sources of atmospheric noise may include the operation of the FPSO facilities (i.e. machinery noise), vessels (primarily engine noise) and the MODU engines and machinery (particularly during active drilling). These noise levels are expected to be relatively minor compared to the other noise sources described above and as such are not considered further.

6.3.7.3 Environmental Impact

Ambient noise

Change in ambient noise

Atmospheric noise emissions will increase the ambient noise in the immediate vicinity of the FPSO facilities, MODU and project vessels. Given the small area that will be affected and the lack of receptors in the area, this increase in ambient noise levels is not considered significant.

Fauna

Noise can result in a variety of responses in species as described in [Section 6.3.8](#).

Marine fauna may be exposed to helicopter noise when on the sea surface (e.g. when basking, resting or breathing). Hearing for marine fauna is adapted for the perception of underwater sound (Popper et al., 2014), where they spend most of their time, as such they are not expected to perceive noise levels from helicopters that may result in PTS or TTS. Potential behavioural impacts for fauna that are present on the surface during a helicopter flyover may include temporary 'startle' responses (e.g. diving). However, typically such responses occur at relatively short ranges (tens of metres) (Hazel et al., 2007) and as such behavioural impacts during a typical helicopter flight are highly unlikely due to the altitude and distance between the helicopter and the potential receptor. Noise levels from a Bell 212 helicopter flying at altitudes of 610 to 152 m respectively were measured at 101 – 109 dB at 3 m water depth (Richardson et al. 1995), which is well below all marine fauna behavioural response thresholds. Although this is not representative of the type of helicopters used to service offshore facilities, provides an indication of received level noise that may be expected from a helicopter.

Change in fauna behaviour - seabirds and migratory shorebirds

Seabirds and migratory shorebirds may be affected by atmospheric noise emissions from helicopters transiting between Broome Heliport and the Browse Development Area. In particular, bird species present around Roebuck Bay and Cable Beach (<1 km from the Broome Heliport) and roosting birds at Scott Reef may be affected. Anthropogenic disturbance is identified in the Wildlife Conservation Plan for Migratory Shorebirds as a threat to the conservation of migratory shorebirds (Commonwealth of Australia, 2015a).

Given the high visibility and noise levels associated with helicopter movements, bird species are expected to actively avoid interaction. Any disturbance from helicopters in transit will be of limited duration as they pass by.

Impacts to bird species in the area surrounding Broome are expected to be negligible as helicopters passing by bird aggregation areas will be at significant altitude.

Impacts to bird species at Scott Reef are also expected to be negligible given the area does not represent a significant aggregation, nesting or roosting area for seabirds and migratory shorebirds; and flight paths will actively avoid roosting areas (Sandy Islet).

Bird species along the remainder of the flight path are expected to occur in low numbers. Given the altitude the helicopters will be flying at, impacts are not considered credible.

Change in fauna behaviour - cetaceans, marine turtles and fish

Underwater noise monitoring by McCauley (2008) at Scott Reef during a drilling program in 2008, demonstrated that noise emissions from helicopters operating from the MODU were not detectable at a noise logger set 4.6 km away (McCauley, 2008). Given this, and the typical characteristics of helicopter flights from Broome Heliport to the Project Area (i.e. duration, frequency, altitude and air speed), the predicted environmental impact of helicopter generated atmospheric levels that may result in behavioural disturbance to cetaceans, marine turtles and fish is not expected to have any lasting effect.

Noise interference is identified as a key threat in both the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) and the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b). Anthropogenic noise and acoustic disturbance are also identified as a key threat in the relevant conservation advice for humpback, sei and fin whales which may occur in the Project Area.

Table 6-36 provides an assessment of the light emissions for the proposed activities in relation to objective and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-36 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – atmospheric noise

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Migratory shorebirds	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)	Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated.	Potential impacts to migratory shorebirds are predicted to be negligible. Therefore, it is considered that the proposed activities are not inconsistent with the Wildlife Conservation Plan for Migratory Shorebirds
Whale shark (<i>Rhincodon typus</i>)	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The potential impact of atmospheric noise emissions resulting from the proposed Browse to NWS Project have been assessed in line with the conservation advice. Given the low numbers and infrequent nature of whale shark presence in the Project Area, there is a high level of confidence that atmospheric noise emissions will not result in adverse impact to whale sharks.
Green turtle (<i>Chelonia mydas</i>) Hawksbill turtle (<i>Eretmochelys imbricata</i>)	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management Actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival.	Atmospheric noise emissions from the proposed Browse to NWS Project are not expected to be of sufficient intensity to alter the behaviour of adults or hatchling turtles. Therefore, there is a high level of confidence that atmospheric noise emissions will not result in displacement of the Scott Reef – Browse Island green turtle genetic stock, from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the BIA at Scott Reef Therefore, it is considered that the proposed activities are not inconsistent with the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area.	Atmospheric noise emissions from the proposed Browse to NWS Project are not expected to be of sufficient intensity to alter the behaviour of cetaceans. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b)

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> Humpback Whale	Anthropogenic noise and acoustic disturbance have been identified as a threat for the recovery of these species.	The level of atmospheric noise is not expected to be enough to alter the behaviour of the cetaceans. Therefore, there is a high level of confidence that the impacts from atmospheric noise would be minimal and that the long-term recovery objectives for these species would not be compromised.
Sei whale	Conservation advice <i>Balaenoptera borealis</i> Sei Whale		
Fin whale	Conservation advice <i>Balaenoptera physalus</i> Fin Whale		

State marine parks and nature reserves

Change in fauna behaviour

The Scott Reef Nature Reserve protects the physical and ecological features of Scott Reef, including important nesting habitat (designated as a BIA and Habitat Critical for Survival of a Species) for the green turtle. As discussed above, the proposed activities are considered to be not inconsistent with the requirements of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) and as such no adverse impacts to the conservation values of the Scott Reef Nature Reserve are predicted.

Other users

Changes to the functions, interests or activities of other users

Given the low frequency of helicopter movements and the distance of the flight paths from Scott Reef, impacts to the tourism, recreation and scientific studies values of Scott Reef are expected to be negligible.

Settlements

Changes to the functions, interests or activities of other users

If selected as the primary means of transfer, noise emissions from helicopter movements to and from Broome Heliport may potentially present a nuisance to Broome residents. Stakeholder consultation ([Chapter 4](#)) undertaken by Woodside in relation to the proposed Browse to NWS Project identified these emissions and resultant disturbance to Broome and Cable Beach suburbs residents as a concern to the community. In many cases however it was noted that the potential economic and social benefits outweighed the negatives associated with increased helicopter noise.

Given the low number of movements expected (in the order of five per week per FPSO), the regulation with respect to civil aviation, and planned mitigation measures such as restricted flight times and adjusted flight paths, noise emissions are not expected to add significantly to existing noise levels.

6.3.7.4 Environmental Risk

There are no anticipated environmental risks in relation to this aspect associated with unplanned project activities.

6.3.7.5 Cumulative Impacts

Helicopter movements to and from Broome Heliport are anticipated to occur through all phases of the proposed Browse to NWS Project, as well as during continued operation of the Prelude and Ichthys developments (operated by Shell and INPEX respectively). Broome International Airport is the primary airport for the Kimberley region and hosts regional, national and international air traffic. Between 2017 and 2018, Broome International Airport saw 5,226 aircraft movements (primarily fixed wing aircraft) (BITRE, 2019). Eight additional helicopter movements per week during operations (4 movements for each FPSO), represents an 8% increase in aircraft movements. While these additional movements are significant in the context of current traffic at Broome International Airport, they represent a marginal increase when compared to historical aircraft movements at Broome International Airport which had a peak level of 6,886 flights in 1995/6 and has had an average annual growth of -0.2% since 1997. Therefore, at a regional scale, the risk of cumulative impacts associated with additional helicopter movements associated with the proposed Browse to NWS Project activities is considered to be low.

6.3.7.6 Impact and Risk Assessment Summary and Acceptability Statement

A summary of the impact assessment for the atmospheric noise is provided in [Table 6-37](#). No credible environmental risks have been identified in relation to atmospheric noise. The acceptability assessment is provided in [Table 6-38](#).

Table 6-37 Impact assessment summary and adopted controls – atmospheric noise

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Ambient noise (medium value (open water))	Change to ambient noise	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health	+ Helicopters will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 + Helicopters shall not operate lower than 1650 feet or within a horizontal radius of 500 m of a cetacean known to be present in the area, except for take-off and landing. + The number of helicopter flights required during installation and operation of the development will be optimised to maximise efficiency and reduce the number of flights where operationally possible + Compliance with Broome International Airport's "Fly Neighbourly Policy" which includes maintaining helicopter flight paths away from homes and businesses.	No lasting effect	Negligible (F)
Seabirds and migratory shorebirds (high value species)	Change in fauna behaviour	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population.		No lasting effect	Slight (E)
Fish (high value species)	Change in fauna behaviour	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No lasting effect	Slight (E)
Marine mammals (high value species)	Change in fauna behaviour	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No lasting effect	Slight (E)
Marine turtles (high value species)	Change in fauna behaviour	Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population	+ Scheduled helicopter flight paths will avoid known seabird roosting sites where possible. This includes no planned flights over Sandy Islet.	No lasting effect	Slight (E)

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Other users - scientific studies, tourism and recreation (high value users)	Changes to the function interests or activities of others and changes in aesthetic value	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Settlements - Broome (medium value users)	Changes to the function interests or activities of others and changes in aesthetic value	Objective 23: To protect social surroundings from significant harm.		No lasting effect	Negligible (F)

Table 6-38 Acceptability assessment – atmospheric noise

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts and risks associated with atmospheric noise as: + Studies have adequately characterised the marine fauna populations and distributions that may potentially be impacted by atmospheric noise. While some knowledge gaps exist with respect to pygmy blue whale and green turtle utilisation of Scott Reef, the lack of predicted impacts to these species from atmospheric noise emissions means that these knowledge gaps do not affect the impact assessment in relation to atmospheric noise emissions. + The use of the Project Area by other marine users is well known and understood + Local stakeholders and residents within Broome are known and the flight paths for helicopters leaving the Broome heliport are understood. Stakeholder consultation with Broome residents will be ongoing.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-37, no lasting effect to any marine fauna (including seabirds, migratory shorebirds, fish, marine mammals and marine reptiles) is predicted to occur as a result of atmospheric noise emissions. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for these receptors will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>Commonwealth marine environment</u> As described in Table 6-37, no lasting effect to any receptors is predicted as a result of atmospheric noise emissions. Given this, with the application of the proposed controls it is predicted that the environmental objectives for each potentially impacted receptor will be achieved. As such, no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>National heritage places</u> No impacts to national heritage places in the Project Area are predicted as a result of atmospheric noise emissions. Conclusion: Acceptable
WA EPA Environmental Objectives An assessment of the impacts of atmospheric noise emissions against the WA EPA Objective is presented in the State Proposal ERD (Chapter 10, Appendix B). <u>Marine fauna</u> As described in Table 6-37, no lasting effect to any marine fauna (including seabirds, migratory shorebirds, fish, marine mammals and marine reptiles) is predicted to occur as a result of atmospheric noise emissions. Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to protect marine fauna so that biological diversity and ecological integrity are maintained” will be achieved. Conclusion: Acceptable

Acceptability Assessment

External context

Stakeholder consultation undertaken by Woodside in relation to the proposed Browse to NWS Project identified noise emissions from helicopters and resultant disturbance to Broome and Cable Beach suburbs residents as a concern to the community.

Given the low number of expected movements associated with the proposed Browse to NWS Project (in the order of five per week per FPSO), the regulation with respect to civil aviation, and planned mitigation measures such as restricted flight times and adjusted flight paths, noise emissions are not expected to add significantly to existing noise levels.

Conclusion: Acceptable

Internal context

This impact assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System.

Woodside environmental performance procedures in relation to atmospheric noise emissions will be adhered to.

Conclusion: Acceptable

Other Requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-36](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)
- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation Management Plan for the Blue Whale
- + Conservation advice *Megaptera novaeangliae* Humpback Whale
- + Conservation advice *Balaenoptera borealis* Sei Whale
- + Conservation advice *Balaenoptera physalus* Fin Whale.

Conclusion: Acceptable

6.3.8 Underwater Noise

Table 6-39 presents an overview of the potential impacts and risks from underwater noise associated with the proposed Browse to NWS Project.

Table 6-39 Underwater noise impact and risk overview

Aspect	Underwater noise
Description	Underwater noise emissions will occur during all stages of the proposed Browse to NWS Project. The primary source activities for underwater noise emissions will include: + piling activities including potential pile driving + drilling and completion activities + seabed preparation prior to infrastructure installation + subsurface evaluation using well bore seismic imaging techniques + project vessel, FPSO and MODU dynamic positioning (DP) and BTL installation Vessels (DP) + subsea infrastructure operations (e.g. wellhead choke noise) + FPSO facilities operations + general project vessel and helicopter movements.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to underwater noise associated with the proposed Browse to NWS Project are Objectives 5, 6, 7, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21. These objectives are detailed in Table 6-7 .
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-70). + EPBC Regulations 2000 Part 8 Division 8.3 (Regulation 8.07), which include the following measures + WA EPA Environmental Factor Guideline - Marine Fauna + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b) + Australian National Guidelines for Whale and Dolphin Watching 2017 (Commonwealth of Australia, 2017b) + Whale shark 'Industry Code of Conduct', as described in Section 4.1.6 of Department of Parks and Wildlife, 2013 + North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Aspect	Underwater noise						
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <i>Physical</i> + ambient noise (medium value (open water)) <i>Ecological</i> + plankton communities (medium value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + marine fauna + fish (high value species) + marine mammals (high value species) + marine reptiles (high value species) + KEFs (medium value) + AMPs (medium value (multiple use zones)) + State marine parks and nature reserves (high value) + other protected places (high value) <i>Socio-economic</i> + managed fisheries (high value user) + other users + tourism and recreation (high value users) + scientific studies (high value users) + aboriginal or indigenous heritage (high value users)						
Potential impacts	+ change in ambient noise + change in fauna behaviour + injury or mortality to fauna + changes to the functions, interests or activities of other users						
Risk	+ significantly larger presence of pygmy blue whales than predicted + subsea valves choke noise within Scott Reef channel significantly higher than predicted.						
Summary of governing impact evaluation	<table><tr><th>Magnitude</th><th>Impact significance level</th><th>Confidence</th></tr><tr><td>Slight</td><td>Minor (D)</td><td>High</td></tr></table>	Magnitude	Impact significance level	Confidence	Slight	Minor (D)	High
Magnitude	Impact significance level	Confidence					
Slight	Minor (D)	High					
Summary of governing risk evaluation	<table><tr><th>Consequence</th><th>Likelihood</th><th>Risk rating</th></tr><tr><td>Minor (C)</td><td>Highly Unlikely (1)</td><td>Moderate (C1)</td></tr></table>	Consequence	Likelihood	Risk rating	Minor (C)	Highly Unlikely (1)	Moderate (C1)
Consequence	Likelihood	Risk rating					
Minor (C)	Highly Unlikely (1)	Moderate (C1)					

6.3.8.1 Source of aspect

Background

Impulsive vs continuous (non-pulsed) noise

Underwater noise is distinguished as two different sound categories: (1) impulsive (such as pile driving); and (2) continuous (non-pulsed) (such as the FPSO, project vessels and ambient sound). Note that impulsive sounds are typically characterised using different measures or metrics compared to continuous sound. Therefore, it is not meaningful to directly compare sound level values in dB between the two types of sound or with given threshold values, without first considering appropriate conversion between the metrics being used to characterise sound level.

Relevant terminology

There are several sound level metrics which are commonly used in underwater acoustics to evaluate impulsive and non-impulsive (continuous or non-pulse) noise and its effects on marine fauna. Relevant definitions used in this assessment reflect the ISO standard for acoustic terminology, ISO/DIS 18405.2:2017 (International Organization for Standardization (ISO), 2017):

Zero-to-Peak sound pressure level (PK; L_{pk} ; $L_{p,pk}$, dB re 1 μ Pa) is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal. However, this metric does not take into account the duration of a noise event.

Sound exposure level (SEL; L_E ; $L_{E,p}$, dB re 1 μ Pa²-s) is a measure related to the acoustic energy contained in one or more acoustic events. SEL can be calculated over periods with multiple acoustic events, or over a fixed duration, the squared pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the individual acoustic events.

Sound pressure level (SPL; L_p ; dB re 1 μ Pa) is the root mean squared pressure level in a stated frequency band over a specified time window containing the acoustic event of interest. It is important to note that SPL always refers to a rms pressure level and therefore not instantaneous pressure. The SPL represents a nominal effective continuous sound over the duration of an acoustic event, which in this assessment is over a fixed duration of 0.125 ms for piling or VSP, and 1s for vessels.

Source activities

Activities resulting in underwater noise emissions that may be undertaken during the phases of the proposed Browse to NWS Project including drilling and completion, installation, commissioning, operations and decommissioning. Specific source activities relevant to this assessment are listed below:

- + drilling and completion and installation activities:
 - + drilling and completions
 - + subsurface evaluation using well bore seismic techniques including VSP
 - + piling to secure mooring lines for the MODU, SURF installations, FPSO turret mooring anchors and BTL export riser bases
 - + MODU and project vessels DP
 - + seabed preparation
 - + vessels movements (including ROV)
 - + helicopters movements
- + commissioning and operational activities:
 - + subsurface evaluation using well bore seismic techniques including VSP
 - + subsea infrastructure operation
 - + routine FPSO operations
 - + support vessel and FPSO facility operations (offtake) use of DP
 - + vessels movements (including ROV)
 - + helicopters movements
 - + IMR activities.
- + decommissioning:
 - + project vessels DP
 - + vessel movements
 - + helicopter movements
 - + infrastructure removal.

These source activities, as they relate to underwater noise emissions, are described below.

Drilling and completion

MODUs (drilling, completion and DP)

The noise emissions from a MODU primarily depend upon the MODU being moored or under DP. MODUs can be hull-based vessels equipped with drilling derrick or platforms, or self-propelled drill ships. Drilling sound usually exhibits tones below 2 kHz, with harmonics present to 10 kHz and can vary substantially between operations (Austin et al., 2018; Kyhn et al., 2014). These two studies are the most recent and detailed published studies on noise from offshore drilling operations, and provide information about the current fleet of larger drilling units, as opposed to older, smaller units (Gales, 1982; Greene, 1987; Richardson et al., 1995), as explained in Lucke et al. (2019). The broadband drilling source levels reported in Austin et al. (2018) were 168.6, 170.1 and 174.9 dB re 1 μ Pa-m for a drilling unit, a semi-submersible and a drillship.

If the propulsion system of a vessel is under heavy load (acceleration, DP) the sound produced by the cavitation process on the propellers will dominate other sources of

vessel sound (machinery, hull vibration, etc.). However, the source level depends upon the thruster, the total number of thrusters and the load placed on each, and as such will change depending upon environmental conditions. Source levels for MODU's drilling vessels similar to the proposed MODU under DP for this project such as those reported in Martin et al. (2019) and MacDonnell (2016) provide important context. Martin et al. (2019) reported a source level of 181.5 dB re 1 $\mu\text{Pa}\cdot\text{m}$, along with 75th and 90th percentiles of 183.7 and 186.3 dB re 1 $\mu\text{Pa}\cdot\text{m}$ respectively, while the Stena IceMAX drillship (which included Offshore Support Vessel (OSV) noise) was estimated to have a broadband source level of 188 dB re $\mu\text{Pa}\cdot\text{m}$ (SPL; MacDonnell, (2016)).

Acoustic modelling undertaken by Jasco Applied Science (Jasco) for the proposed Browse to NWS Project (Section 6.3.8.2, Chapter 10, Appendix D.3) presents a comparison of different source signatures (and levels). The modelling considers each thruster as an individual source; however, a MODU source level of 191 dB re 1 $\mu\text{Pa}\cdot\text{m}$, corresponding to the noise generated by eight thrusters operating simultaneously, was presented for comparison to measurement studies.

Well bore seismic imaging techniques

Well bore seismic imaging techniques, including Vertical Seismic Profiling (VSP), use a small seismic airgun array. This assessment considered a 750 in³ array operated at 6 m with a broadband (10–25,000 Hz) unweighted per-pulse SEL source level of 214 dB 1 $\mu\text{Pa}^2\text{m}^2\text{s}$ in the broadside and endfire direction (McPherson et al., 2019; Table 6-40). The well bore seismic process is repeated as required for different stations in the well.

Mooring installation (piling)

Existing measurements for subsea pile driving are limited but indicate that source levels are comparable with surface pile driving. Sound levels produced depend upon several factors such as pile size, hammer strike energy, and type of seabed, but field measurements of pile driving show that source, or near-source levels are typically in the range of 210 to 250 dB re 1 μPa (Bailey et al., 2010; McHugh, 2005; Tougaard et al., 2009) and frequency is predominantly <1 kHz (Matuschek and Betke, 2009; Robinson et al., 2012, 2007; Tougaard et al., 2009), although they can extend to much higher frequencies (MacGillivray, 2018), including at least 100 kHz (Tougaard et al., 2009). Deep and shallow-water conductor driving generate similar sound pressures; however, in deep water the pile can be much longer so the ensonified area (area impacted by noise) is greater (MacGillivray, 2018).

The acoustic modelling study predicted that for piling for the FPSO mooring broadband (10 Hz to 25 kHz) sound energy at 10 m for each penetration depth will range from 184.6–199.4 dB re 1 $\mu\text{Pa}^2\text{s}$ (inclusive of both IHC S-600 and IHC S-1200 hammers) with the peak sound energy concentrated in the frequency range 70 to 300 Hz, with levels from the pile at the shallowest modelled penetration depth having the highest energy. Piling may also be required for mooring the MODU, however if required these piles are expected to be significantly smaller than those used for the FPSO mooring system.

Table 6-40 Far-field source level specifications for the 750 in³ array, for a 6 m operational depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted

Direction	Peak source pressure level ($L_{s,pk}$; dB re 1 $\mu\text{Pa}\cdot\text{m}$)	Per-pulse source SEL (LS, E; dB 1 $\mu\text{Pa}^2\text{m}^2\text{s}$)	
		10–2000 Hz	2000–25,000 Hz
Broadside	239.8	214.0	168.7
Endfire	240.1	214.1	175.3
Vertical	239.7	214.0	173.2
Vertical (surface affected source level)	239.7	216.2	176.1

Vessel movements

The operation of motorised vessels involves numerous mechanical processes which create underwater sound as a by-product; these range from sound of the propeller, cavitation caused at the propeller edges, machinery or simply the flow noise of the vessel moving through the water. Sound emitted from vessel differs strongly depending mainly on size, speed, load, type and state of propulsion system, meteorological and oceanographic factors such as sea surface conditions and currents (MacGillivray et al. 2018).

The acoustic modelling study only considered vessels under DP (because moored vessels emit less noise than DP vessels and depth is likely to preclude moorings) and used the *MMA Inscription* as being a representative OSV. While the modelling considers each thruster as an individual source, a representative mean source level (MSL) of 183 dB re 1 μ Pa-m was used.

Commissioning and operations

FPSO

The proposed FPSO facility is a turret moored dynamically positioned production vessel, with thrusters to assist with operational heading control. It is approximately 370 m long and 67 m wide with a draft of 16 m. While in DP mode, it operates on two stern thrusters positioned laterally on the keel at the stern of the ship, right next to each other. Each thruster is proposed to be rated at 3 MW (noting that the modelling was undertaken based on 5 MW thrusters which provides a level of conservatism in the modelling results). The vessel type and specifications are similar to the Woodside FPSO facilities *Ngujima Yin* and *Nganhurra*, from which JASCO gathered measurements in 2010 (Erbe et al. 2013). The measured spectra for these two vessels were averaged and used as a surrogate for the FPSO facility. Because the *Ngujima Yin* and *Nganhurra* were moored, they were not offloading, and the weather was calm, they were not under DP when they were measured. These averaged source levels were used in this report to model FPSO operations without DP.

To model operations that include DP, sound levels of thruster noise were added to the (non-DP) source spectrum. Sound levels for DP thruster noise were based on measurements of the dive support vessel *DSV Fu Lai* (MacGillivray 2006). The composite source spectrum (i.e., non-DP and DP components) was adjusted for the difference in total operational power level between the *DSV Fu Lai* and the FPSO facility (based on early assumption the FPSO would have two 5 MW thrusters). The source spectrum was additionally modified to consider the operational level of the *Fu Lai* thrusters relative to the desired operational level for the FPSO facility. Given that DP does not require full thrust, the *Fu Lai*'s thrusters only operated at between 20% and 30%

of capacity when measured. To achieve a conservative estimate, FPSO facility thrusters were modelled at 50% power capacity, at a constant speed, noting the majority of time thrusters will be operating at much lower capacity.

Noting that the design of the FPSO is not yet finalised, it is expected that the thrusters will be located at the keel of the hull, which is approximately 16m below MSL. While this depth may change during detailed design and also as the ship's load changes due to operational requirements, modelling assumes the point source for thruster noise is 16m below MSL, which is an inherently conservative approach.

The thrusters are located at the stern section of the vessel; for modelling purposes, however, the source location was placed in the planar centre of the vessel to approximate a point source. Because this assessment is focused on the far-field noise from all sources on the vessel (including not just thruster noise, but also noise from ancillary equipment for power generation, etc.) the point source location approximation is suitable.

In summary for FPSO operations including DP, such as holding position for offtake, modelling considered each thruster as an individual source with a representative broadband (10 Hz to 63 kHz) MSL of 189 dB re 1 μ Pa-m.

Project vessels and use of DP

The acoustic modelling study only considered vessels under DP (because moored vessels emit less noise than DP vessels and depth is likely to preclude moorings) and used the *MMA Inscription* as being a representative OSV. While the modelling considers each thruster as an individual source, a representative MSL of 183 dB re 1 μ Pa-m was used.

Subsea infrastructure operation (wellheads - choke valve)

Noise will also be generated during hydrocarbon extraction as a result of the operation of the wellheads and subsea infrastructure. McCauley (2002) recorded noise from an oil producing subsea wellhead associated with the Cossack Pioneer FPSO and estimated the broadband source level to be 161.5 dB re 1 μ Pa-m (SPL).

Table 6-41 Indicative noise levels for key proposed Browse to NWS Project activities

Activity/source	Indicative noise levels (dB re 1 μ Pa)
MODU under DP	191 dB re 1 μ Pa·m (SPL)
Impact piling	184.6–199.4 dB re 1 μ Pa ² ·s at 10 m (IHC S-600 and IHC S-1200 hammers, respectively)
VSP	Per-pulse SEL source level of 214 dB 1 μ Pa ² ·m ² ·s (based on a 750 in ³ seismic source)
Support vessel under DP	183 dB re 1 μ Pa·m (SPL)
Wellheads (choke valve)	161.5 dB re 1 μ Pa·m (SPL)
Helicopters	Received level of 101 to 109 dB re 1 μ Pa (SPL) at 3 m water depth for altitudes of 610 to 152 m, respectively
FPSO during normal operations	174 dB re 1 μ Pa·m (SPL)
FPSO on DP	189 dB re 1 μ Pa·m (SPL)
FPSO facility during offloading activities (FPSO under DP, silent condensate tanker, OSV under DP)	Received level of 180 dB re 1 μ Pa (SPL) at 0.03 km from the centroid of the FPSO and OSV thrusters

6.3.8.2 Underwater Noise Modelling

Underwater noise modelling has been undertaken for a number of the key project activities. The modelling locations are presented in [Figure 6-10](#) with the results presented in the sections below. The acoustic modelling report is provided in [Chapter 10, Appendix D.3](#).

Specifically, modelling was undertaken for the following activities:

1. Pile driving for the FPSO moorings at Torosa and Brecknock - Two scenarios at each location were modelled based on differing piling hammer sizes.
 - a. Light hammer (i.e. 600 Kj), with a single strike of a single pile and complete driving of single pile.
 - b. High energy hammer (1200 Kj), with a single strike of a single pile and complete driving of single pile.
2. FPSO operational noise during offtake, including the FPSO under DP and an OSV near each FPSO (presented in isolation). Note that the condensate tanker typically does not operate its engine during offtake and therefore is not incorporated .
3. Normal operations of the MODU on DP at Torosa (TRD drill centre) and Brecknock.
4. In well VSP at Torosa (TRD well) and Brecknock.
5. Subsea wellheads (undertaken as part of previously proposed FLNG development concept).

The modelling study specifically assessed distances from operations where underwater sound levels reached thresholds corresponding to various levels of impact to marine fauna. The animals considered here included marine mammals (pygmy blue whales), turtles, and fish (including fish eggs and larvae). Due to the variety

of species considered, there are several different thresholds for evaluating effects, including: mortality, injury, temporary reduction in hearing sensitivity, and behavioural disturbance. Different approaches were used to model acoustic sources (driven piles, vessels and VSP), and outlined in detail within McPherson et al. (2019) ([Chapter 10, Appendix C.3](#), McCauley (2002) and Duncan (2011)¹⁰.

10 Duncan (2011) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

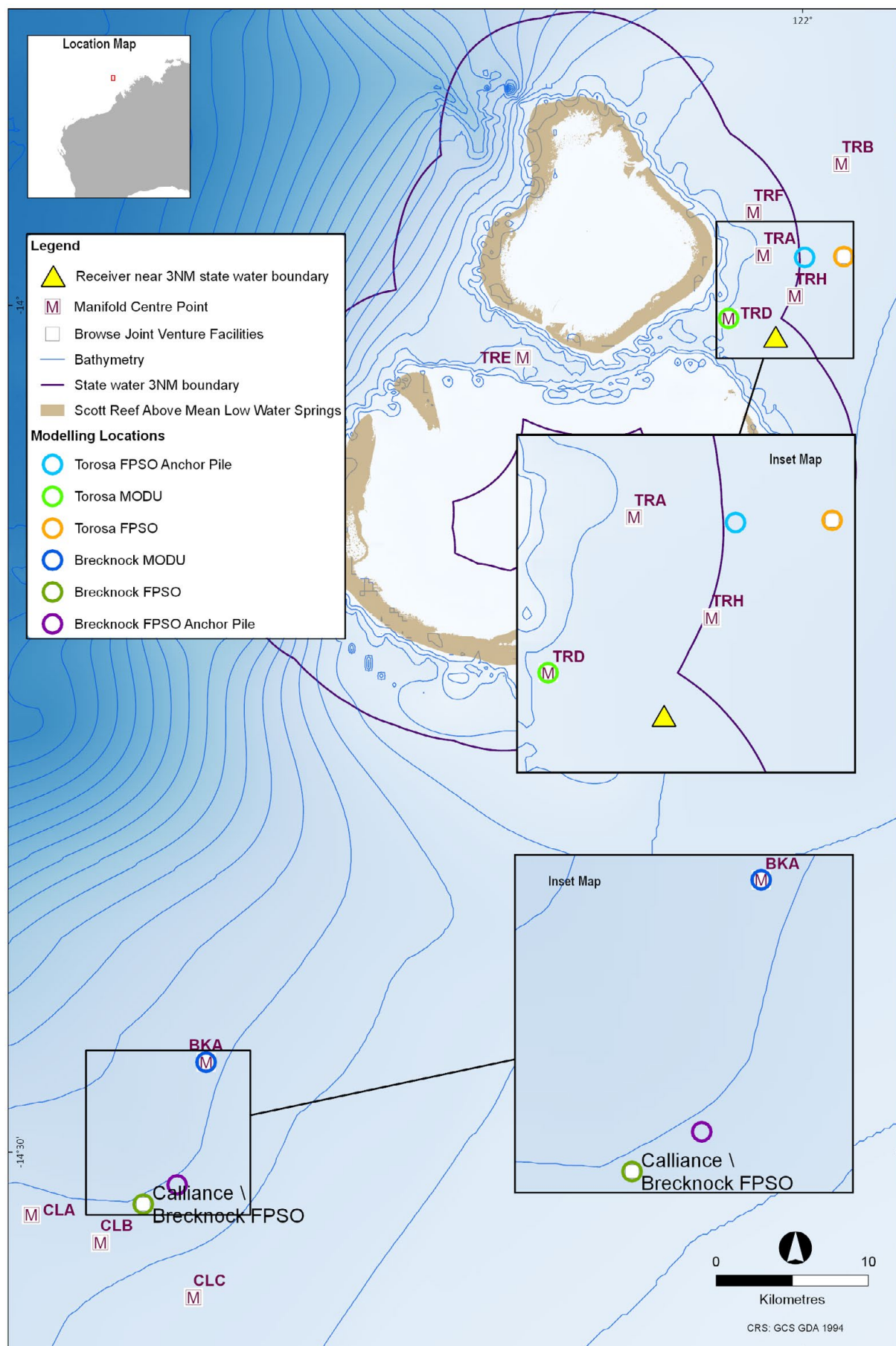


Figure 6-10 Noise modelling locations

6.3.8.2.1 Animal Movement and Exposure Modelling

In addition to the propagation modelling outlined above, McPherson et al. (2019) modelled predictions of sound levels that individual animals may receive during piling operations. This approach incorporated representative and published animal density, movement and behavioural characteristics into the propagation model (referred to as ANIMAT modelling) for the following representative scenarios;

- + pygmy blue whale migration
- + pygmy blue whale foraging
- + green turtle migration
- + green turtle interesting.

This type of animal movement and exposure modelling approach provides the most realistic prediction of the maximum expected SPL, PK, and the temporal accumulation of SEL that are considered the most relevant sound metrics for impact assessment. The most recent science in the peer-reviewed literature regarding sound propagation and animal movement modelling was used.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of animats (virtual marine mammals) to sound arising from the pile driving for the Torosa and Brecknock FPSO anchor piles. Detailed information on this approach is provided in [Chapter 10, Appendix D.3](#).

Sound exposure models like JASMINE integrate the predicted sound field with biologically meaningful movement rules for each marine mammal species (here: pygmy blue whales and green turtles) that result in an exposure history for each animat in the model. In JASMINE, the sound received by the animats is determined by the proposed pile driving activity pattern. Animats are programmed to behave like the marine animals that may be present in the area. The parameters used for forecasting realistic behaviours (e.g., diving and foraging depth, swim speed, surface times) are determined and interpreted from marine studies (e.g., tagging studies) where available, or reasonably extrapolated from related or comparable species. An individual animat's sound exposure levels are summed over a specified duration, such as 24 h or the entire simulation, to determine its total received energy, and then compared to the threshold criteria.

The exposure criteria for impulsive sounds ([Table 6-44](#), [Table 6-45](#) and [Table 6-47](#)) were used to determine the number of animats exceeding thresholds. Model simulations were seeded with high animat densities of 15 animats/ km² for pygmy blue whales and 15 animats/ km² for green turtles to generate a statistically reliable probability density function for each species and estimate exposure ranges. To calculate the number of actual animals potentially exposed, the exposure results based on the higher seeded density of 15 animat/ km²

were scaled down using representative 'real world' density values for each species defined in the sections below. To evaluate potential injury (PTS), TTS, and behavioural disturbance, exposure results were summed over the driving of a single pile (refer to [Section 6.3.8.2.1](#) for explanation of impact categories).

Specific areas of interest are defined for both pygmy blue whales and green turtles depending on behavioural mode (e.g. migrating, foraging, interesting).

Pygmy blue whales – animal behaviour

Two animat behavioral profiles were considered for pygmy blue whales, defined as foraging and migration. The research summarised in this section was used to inform the species animat behavioural profiles ([Table 6-42](#) and [Table 6-43](#)). The input values within this section are based on best available science and where uncertainty exists due to limited sample sizes, conservatism has been applied as described below.

Detailed, fine-scale diving behaviour of a migrating pygmy blue whale was derived from Owen et al. (2016) who equipped an individual with a multi-sensor tag off the west coast of Australia. The study identified areas of high residence using the horizontal movement data; the analysis of the dive data showed that the depth of migratory dives was highly consistent over time and unrelated to local bathymetry. Blue whales (*Balaenoptera musculus*) are known to primarily migrate and feed in the first few hundred metres of the water column (Goldbogen et al. 2011), with the deepest dive being reported from a pygmy blue whale being 506 m (Owen et al. 2016). Dives were identified as migratory, feeding, or exploratory behaviour. The mean depth of migratory dives (82% of all dives) was 14 m ± 4 m, and the whale spent 94% of observed time and completed 99% of observed migratory dives at water depths of less than 24 m. A total of 21 feeding dives were identified during the duration of the tag deployment (one week) with a mean maximum depth of 129 ± 183 m (range 13–505 m). The mean maximum depth of exploratory dives (107 ± 81 m, range 23–320 m) was similar to the mean maximum depth of feeding dives (129 m) and did not appear to be related to seafloor depth.

To incorporate conservatism into the modelling, the behaviour of pygmy blue whales was modelled without migration bias, i.e. the animats were resident in the ANIMAT modelling area over the entire modelling period. In reality, pygmy blue whales can be expected to transit through the area in less than half a day (based on McCauley and Jenner 2010); accordingly, the approach used is conservative as it results in higher exposure levels and higher number of animals exposed to levels exceeding the criteria thresholds.

For migratory pygmy blue whales, two dive behaviours (migratory dives (14 m ± 4 m) and exploratory dives (107 m ± 81 m)) were modelled at an even probability

of occurrence (i.e. probability for transitioning from one behaviour to another was 0.5 for both) while dive data published by Owen et al. (2016) suggest a higher likelihood (82%) for migratory dives (14 m $\pm$ 4 m) to occur and noted 94% of observed time the whale was at water depths less than 24m depth. This approach was chosen in the absence of quantitative information on the true proportion between the two dive behaviours and conservatively addresses any potential variability

in the migratory dive depths. It represents another conservative measure, given the assumption that for sub-sea piling, exposure levels are higher at depth as compared to the surface. [Table 6-42](#) and [Table 6-43](#) provide a detailed overview of the behavioural input values (and associated literature) adopted for both Foraging ANIMATS and Migratory ANIMATS, respectively. Further definition on each variable is provided within [Chapter 10, Appendix D.3](#).

Table 6-42 Foraging pygmy blue whale ANIMATS: Data values and references associated with diving behaviour

Behavioural Profile	Variable	Deep Foraging Dive -Value	Reference
Foraging pygmy blue whale	Travel direction	Correlated random walk	Houser (2006), D. Houser, pers.comm.
	Perturbation value	10	Houser (2006), D. Houser, pers.comm.
	Termination coefficient	0.2	Houser (2006), D. Houser, pers.comm.
	Travel rate (m/s)	Gaussian 1.25 (0.42)	Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 1.6 (0.5)	Goldbogen et al. (2011)
	Descent rate (m/s)	Gaussian 2.6 (0.5)	Goldbogen et al. (2011)
	Dive depth (m)	Gaussian 129.0 (183.0)	Owen et al. (2016)
	Reversals	3.5 (1.1)	Goldbogen et al. (2011)
	Probability of reversal	0.7	Approximated
	Reversal ascent dive rate (m/s)	Random 1.7–0.37	Goldbogen et al. (2011)
	Reversal descent dive rate (m/s)	Random 1.4–0.46	Goldbogen et al. (2011)
	Time in reversal (s)	Random 26.3–52.5	Approximated
	Surface interval (s)	Gaussian 162.0 (66.0)	Goldbogen et al. (2011)
	Bout duration (s)	Gaussian 12600 (1800)	Owen et al. (2016)
General	Shore following (m)	30	Approximated
	Depth limit on seeding (m)	100.0 (minimum), 110000.0 (maximum)	Approximated

Table 6-43 Migratory pygmy blue whale ANIMATS: Data values and references associated with diving behaviour

Behavioural Profile	Variable	Migratory Dive Values	Exploratory Dive Values	Reference
Migratory pygmy blue whale*	Travel direction	Correlated random walk (i.e. no migration bias)	Correlated random walk (i.e. no migration bias)	Houser (2006), D. Houser, pers.comm.
	Perturbation value	10	10	Houser (2006), D. Houser, pers.comm.
	Termination coefficient	0.2	0.2	Houser (2006) Houser (2006), D. Houser, pers.comm.
	Travel rate (m/s)	Gaussian 0.78 (0.61)	Gaussian 1.25 (0.42)	(Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 0.7 (0.2)	Gaussian 1.6 (0.5)	Goldbogen et al. (2011)

Behavioural Profile	Variable	Migratory Dive Values	Exploratory Dive Values	Reference
Migratory pygmy blue whale*	Descent rate (m/s)	Gaussian 1.5 (0.1)	Gaussian 2.6 (0.5)	Goldbogen et al. (2011)
	Dive depth (m)	Gaussian 14.0 (4.0)	Gaussian 107.0 (81.0)	Owen et al. (2016)
	Reversals	No	No	Owen et al. (2016)
	Surface interval (s)	Gaussian 60.0 (66.0)	Gaussian 162.0 (66.0)	Owen et al. (2016), approximated
	Bout duration (s)	Gaussian 12060 (1800)	Gaussian 516 (120)	Owen et al. (2016)
	Shore following (m)	30	30	Approximated
	Depth limit on seeding (m)	100.0 (minimum), 110000.0 (maximum)	100.0 (minimum), 110000.0 (maximum)	Approximated

* two migratory dive behaviours (migratory dives and exploratory dives) were modelled at an even probability of occurrence (i.e. probability for transitioning from one behaviour to another was 0.5 for both)

Pygmy blue whales – density estimates

Density estimates were derived from the acoustic detection data published by McCauley and Jenner (2010), which revealed a maximum of three pygmy blue whales on a single day passing through the area during their southward migration (November to late December). The listening range of the noise logger was estimated to be 120 km. Based on an average swimming speed for the southbound pygmy blue whales of five knots (9.26 km/hr), McCauley and Jenner (2010) calculated a transit time through the area of 0.54 days; therefore, the number of animals detected per day equates to an estimated density for vocalising animals in the area of 0.0031207 animals per km² for their study; using a more precautionary 60 km listening range, as opposed to the referenced 120 km. As not all animals are emitting calls during their migration, this density estimate has to be corrected for the percentage of animals calling ('calling rate'). McCauley and Jenner (2010) proposed that 8.5–20% of the animals present in an area could be vocalising, considering information relating to humpback whales (8.5%, Cato et al. (2001)), and pygmy blue whales (<20%, (McCauley et al. 2001), to take a precautionary approach this study has adopted the lower bound value (8.5%). If the vocalisation rate of pygmy blue whales in the Perth Canyon was applied, the resulting density of animals would be 2.35 times smaller than the precautionary 8.5% vocalisation rate applied in this impact assessment.

The entire region off the northwestern coast of Australia is a vast area with limited studies on the total abundance and distribution of pygmy blue whales. As described in McCauley et al. (2018), there are two estimates for the Eastern Indian Ocean pygmy blue whale population size along the coastline of Western Australia (WA), the first

calculated in 2004 by McCauley and Jenner (2010) at 662–1559 southbound animals, using passive acoustics, and the second calculated over 2002–2006 by Jenner et al. (2008) of 712–1754. Neither of these estimates account for whales further west in the Indian Ocean, and there is evidence that along the WA coast north of latitude ~ 19° S that the migratory pathway spreads out (Gavrillov et al. 2018), with not all animals following the Australian coastline; therefore it is unknown what proportion of the Eastern Indian Ocean pygmy blue whale population either follow the coast or travel further west (McCauley et al. 2018). McCauley et al. (2018) provides an estimate for the annual growth rate of pygmy blue whales at Portland (Victoria) of 4.3% per year. However, described by the authors, this growth rate applies only to the proportion of the population using the south eastern Australian coast, and as such may not reflect the growth rate of the full population. However, in the absence of other population growth estimates, this estimate has been applied as a conservative estimate to the proportion of the population also using the WA coast, in particular the migratory BIA.

Considering an annual growth rate of 4.3%, the two population estimates provided in McCauley and Jenner (2010) and Jenner et al. (2008) have been considered to determine the potential current population, and thus the possible percentage increase to the density estimate derived from the McCauley and Jenner (2010) acoustic detection data, as shown in [Table 19](#) and [Table 20](#) within [Chapter 10, Appendix D.3](#).

Green turtles – animal behaviour

Two behavioural profiles were considered for green turtles, internesting and migrating. The research summarised in this section inform the species behavioural definition adopted in the animal movement and exposure modelling (Table G-1 of Chapter 10, Appendix D.3). Satellite tracking of the green turtle population on Sandy Islet, Scott Reef by Guinea (2011) demonstrated satellite tracked internesting turtles have a maximum dive depth of 45 m and an average dive duration of 15–25 minutes, with a dive duration range of 20 seconds to 55 minutes (Guinea, 2011). Migratory turtle records indicate a maximum dive depth of 80 m (average: 49 m) and an average dive duration of 10–15 minutes.

Internesting turtle swimming speeds are not available for the Scott Reef green turtle population. As such an analogue based on information from a satellite tagging study of green turtle behaviour and movements conducted by the Department of Biodiversity, Conservation and Attractions (DBCA) during the 2018 and 2019 nesting period at Ningaloo has been derived. The inferred average internesting swimming speed for green turtles at Scott Reef adopted for this study was 1.4 km/h.

For the Scott Reef population, the average swim speed of migrating green turtles ranged from 1.3–2.7 km/h (Pendoley 2005, Guinea 2011).

Green turtles – ANIMAT modelling assessment areas

Three areas of interest are defined for the ANIMAT assessment of green turtles:

1. the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer, as defined in the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
2. an internesting area defined by the 50 m contour around North and South Scott Reef, including the corridor connecting the two reefs. This area was based upon data from green turtle movement when internesting at Scott Reef (Guinea, 2011) which is in depths of <50 m and adopting a conservative approach by incorporating all shallow coral reef habitat for the Scott Reef system into the model.
3. a migratory area based upon data of migrating green turtles from Scott Reef (Guinea, 2011).

Green turtles – density estimates

Based on beach monitoring at Sandy Islet, Scott Reef, Guinea (2011) estimated a green turtle abundance of 779 ± 383 ($\pm$ SE) in the years 2008 and 2009. For the purposes of calculating a representative density estimate for internesting green turtles, a precautionary upper value of 5000 turtles was adopted, along with the representative estimate of nesting green turtles (1162 individuals). The ANIMAT modelling conservatively

assumes the entire population of turtles are evenly distributed within the defined modelling area, whereas literature suggests internesting turtles are concentrated directly adjacent to their nesting location (Guinea, 2011). Accordingly, the density of turtles per km² was calculated by dividing the total population number by the area of the defined internesting area. No density estimates were calculated for migrating green turtles as no data were available.

6.3.8.2.2 Modelling Thresholds

Terminology

Potential impacts to marine fauna from underwater noise emissions are typically categorised as follows:

- + Mortality or potential mortality – physical injury that may result in the death of an individual.
- + Impairment – recoverable injury – physical injury from which an individual is expected to recover.
- + Permanent Threshold Shift (PTS) – PTS is considered a reduction in hearing sensitivity from which marine fauna do not recover (permanent hair cell or receptor damage). PTS is considered injurious. Southall et al. (2007) define the minimum exposure criterion for injury as the level at which a single exposure is estimated to cause onset of PTS. This definition is reiterated within the (Finneran, 2016) review of TTS studies where injury is classified as the level necessary to induce 40 dB of TTS. During the initial revision of the marine mammal acoustic thresholds in 2013 the US National Ocean and Atmospheric Administration (NOAA) provided guidance that PTS effects (not TTS) are considered auditory injury (National Oceanic and Atmospheric Administration (NOAA), 2010).
- + Temporary Threshold Shift (TTS) or Auditory Fatigue – a temporary reduction in the ability of an individual to perceive sound associated with auditory fatigue. TTS is temporary, and full recovery has been demonstrated in a relatively short timeframes (minutes to hours) (Finneran et al., 2017). Unlike PTS, TTS is not classified as an injurious effect. Ward (1997) concludes that “TTS is within the normal bounds of physiological variability and tolerance and does not represent physical injury”. In addition, Southall et al. (2007) indicates that the onset of tissue injury from noise exposure is considered as PTS-onset, but TTS is not considered as auditory injury because the reduced hearing sensitivity following exposure to intense sound results primarily from fatigue, not loss, of cochlear hair cells and supporting structures, and is reversible. Accordingly, the NMFS does not consider TTS to constitute auditory injury and have explicitly stated this in recent ‘Incidental Take of Marine Mammals’ authorisation notices in the US Federal Register (e.g. Federal Register / Vol. 84, No. 166, August 27 2019).

More recently (Kujawa and Liberman (2009, 2015) demonstrated that high levels of TTS (>40 dB) in mice and guinea pigs can result in neuron degeneration of synaptic contacts between hair cells and nerves (cochlear synaptopathy). In these experiments mice and guinea pigs were exposed to an 8-6 kHz acoustic tone stimulus of 2-hours of continuous noise that resulted in >40 dB of TTS (measured 24 hours post exposure), before returning to normal. In other animal experiments, shorter or less intense noise exposures that result in smaller TTS changes do not result in synaptopathic injury or neuronal loss (Hickox 2014; Fernandez et al., 2015; Jensen et al., 2015, 2017). For example, in studies with animals, 20 - 30 dB TTS generally has not been associated with synaptopathic change, whereas 40 - 50 dB TTS, 24-hour post exposure clearly has been associated with synaptopathic damage (Lichtenhan et al. 2018). Considering PTS onset in marine mammals is conservatively set at the onset of 40 dB of TTS; the high-level TTS exposures in these experiments where synaptopathic injury was observed, would already be classified as a PTS injury for a marine mammal.

- + Masking – no change in the ability of an individual to perceive sound, but biologically meaningful sounds (vocal communication, echolocation, signals and sounds produced by predators or prey) may be drowned out by anthropogenic noise.
- + Behavioural disturbance – typically short-term behavioural responses such as avoidance, displacement, or increased surfacing etc. Occurrence and intensity of behavioural disturbance can be highly variable and depends on a range of factors relating to the individual and situation. Behaviour will return to normal following cessation of the anthropogenic noise.

Sound level thresholds above which injury (PTS), auditory fatigue (TTS) or behavioural disturbance may occur vary widely between species.

Cetaceans

Cetaceans use sound for communication, to navigate, to find food, and avoid predators. Current research shows that cetaceans differ in their hearing capabilities, in both absolute hearing, and as well as the frequency band of hearing (Richardson et al., 1995; Southall et al., 2007; Wartzok and Ketten, n.d.). Southall et al. (2019) defines cetacean into three functional hearing groups based on their frequency hearing ranges:

- + Low-Frequency (LF) cetaceans - all of the mysticetes, i.e. humpback and pygmy blue whale etc.
- + High-frequency (HF) cetaceans - most delphinid species, beaked whales, sperm whales, and killer whales

- + Very-high frequency (VHF) cetaceans - porpoises, most river species, pygmy/dwarf sperm whales as well as a number of oceanic dolphins.

Southall et al. (2019) revisited the interim criteria published in 2007; all noise exposure criteria in NMFS (2018) and Southall et al. (2019) are identical (for impulsive and non-impulsive sounds), however the mid-frequency cetaceans from NMFS (2018) are classified as high-frequency cetaceans in Southall et al. (2019), and high-frequency cetaceans from NMFS (2018) are classified as very-high-frequency cetaceans in Southall et al. (2019). The impact assessment continues to apply the terminology from NMFS(2018) for consistency with other projects.

The type and scale of the effect on cetaceans to underwater noise emissions depends on a number of factors including the:

- + the level of exposure
- + the physical environment
- + the location of the animal in relation to the noise source
- + how long the individual is exposed to the noise source
- + the exposure history
- + how often the sound repeats (repetition period)
- + the ambient sound levels.

The context of noise exposure plays a critical and complex role in the way an animal might respond to noise (NMFS, 2018; Southall et al., 2019, 2017).

Table 6-44 and **Table 6-45** summarises the impulsive and non-impulsive sound impact thresholds that may result in PTS or TTS or behavioural disturbance to LF cetaceans such as humpback whales.

Table 6-44 Acoustic effects of impulsive noise on marine mammals: unweighted SPL, SEL_{24h}, and PK thresholds

Hearing group	NMFS (2014)	NMFS (2018) & Southall et al. (2019)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L _p ; dB re 1 µPa)	Weighted SEL _{24h} (L _{E,24h} ; dB re 1 µPa ² ·s)	PK (L _{pk} ; dB re 1 µPa)	Weighted SEL _{24h} (L _{E,24h} ; dB re 1 µPa ² ·s)	PK (L _{pk} ; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

L_p denotes sound pressure level period and has a reference value of 1 µPa.

L_{pk flat} denotes peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.

L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa²·s.

Table 6-45 Acoustic effects of continuous noise on marine mammals: unweighted SPL and SEL_{24h} thresholds

Hearing group	NMFS (2013)	NMFS (2018); Southall et al. (2019)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL (L _p ; dB re 1 µPa)	Weighted SEL _{24h} (L _{E,24h} ; dB re 1 µPa ² ·s)	Weighted SEL _{24h} (L _{E,24h} ; dB re 1 µPa ² ·s)
Low-frequency cetaceans	120	199	179
Mid-frequency cetaceans		198	178
High-frequency cetaceans		173	153

Marine turtles

There is limited information on marine turtle hearing, migrating turtles may use various acoustic cues, and acoustic disturbances may potentially interfere with their navigational ability (McCauley, 1994). Turtle auditory perception probably occurs through a combination of bone and water conduction (Bartol et al., 1999; Lenhardt, 1982; Lenhardt et al., 1983; Lenhardt and Harkins, 1983). Sea turtle hearing is believed to be limited to low frequencies, between 0.25 – 0.75kHz (Bartol et al., 1999).

Studies indicate that marine turtles began to show behavioural responses to an approaching seismic array (impulsive sound) at received sound levels of 166 dB re 1 µPa (SPL) and behavioural disturbance/avoidance at around 175 dB re 1 µPa (SPL; McCauley et al., 2003; [Table 6-46](#)). Startle responses and other behavioural changes are more likely from high level pulsed noise sources such as those produced during seismic surveys, rather than continuous noise sources such as vessels.

Table 6-46 Acoustic effects of impulsive noise on turtles: Unweighted SPL, SEL_{24h}, and PK thresholds

NSF (2011)	Moein et al. (1995)	Finneran et al. (2017)			
Behaviour Response	Behavioural Disturbance/Avoidance	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
SPL (L _p ; dB re 1 µPa)		Weighted SEL _{24h} (L _{E,24h} ; dB re 1 µPa ² ·s)	PK (L _{pk} ; dB re 1 µPa)	Weighted SEL _{24h} (L _{E,24h} ; dB re 1 µPa ² ·s)	PK (L _{pk} ; dB re 1 µPa)
166	175	204	232	189	226

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

L_p denotes sound pressure level period and has a reference value of 1 µPa.

L_{pk,flat} denotes peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.

L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa²·s.

Fish

Fish sensitivity and resilience varies greatly depending on the species, hearing capability, habits, proximity to the activity and if the noise occurs during a critical part of the fish lifecycle (McCauley and Salgado Kent, 2008). Fish vary widely in their vocalisations and hearing abilities, but generally hear best at low frequencies below 1 kHz (Ladich, 2013). Majority of fish species are hearing generalists (Amoser and Ladich, 2005) with relatively poor hearing. Hearing generalists are not as sensitive to noise and vibration as hearing specialists, which have developed hearing specialisations and can be particularly vulnerable to noise and particle motion as they possess an air-filled swim bladder (Gordon et al., 2003). Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure varies depending on the species and the presence and role of the swim bladder in hearing (Popper et al., 2014). Therefore, different thresholds are proposed for fish without a swim bladder, fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing.

There are a number of fish species that occur in the vicinity of the Project Area, including seahorses, pipefish, sharks, skates and rays, that lack specific studies on hearing and noise sensitivity, however as these species lack a gas filled cavity or swim bladder, they are not as vulnerable to trauma from extreme pressure changes as fish with a gas-filled space. This difference has been demonstrated by comparing the effects of pile driving sounds on fish with and without a swim bladders (Halvorsen et al., 2012). Syngnathids (a family of fish including seahorses, seadragons and pipefish), for example, produce large click sounds during feeding, perhaps for communication, which indicates that sound is important to this group of fish (Bergert and

Wainwright, 1997; Colson et al., 1998; Ripley and Foran, 2006). Furthermore, syngnathids can only hear up to approximately 1,500 Hz and have relatively high hearing thresholds (SVT, 2010). Behavioural effects of noise on fish may include changes to schooling behaviour and avoidance of the noise source (Simmonds and MacLennan, 2005).

In contrast, elasmobranchs rely on low frequency sound to locate prey (Myrberg, 2001). Elasmobranchs or cartilaginous fish (such as sharks and rays) lack a swim bladder and are considered less sensitive to sound than bony fish. The hearing capabilities of the whale shark have not been studied, but it has been suggested that they are likely to be most responsive to low frequency sounds (Myrberg, 2001). Silky sharks (*Carcharhinus falciformis*) have been observed to dive upon ignition of nearby inboard vessel motors, which may be a response to the low frequency sound signature of such motors (Myrberg, 1978).

Pelagic species may avoid sound exposure by swimming away from the source, with one example being recorded by Slotte et al. (2004) who used sonar to observe pelagic blue whiting and Norwegian herring swimming to greater depths after exposure to a seismic source. Review work by Turnpenny and Nedwell (1994) also indicated that pelagic fish swim horizontally away from the sound source, while demersal fish most likely dive toward the bottom or into deeper waters. At some noise level, demersal fish also respond by forming tight schools and reducing their depth (R.D McCauley et al., 2000). However, fish of different sizes (ages) within a single species may show differences in behaviour (Normandeau Associates, 2012).

Furthermore, noise exposure studies conducted by Miller and Cripps (2013) at Scott Reef showed no significant effect of a seismic survey on the overall abundance or species richness of the small demersal site attached Pomacentridae family and non-Pomacentridae larger roving demersal species. The six most abundant fish species were also analysed individually. In all cases no detectable effect of the seismic survey was found on the abundance of these fish species at Scott Reef associated with received cumulative sound exposure levels up to 187 dB re 1 $\mu\text{Pa}^2\text{s}$. This received level is just above the referenced TTS 186 dB re 1 $\mu\text{Pa}^2\text{s}$ $\text{SEL}_{24\text{h}}$ threshold for pile driving as articulated in Popper et al. (2014).

Table 6-47 summarises approximate threshold levels of noise that may result in mortality and potential mortal injury, recoverable injury, TTS, masking and behavioural disturbance to fish, sharks and rays. Although these potential impacts from pile driving and seismic noise are likely to be variable and context-specific, these thresholds are widely accepted as appropriate for the assessment of impacts on receptors from underwater noise, being based on peer-reviewed and published scientific research.

Sea snakes

There is limited information available on hearing in sea snakes, but they are known to be capable of detecting

pressure changes (Mick Guinea pers. comm.). However, it is likely that sea snakes rely more heavily on vision and olfaction than on hearing (Hibbard, 1975). Scientific evidence demonstrates that snakes have dual auditory pathways to detect both airborne and ground-borne vibrations using the surface of their body and their inner ears (Young, 2003), and their lower jaws may be stimulated by surface waves and vibrations (Christensen et al., 2012; Friedel et al., 2008).

The research and monitoring program on the potential effects on marine life conducted at Scott Reef for the Woodside Maxima 3D seismic survey demonstrated that the survey did not cause any observed physiological effects or mortality in marine fauna, including sea snakes (Woodside, 2007a, 2007b). In the absence of observations of sea snakes exposed to air gun noise, either of captive individuals or in the field, a conservative and precautionary approach would presume that sea snakes will respond in a similar way as other marine reptiles (e.g. marine turtles), such as exhibiting behavioural change to a sound source. As such, the acoustic impact criterion thresholds for marine turtle behavioural response to anthropogenic sounds are considered a reasonable proxy for sea snakes. However, as quantifiable distances for assessing impacts from continuous sounds only exist for fish, fish have been used as a surrogate for this assessment.

Table 6-47 Criteria for pile driving and seismic noise exposure for fish, adapted from Popper et al. (2014)

Type of animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	> 219 dB $\text{SEL}_{24\text{h}}$ or > 213 dB PK	> 216 dB $\text{SEL}_{24\text{h}}$ or > 213 dB PK	>> 186 dB $\text{SEL}_{24\text{h}}$	Pile driving: (N) Moderate (I, F) Low Seismic: (N, I, F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB $\text{SEL}_{24\text{h}}$ or > 207 dB PK	203 dB $\text{SEL}_{24\text{h}}$ or > 207 dB PK	>> 186 dB $\text{SEL}_{24\text{h}}$	Pile driving: (N) Moderate (I, F) Low Seismic: (N, I, F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB $\text{SEL}_{24\text{h}}$ or > 207 dB PK	203 dB $\text{SEL}_{24\text{h}}$ or > 207 dB PK	186 dB $\text{SEL}_{24\text{h}}$	Pile driving: (N, I) High (F) Moderate Seismic: (N, I) Low (F) Moderate	(N, I) High (F) Moderate
Fish eggs and fish larvae	> 210 dB $\text{SEL}_{24\text{h}}$ or > 207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	Pile driving: (N) Moderate (I, F) Low Seismic: (N, I, F) Low	(N) Moderate (I, F) Low

Peak sound pressure level dB re 1 μPa ; $\text{SEL}_{24\text{h}}$ dB re 1 $\mu\text{Pa}^2\text{s}$.

All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist.

Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

Plankton

Plankton are a diverse group of organisms defined by their pelagic habitat and inability to swim actively against a current. Some organisms form part of the plankton for only part of their life cycle, e.g. as eggs and larvae. Excluding fish eggs, larvae and other minute planktonic organisms within a few metres of an airgun, no planktonic organisms are likely to be affected significantly by acoustic array discharges (McCauley, 1994). Most studies on effects of impulsive sound have reported damage in fish larvae when they were 1.5 m or closer to airguns and little or no effect has been observed at distances of >5 m with the exception of (Carroll et al., 2017; Fields et al., 2019). McCauley et al. (2017), demonstrated increased mortality at distances up to 1200 m; however, the results in this study are inconsistent with the low mortalities reported in both existing and more recent literature, raising speculation that causes of the higher mortality could be unrelated to the airgun source and rather associated with the cavitation produced from the small sampling boat (Fields et al., 2019). Various aspects of the McCauley et al. (2017) study methodology were reviewed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), which noted that there were some aspects of the study that warrant further investigation (Richardson et al., 2017).

More recently Fields et al. (2019) demonstrated an impulsive airgun source had limited effects on the mortality of *Clanus* sp (zooplankton) within 10 m of the source and no measurable impact at greater distances.

Sound exposure guidelines published by Popper et al. (2014) are considered the most relevant impulsive noise acoustic threshold for fish eggs and larvae. This threshold indicates that accumulated SEL levels >210 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ ($\text{SEL}_{24\text{h}}$) or >207 dB re 1 μPa (PK) may incur mortality or potential mortal injury to fish eggs and larvae (Table 6-47). These thresholds are based on a study by Bolle et al. (2012) using pile driving noise emissions, which found no damage to larval fish at these sound exposure and pressure levels.

Coral and benthic organisms

Currently, there is limited published literature on potential impacts of noise on hard and soft corals. Benthic invertebrates, such as coral, are keystone features of shoals and reefs, but are only sensitive to noise in the nearfield (10-20 m) and therefore will not be sensitive to noise more than 1 km away. Woodside's Maxima study on the potential effects on marine life from seismic noise on Scott Reef estimated that corals required received levels of PK-PK exceeding 260 dB re 1 μPa (SPL) to induce injury (Woodside, 2007a).

Heyward et al. (2018) monitored scleractinian corals, in families Agariciidae and Acroporidae, and soft corals in situ before, during and after the Maxima 3D seismic

survey and found no detectable impacts on scleractinian coral mortality, skeletal damage or visible signs of stress immediately after and up to four months following the 3D marine seismic survey. Corals were exposed to noise levels up to 204 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ (SEL) and 226 dB re 1 μPa PK (L_{pk}) during this study. It noted that there are studies which have demonstrated sub-lethal impacts to invertebrates from impulsive sound; however' the disparate results between these studies points to the differences in received sound exposure levels and particle motion along with potential noise interference and propagation issues associated with undertaking sound exposure experiments in artificial tanks (Carroll et al., 2017; Popper et al., 2019).

Existing field-based studies that showed no increased mortality on adult populations of marine invertebrates from impulsive seismic sources were articulated by Carroll et al. (2017) and include no increased mortality to; scallops up to ten months after exposure (Harrington et al., 2010; Parry et al., 2002; Przeslawski et al., 2018), clams two days after exposure (La Bella et al., 1996), or lobsters up to eight months after exposure (Day et al., 2016; Payne et al., 2007). Similarly, there was no evidence of mortality-associated population effects such as reduced abundance or catch rates in reef associated invertebrates four days after exposure (Wardle et al., 2001), snow crabs up to 12 days after exposure (Christian et al., 2003), shrimp two days after exposure (Andriguetto-Filho et al., 2005) or lobsters weeks or years after exposure (Parry and Gason, 2006). However, Day et al. (2016) found dose-dependent increase in mortality in transplanted scallops reared in suspended lantern nets four months after repeated exposures to an airgun at very close ranges (5-10 m); however, the observed increase in mortality was still well within the natural mortality range for that species.

6.3.8.2.3 Driven Piling Modelling Results

Cetaceans

At the Torosa piling location the results of the modelling studies indicate the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h}) for LF cetaceans (Table 6-48) are predicted to be within 5.15 km (R_{max}) and 26.10 km (R_{max}), respectively for the IHC S-600 hammer and within 5.35 km (R_{max}) and 29.46 km (R_{max}) respectively for the IHC S-1200 hammer (McPherson et al., 2019). For the Brecknock piling location the modelling studies indicate that the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h}) for LF cetaceans (Table 6-48) are predicted to be within 4.58 km (R_{max}) and 23.11 km (R_{max}), respectively for the IHC S-600 hammer and within 4.62 km (R_{max}) and 24.75 km (R_{max}) respectively for the IHC S-1200 hammer (McPherson et al., 2019).

However, the radii that correspond to SEL_{24h} typically represent an unlikely worst-case scenario for SEL-based

exposure. More realistically, marine fauna (mammals or fish) would not stay in the same location or at the same range for an extended period. Therefore, a reported radius of SEL_{24h} criteria does not mean that any animal travelling within this radius of the source *will* be impacted, but rather that it could be impacted if it remained stationary in that range for the entire period of piling. Because of the conservative nature of the SEL_{24h} criteria when applied in this manner, animal movement and exposure modelling was also undertaken for pygmy blue whales, providing a more accurate and representative assessment of sound exposure.

The maximum distances to the NMFS (2014) PTS and TTS criteria (PK) are associated with the shallowest penetration of 17 m for the both the IHC S-600 and IHC S-1200 hammers (Table 6-48)

Sound level contour maps for piling at each FPSO location have been provided (Figure 6-11 and Figure 6-12).

Table 6-48 Marine mammal injury and hearing sensitivity changes: Maximum-over-depth distances (in km) from the pile to Torosa piling: Maximum-over-depth distances (in km) to frequency-weighted SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018)

Hearing group	PTS				TTS			
	IHC S-600		IHC S-1200		IHC S-600		IHC S-1200	
	R _{max} (km)	R _{95%} (km)	R _{max} (km)	R _{95%} (km)	R _{max} (km)	R _{95%} (km)	R _{max} (km)	R _{95%} (km)
Torosa								
LF cetaceans	5.15 [#]	5.00 [#]	5.35 [#]	5.12 [#]	26.10 [#]	20.79 [#]	29.46 [#]	22.60 [#]
MF cetaceans	<0.02 [†]		<0.02 [†]		0.03 [#]		0.06 [#]	0.06 [#]
HF cetaceans	0.21 [†]		0.26 [†]		0.35 [†]	0.30 [#]	2.20 [#]	2.06 [#]
Brecknock								
LF cetaceans	4.58 [#]	4.05 [#]	4.62 [#]	4.40 [#]	23.11 [#]	20.04 [#]	24.75 [#]	20.80 [#]
MF cetaceans	<0.02 [†]		<0.02 [†]		<0.02 [†]		0.05 [#]	0.05 [#]
HF cetaceans	0.19 [†]		0.26 [†]		0.36 [†]	0.31 [#]	2.33 [#]	2.20 [#]

[†] PK (L_{pk} ; dB re 1 μ Pa)

[#] Frequency weighted SEL_{24h} ($L_{E,24h}$; dB re 1 μ Pa²·s)

For the SEL_{24h} criteria, the model does not account for shutdowns.

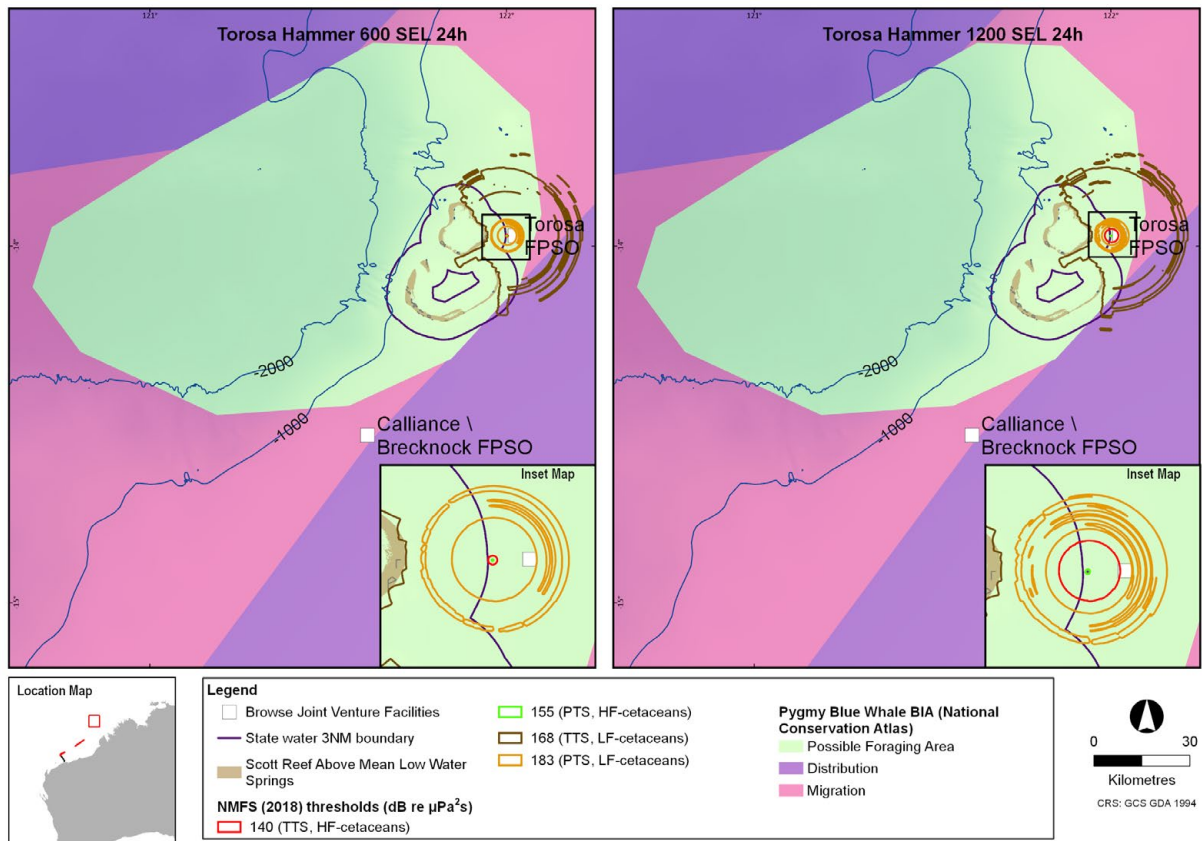


Figure 6-11 Torosa piling - IHC S-600 and IHC S-1200 SPL, 17 m penetration depth: Sound level contour map, showing maximum-over-depth results - cetaceans

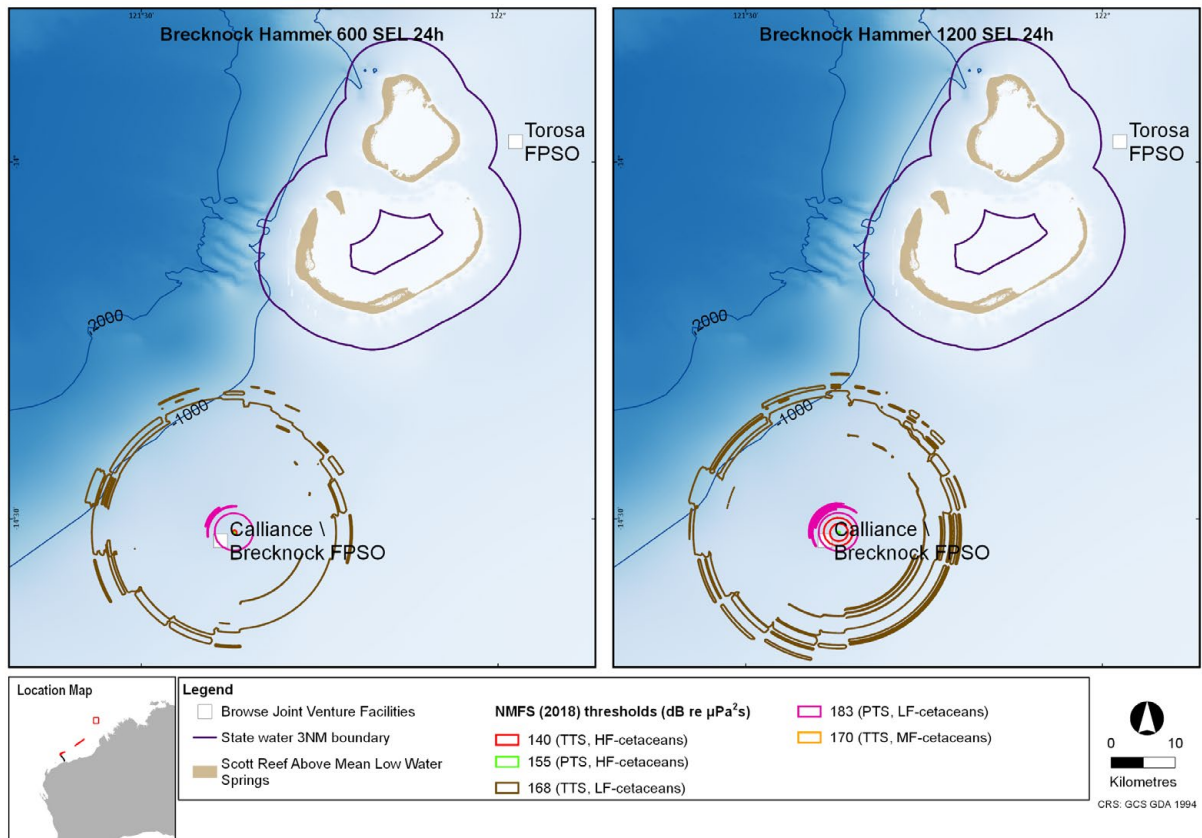


Figure 6-12 Brecknock piling - IHC S-600 and , IHC S-1200 SPL: Sound level contour map, showing maximum-over-depth results - cetaceans

For the Torosa piling location the maximum distances to the NMFS (2014) marine mammal behavioural response criterion of 160 dB re 1 μ Pa (SPL) are associated with the shallowest penetration of 17 m for the both the IHC S-600 and IHC S-1200 hammers, with the maximum distances of behavioural impacts predicted to be within 10.48 km (R_{max}) and 17.15 km (R_{max}), respectively (Table 6-49 and Figure 6-13). Note that as the pile penetration depth continues to increase the associated behavioral response distance reduces significantly. At the Torosa piling location and for the 45 m penetration depth, distances to behavioural impacts are predicted to reduce

to 5.28 km (R_{max}) and 9.68 km (R_{max}) for the IHC S-600 and IHC S-1200 hammers, respectively (Table 6-49)

For the Brecknock piling location the maximum distances to the NMFS (2014) marine mammal behavioural response criterion of 160 dB re 1 μ Pa (SPL) are also associated with the shallowest penetration of 17 m for the both the IHC S-600 and IHC S-1200 hammers, with the maximum distances of behavioural impacts predicted to be within 7.06 km (R_{max}) and 13.97 km (R_{max}), respectively and reduce further as the piling penetration depth increases (Table 6-49 and Figure 6-14).

Table 6-49 Torosa piling, marine mammal behavioural response thresholds, 160 dB re 1 μ Pa SPL: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to modelled maximum-over-depth isopleths per penetration depth

Piling Location	IHC S-600						IHC S-1200					
	Penetration depth (m)						Penetration depth (m)					
	17		31		45		17		31		45	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
Torosa	10.48	6.74	9.14	5.57	5.28	5.11	17.15	11.63	16.29	10.95	9.68	5.51
Brecknock	7.06	6.40	6.40	5.78	4.54	4.41	13.97	11.87	11.51	10.26	6.19	5.61

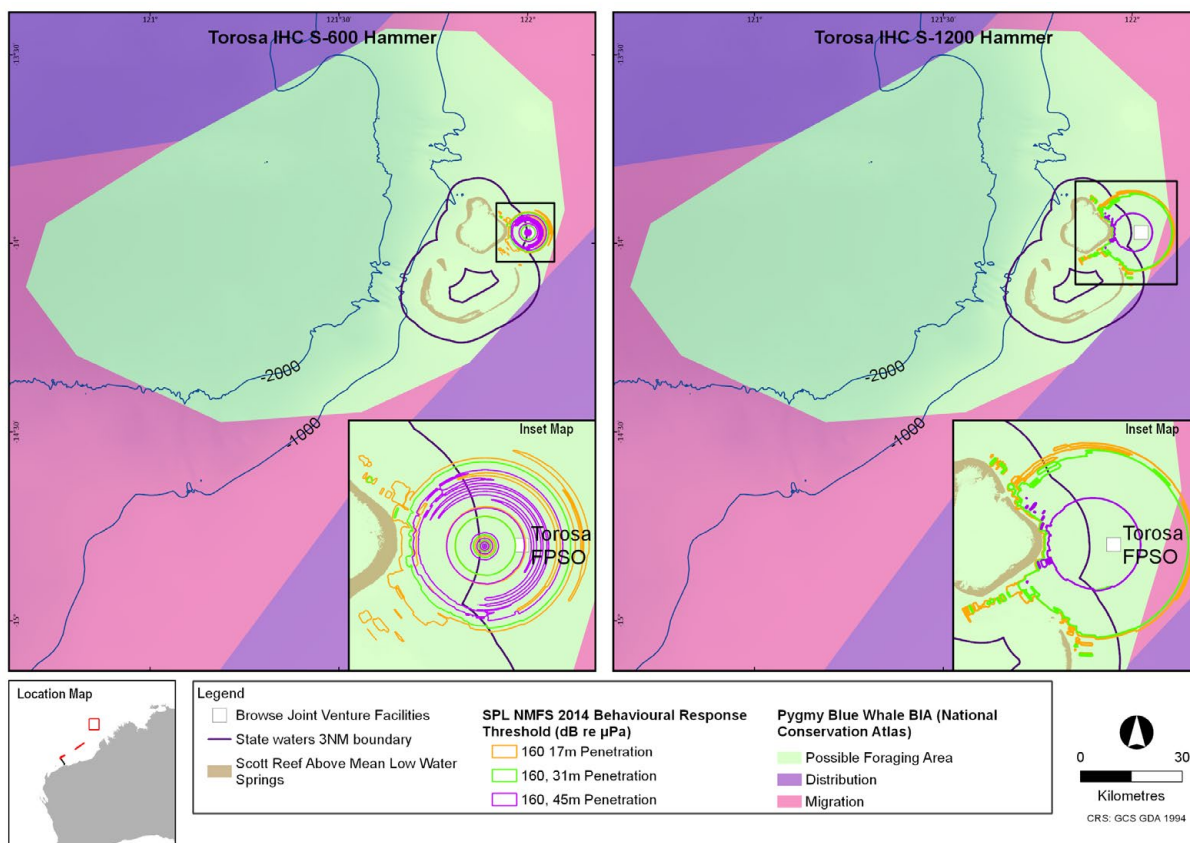


Figure 6-13 Torosa piling - marine mammal behavioural response thresholds, 160 dB re 1 μ Pa SPL: Maximum (R_{max}) horizontal distances (in km) to modelled maximum-over-depth isopleths per penetration depth

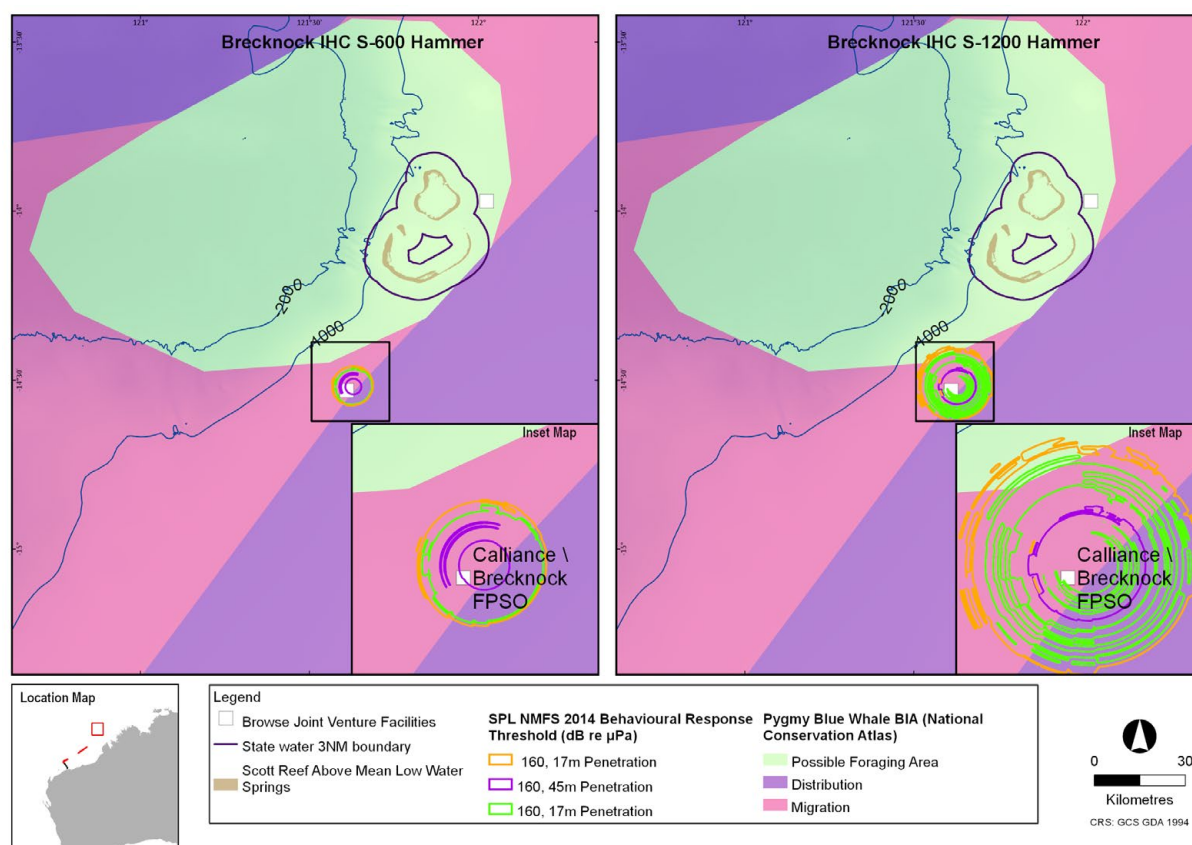


Figure 16-14 Brecknock piling - marine mammal behavioural response thresholds, 160 dB re 1 μ Pa SPL: Maximum (R_{max}) horizontal distances (in km) to modelled maximum-over-depth isopleths per penetration depth

Pygmy blue whales

The estimated sound fields produced by source and propagation models for the driving of a single pile were incorporated into an animal movement and sound exposure model to estimate the number of potential foraging or migrating pygmy blue whales potentially exposed to levels above defined thresholds. A detailed description of the specific pygmy blue whale behaviour and density inputs that have been incorporated into the model are provided within [Section 6.3.8.2.1](#). The range within which 95% of the exposure exceedances occur is reported below, along with the number of individuals that could potentially be exposed above relevant thresholds. Tabulated results are provided in [Table 30](#) (Torosa) and [Table 39](#) (Brecknock) of [Chapter 10, Appendix D.3](#). A summary of the animal movement and exposure modelling results for Torosa and Brecknock is provided in [Table 6-50](#).

Injury - PTS

For both Brecknock and Torosa piling, animal movement modelling simulation results showed that incorporation of shutdowns eliminated any potential for injury to both migrating and possible foraging pygmy blue whales within the DoEE migratory and possible foraging BIAs.

Auditory Fatigue - TTS

For migrating whales at the Torosa location, the IHC S-600 and IHC S-1200 hammers are estimated to expose only 1.05 and 1.13 individual migrating pygmy blue whales per pile above the defined TTS threshold with an estimated exposure range of approximately 7.75 km and 8.58 km (P_{95}), respectively; assuming no mitigation measures are applied. Similarly, at the Brecknock location the IHC S-600 and IHC S-1200 hammers are estimated to expose only 1.26 and 1.45 individual migrating pygmy blue whales above the defined TTS threshold with an estimated exposure range of approximately 7.67 km and 8.18 km (P_{95}).

For possible foraging whales at the Torosa location, the IHC S-600 and IHC S-1200 hammers are estimated to expose only 1.52 and 1.64 individual foraging pygmy blue whales per pile above the defined TTS threshold with an estimated exposure range of approximately 10.84 km and 12.03 km (P_{95}), respectively; assuming no mitigation measures are applied. This equates to only 3.39% overlap with the pygmy blue whale possible foraging area. Similarly, at the Brecknock location the IHC S-600 and IHC S-1200 hammers are estimated to expose only 0.02 and 0.08 individual migrating pygmy blue whales above the defined TTS threshold with an estimated exposure range of approximately 11.19 km and 12.05 km (P_{95}) and only 0.02% and 0.07% of the pygmy blue whale possible foraging area.

Behavioral Response

For migrating whales at the Torosa location, the IHC S-600 and IHC S-1200 hammers are estimated to expose only 0.32 and 1.22 individual animals per pile above the defined behavioral response threshold with an estimated exposure range of approximately 6.87 km and 9.73 km (P_{95}) respectively, assuming no mitigation measures are applied. Similarly, at the Brecknock location the IHC S-600 and IHC S-1200 hammers are estimated to expose only 0.32 and 1.56 individual migrating pygmy blue whales above the defined behavioral response threshold with an estimated exposure range of approximately 3.91 km and 8.73 km (P_{95}). It should be noted that as the pile increases its penetration depth the associated behavioral response levels will decrease significantly (Table 6-49); however, when assessing behavioral response the animal movement and exposure modelling only assessed the largest range penetration depth (17 m).

For possible foraging whales at the Torosa location, the IHC S-600 and IHC S-1200 hammers are estimated to expose up to 0.32 and 1.22 individual foraging pygmy blue whales per pile above the defined behavioral response threshold with an estimated exposure range of

approximately 6.91 km and 10.83 km (P_{95}), respectively. This equates to approximately 1.2% and 2.8% overlap with the pygmy blue whale possible foraging area. At the Brecknock location, the larger IHC S-1200 hammer is estimated to expose approximately 0.08 individual migrating pygmy blue whales above the defined behavioral response threshold with only 0.07% of the pygmy blue whale possible foraging area ensounded. Behavioural response levels associated with smaller IHC S-600 hammer piles did not reach the possible foraging area boundary.

The potential number of individual whales exposed to TTS or behavioral response represents a very small proportion of the estimated Eastern Indian Ocean pygmy blue population and reflects the small area of the migratory or possible foraging BIA ensounded (up to 3.39%). It is important to note that these values are considered a precautionary estimate as the values do not incorporate migration movement, behavioral avoidance, pre-start observations, soft starts, potential TTS recovery between pulses or likely reduction of accumulated sound exposure associated with piling shutdown periods.

Table 6-50 Torosa and Brecknock piling – Summary of animal behaviour and exposure modelling simulation results for migratory and foraging pygmy blue whales (results per individual pile)

Potential Impact	IHC S-600 Hammer – Threshold Exceedance (with 2000 m shutdown exclusion)		IHC S-1200 Hammer - Threshold Exceedance (with 2000 m shutdown exclusion)	
Torosa Piling Location				
	Possible Foraging Area (% spatial overlap)	Migrating BIA	Possible Foraging Area (% spatial overlap)	Migrating BIA
PTS - Injury	No	No	No	No
TTS – Auditory Fatigue	1.52 Individuals* (2.8%)	1.05 individuals*	1.64 individuals* (3.39%)	1.65 individuals*
Behavioural Response (17m penetration depth)	0.43 Individuals* (1.2%)	0.32 individuals*	1.28 individuals* (2.84%)	1.22 individuals*
Brecknock Piling Location				
	Possible Foraging BIA (% spatial overlap)	Migrating BIA	Possible Foraging BIA (% spatial overlap)	Migrating BIA
PTS - Injury	No	No	No	No
TTS – Auditory Fatigue	0.02 Individuals* (0.02%)	1.26 individuals*	0.08 individuals* (0.07%)	1.45 individuals*
Behavioural Response (17m penetration depth)	No	0.32 individuals*	0.08 individuals* (0.7%)	1.65 individuals*

* Animal movement and exposure modelling results are precautionary as they do not incorporate migratory travel direction, behavioural avoidance, industry standard pre-start observations and soft starts, reduction of cumulative sound exposure associated with pausing and restarting piling to account for potential shutdowns or potential TTS recovery between pulses.

Marine turtles

At the Torosa piling location the results of the acoustic modelling indicated the maximum distance to the Finneran et al. (2017) PTS and TTS criteria (SEL_{24h}) for marine turtles are predicted to be within 0.25 km (R_{max}) and 5.07 km (R_{max}), respectively (Figure 6-15). As displayed within Table 6-20, the maximum range (R_{max}) of TTS associated with Torosa piling is considered conservative, as there is a large portion of this R_{max} distance that is not ensonified above TTS levels. For example, the $R_{95\%}$ distance for the IHC S-600 hammer is significantly smaller than the R_{max} distance, 2.36 km and 4.79 km, respectively.

At the Brecknock piling location the maximum distance to the Finneran et al. (2017) PTS and TTS criteria (SEL_{24h}) for marine turtles are predicted to be within 0.25 km (R_{max}) and 2.06 km (R_{max}), respectively (Figure 6-16). These impact ranges are based on the cumulative SEL_{24h} metric; therefore, PTS would only occur if individuals remained stationary within these ranges for the duration of piling at the depth of the loudest received level, without consideration of the turtle's behaviour or movement, which is unlikely to occur.

At the Torosa piling location the maximum distances to the NSF (2011) marine turtle behavioural response criterion of 166 dB re 1 μ Pa (SPL) are associated with the shallowest penetration of 17 m for the both the IHC S-600 and IHC S-1200 hammers, with the maximum distances predicted to be within 5.11 km (R_{max}) and 9.11 km (R_{max}), respectively. The maximum distances to the Moein et al. (1995) turtle behavioural disturbance criterion of 175 dB re 1 μ Pa (SPL) are also associated with the shallowest penetration of 17 m for the both the IHC S-600 and IHC S-1200 hammers (McPherson et al., 2019). As the piling penetration depth increases, the behavioural response and disturbance distances reduce significantly; for example, at 45 m penetration depth the IHC-600 hammer range to behavioural response and behavioural disturbance reduces to 950 m and 250 m, respectively (Table 6-51).

For the Torosa FPSO piling location only the larger IHC S-1200 hammer exceeds the marine turtle behavioural response criteria (166 dB re 1 μ Pa; 17 m penetration, greatest distance) within the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area. The area ensonified is predicted to overlap 0.2% of the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area, therefore highly unlikely to displace internesting turtles from this habitat. Moreover, as outlined above, as the pile reaches deeper penetration depths (30 m and 43 m below seabed), the behavioural response range reduces significantly and no longer overlaps the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area.

For the Brecknock piling location, for both the IHC S-600 and IHC S-1200 hammer, there is no overlap of the predicted behavioural response ensonified

area with the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area. At the Brecknock piling location the maximum distances to the NSF (2011) turtle behavioural response criterion of 166 dB re 1 μ Pa (SPL) are associated with the shallowest penetration of 17 m for the both the IHC S-600 and IHC S-1200 hammers, with the maximum distances of behavioural impacts predicted to be within 2.87 km (R_{max}) and 6.38 km (R_{max}), respectively. The maximum distances to the Moein et al. (1995) turtle behavioural disturbance criterion of 175 dB re 1 μ Pa (SPL) are also associated with the shallowest penetration of 17 m for the both the IHC S-600 and IHC S-1200 hammers, with the maximum distances of behavioural impacts predicted to be within 0.67 km (R_{max}) and 1.87 km (R_{max}), respectively (McPherson et al., 2019). As the piling penetration depth increases, the behavioural response and disturbance distances reduce significantly; for example, at 45 m penetration depth the IHC-600 hammer range to behavioural response (166 dB) and behavioural disturbance (175 dB) reduces to 840 m and 280 m, respectively (Table 6-52).

When incorporating green turtle movement into the sound exposure model for both IHC S-600 and IHC S-1200 hammers at Torosa and Brecknock locations, results demonstrate that it is not credible that any green turtle (internesting or migrating) would be exposed to levels associated with injury (PTS) (Table 6-53). Accordingly, no turtles within the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area would be exposed to received levels associated with injury.

When incorporating green turtle movement into the sound exposure model for FPSO anchor piling, results demonstrate that green turtles within the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area are not exposed to sound levels associated with injury (PTS), auditory fatigue (TTS) or behavioural disturbance (175 dB). Only the larger IHC S-1200 hammer exceeded the behavioural response (166 dB) threshold within the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area and this is limited to the 17 m shallow penetration depth. Results demonstrate it is highly unlikely (0.15 turtles per pile) that turtles would be exposed to received sound levels above behavioural response thresholds. This is a conservative assessment as it assumes a population of 5000 turtles, all distributed evenly within the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area. The 'Recovery Plan for Marine Turtles in Australia 2017-2027' (Commonwealth of Australia, 2017) states a population of between 1,000 and 5,000 individuals utilise Sandy Islet for breeding. When scaling results for a lower estimated population of 1,162 turtles (Guinea, 2011), evenly distributed within the Scott Reef (Sandy Islet) 20 km habitat critical internesting buffer area, results demonstrate 0.03 turtles per pile would be exposed to received sound levels above behavioural response thresholds.

Furthermore, the available literature indicates that green turtles are highly unlikely to exceed depths greater than 40 m during internesting (Hays et al., 2000; Guinea, 2010). Therefore, an assessment against the Scott Reef

50 m contour interesting area, demonstrates that received sound levels that could cause behavioural responses in turtles are not exceeded within this area with no animals exposed.

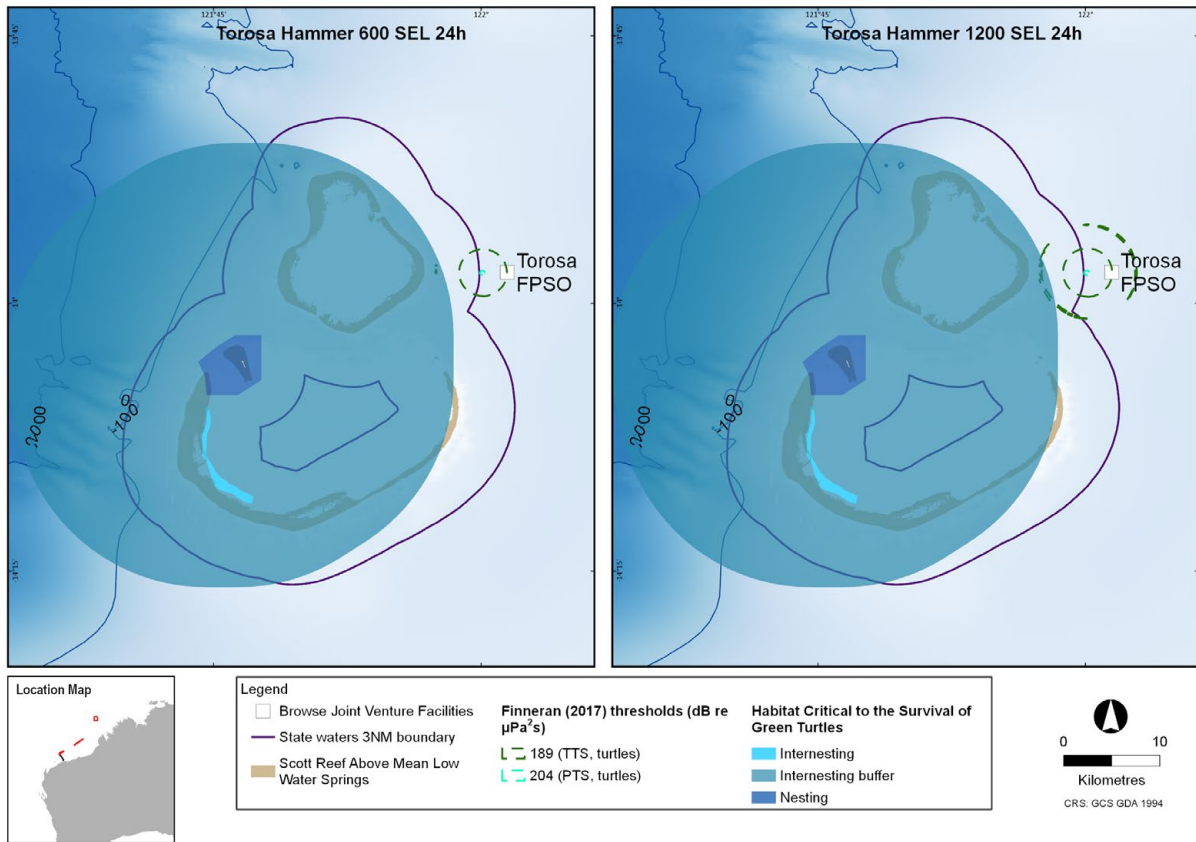


Figure 6-15 Torosa piling - IHC S-600 and , IHC S-1200 SPL: Sound level contour map, showing maximum-over-depth results – marine turtles

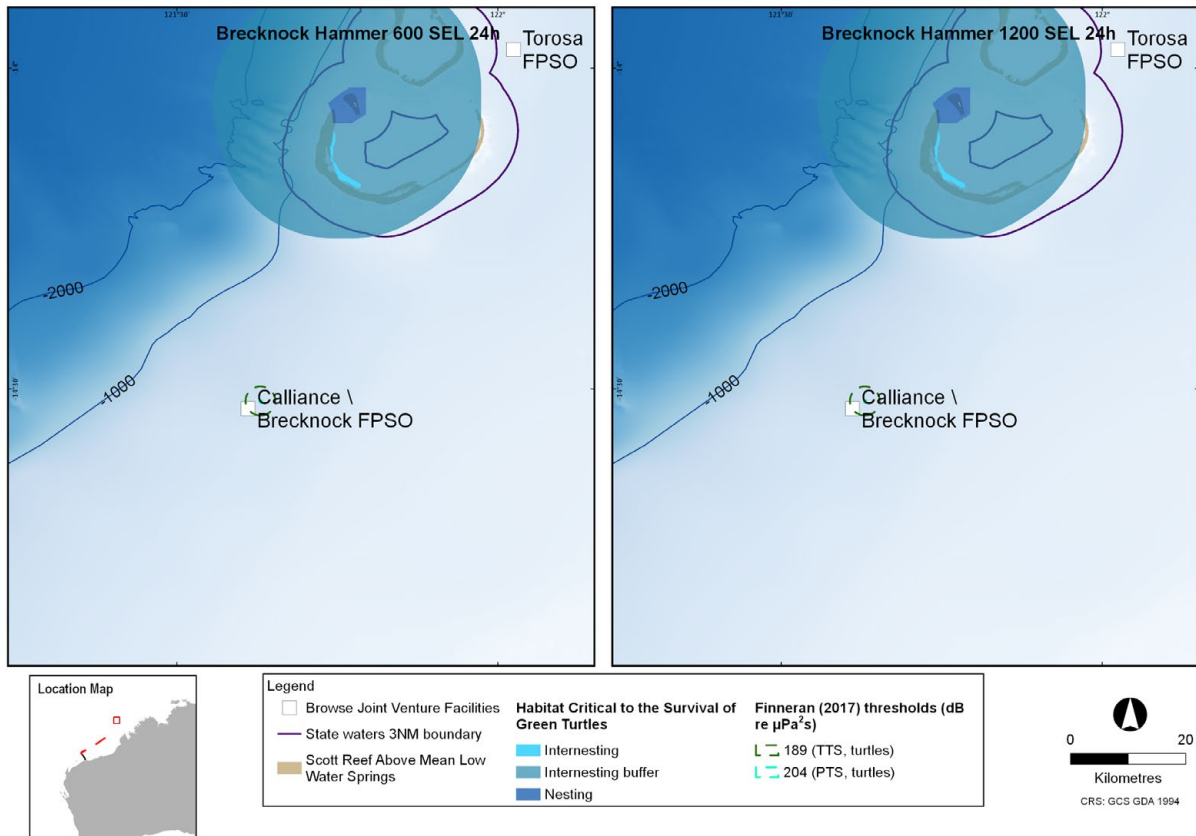


Figure 6-16 Brecknock piling – IHC S-600 and , IHC S-1200 SPL,: Sound level contour map, showing maximum-over-depth results – marine turtles

Table 6-51 Torosa piling, turtle behavioural response thresholds, SPL: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the pile to modelled maximum-over-depth isopleths per penetration depth

Threshold	IHC S-600						IHC S-1200					
	Penetration depth (m)						Penetration depth (m)					
	17		31		45		17		31		45	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
Turtle behaviour, SPL: 166 dB re 1 μ Pa (NSF 2011)	5.11	4.99	2.07	1.97	0.95	0.91	9.11	5.66	9.06	5.46	4.84	4.46
Turtle behaviour, SPL: 175 dB re 1 μ Pa (Moein et al., 1995)	0.68	0.64	0.43	0.40	0.29	0.28	1.87	1.79	0.72	0.69	0.48	0.46

Table 6-52 Brecknock piling, turtle behavioural response thresholds, SPL: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the pile to modelled maximum-over-depth isopleths per penetration depth

Threshold	IHC S-600						IHC S-1200					
	Penetration depth (m)						Penetration depth (m)					
	17		31		45		17		31		45	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
Turtle behaviour, SPL: 166 dB re 1 μ Pa (NSF 2011)	2.87	2.70	2.06	1.95	0.84	0.80	6.38	5.92	5.93	5.51	2.12	2.04
Turtle behaviour, SPL: 175 dB re 1 μ Pa (Moein et al. 1995)	0.67	0.63	0.42	0.39	0.28	0.26	1.87	1.77	0.69	0.64	0.45	0.42

Table 6-53 Torosa FPSO piling – Summary of animal behaviour and exposure modelling (ANIMAT) for migratory and internesting turtles

Potential Impact	IHC S-600 Hammer – Threshold Exceedance (no shutdown exclusion)			IHC S-1200 Hammer – Threshold Exceedance (no shutdown exclusion)		
	<i>Green turtle habitat critical (20 km radius internesting buffer around Sandy Islet)</i>	<i>Internesting – Scott Reef 50 m depth contour</i>	<i>Migrating turtles</i>	<i>Green turtle habitat critical (20 km radius internesting buffer around Sandy Islet)</i>	<i>Internesting – Scott Reef 50 m depth contour</i>	<i>Migrating Turtles</i>
PTS - Injury	No	No	No	No	No	No
TTS – Auditory Fatigue	No	No	1.69 km*	No	No	1.81 km*
Behavioural Response	No	No	2.54 km*	No	6.4 km* (0.15 individuals per pile)	4.71 km*
Behavioural Disturbance/Avoidance	No	No	No	No	No	1.78 km*

* Animal movement and exposure modelling results presented here do not incorporate shutdowns, behavioural avoidance, migratory travel direction, or industry standard pre-start observations or soft starts. Distances from source are presented as 95% probability of exposure.

Fish

For the most sensitive fish groups (fish with swim bladder involved in hearing) the distance from pile driving at the Torosa location at which sound levels could exceed mortality and potential mortal injury are predicted to be within 210 m (SEL_{24h}) for the IHC S-600 hammer, and 220 m (SEL_{24h}) for the IHC S-1200 hammer (Table 6-54; Figure 6-17). For the Brecknock location, the distance at which sound levels could exceed mortality and potential mortal injury are predicted to be within 200 m (SEL_{24h}) for the IHC S-600 hammer, and 220 m (SEL_{24h}) for the IHC S-1200 hammer (Table 6-55; Figure 6-18).

For fish, including sharks, the distance from pile driving at the Torosa location, which sound levels could exceed TTS are predicted to be within 9.05 km (SEL_{24h}) for

the IHC S-600 hammer, and 9.15 km (SEL_{24h}) for the IHC S-1200 hammer (Table 6-54). For the Brecknock location, the distance which sound levels could exceed TTS are predicted to be within 6.12 km (SEL_{24h}) for the IHC S-600 hammer, and 6.27 km (SEL_{24h}) for the IHC S-1200 hammer (Table 6-55).

However, the radii that correspond to SEL_{24h} typically represent an unlikely worst-case scenario for SEL-based exposure. More realistically, marine fauna (pelagic and demersal fish species) would not stay in the same location or at the same range for an extended period. Therefore, a reported radius of SEL_{24h} criteria does not mean that any animal travelling within this radius of the source *will* be impacted, but rather that it *could* be impacted if it remained in that range for the entire period of driving a single pile.

Table 6-54 Torosa piling fish effect thresholds - Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios

Relevant hearing group	Effect criteria	IHC S-600		IHC S-1200	
		Metric associated with longest distance to effect criteria	R _{max} (km)	Metric associated with longest distance to effect criteria	R _{max} (km)
Fish: No swim bladder	Injury	PK	0.08	PK	0.1
	TTS	SEL _{24h}	9.05	SEL _{24h}	9.15
Fish: Swim bladder not involved in hearing	Injury	SEL _{24h}	0.15	PK	0.17
	TTS	SEL _{24h}	9.05	SEL _{24h}	9.15
Fish: Swim bladder involved in hearing	Injury	SEL _{24h}	0.21	SEL _{24h}	0.22
	TTS	SEL _{24h}	9.05	SEL _{24h}	9.15
Fish eggs, and larvae	Injury	SEL _{24h}	0.15	PK	0.17

Fish I-No swim bladder; Fish II-Swim bladder not involved with hearing; Fish III-Swim bladder involved with hearing

Table 6-55 Brecknock piling fish effect thresholds - Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios

Relevant hearing group	Effect criteria	IHC S-600		IHC S-1200	
		Metric associated with longest distance to effect criteria	R _{max} (km)	Metric associated with longest distance to effect criteria	R _{max} (km)
Fish: No swim bladder	Injury	PK	0.04	PK	0.07
	TTS	SEL _{24h}	6.12	SEL ₂₄	6.27
Fish: Swim bladder not involved in hearing	Injury	SEL _{24h}	0.14	PK	0.16
	TTS	SEL _{24h}	6.12	SEL _{24h}	6.27
Fish: Swim bladder involved in hearing	Injury	SEL _{24h}	0.20	SEL _{24h}	0.22
	TTS	SEL _{24h}	6.12	SEL _{24h}	6.27
Fish eggs, and larvae	Injury	SEL _{24h}	0.14	PK	0.16

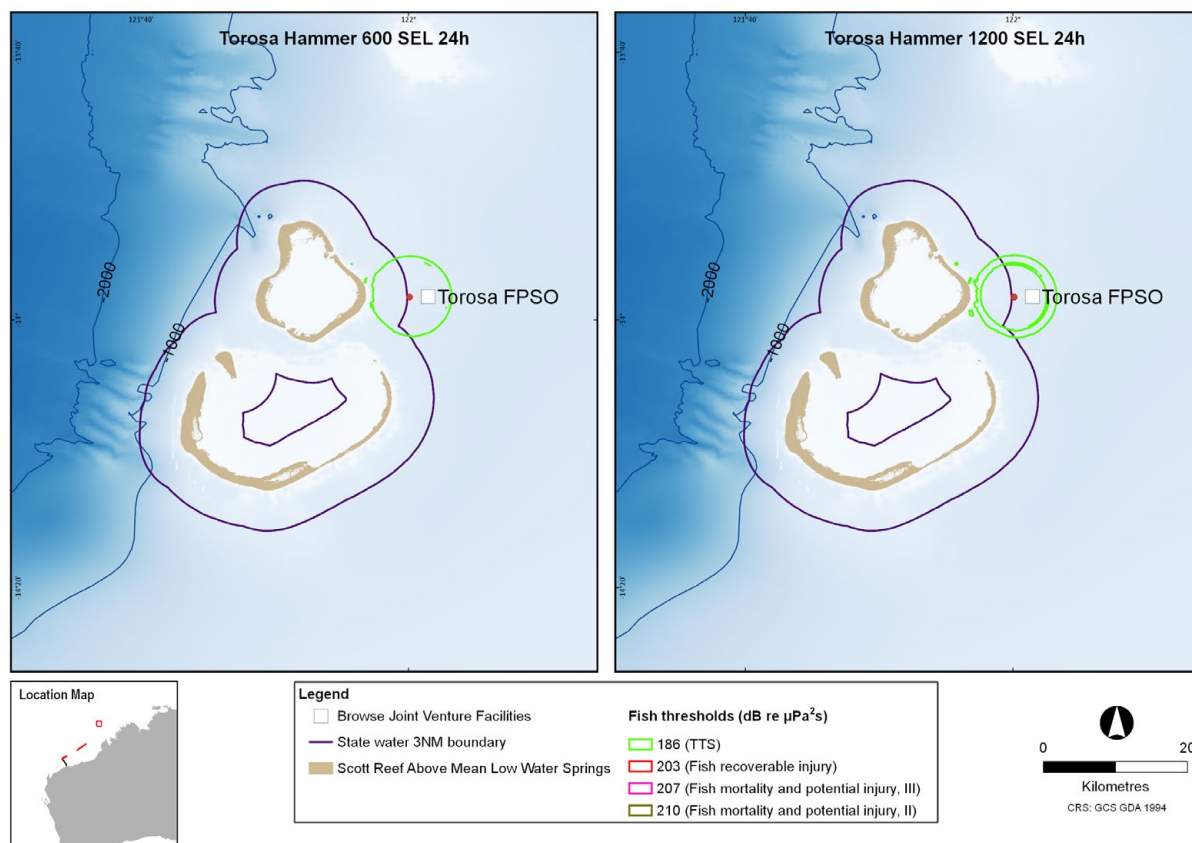


Figure 6-17 Torosa piling - IHC S-600 and IHC S-1200 SPL, 17 m penetration depth: sound level contour map, showing maximum-over-depth results. Isopleths for fish (SEL_{24h}) mortality and potential injury, fish recoverable injury and TTS criteria are shown

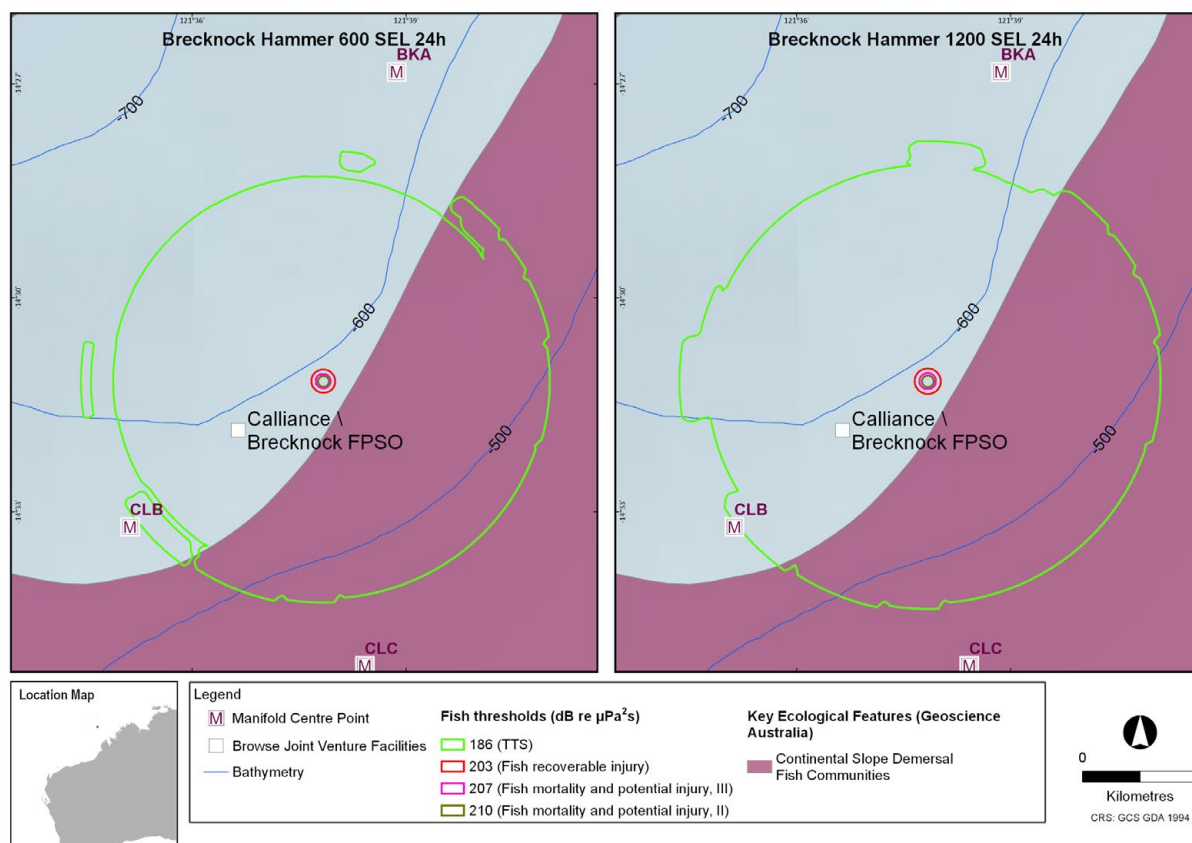


Figure 6-18 Brecknock piling - IHC S-600 and IHC S-1200 SPL, 17 m penetration depth: sound level contour map, showing maximum-over-depth results. Isopleths for fish (SEL_{24h}) mortality and potential injury, fish recoverable injury and TTS criteria are shown

Plankton

At the Torosa and Brecknock piling locations the results of the modelling studies indicate the maximum distance to the (Popper et al., 2014) criteria (SEL_{24h}) for plankton, fish eggs and larvae mortality and potential mortal injury are predicted to be within 150 m and 170 m, respectively (Table 6-55; Table 6-56). Distances to the maximum mortality and potential mortal recoverable injury thresholds (PK) distances are predicted to be within 127 m of the IHC S-600 hammer and within 166 m of the IHC S-1200 hammer. Therefore, at both locations, during piling noise levels of 210 dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24h}) or 210 dB re 1 μPa (PK) using the IHC S-600 and IHC S-1200 hammer are not predicted to reach the reef edge at Scott Reef.

6.3.8.2.4 MODU with DP Modelling Results

Cetaceans

At the Torosa TRD location for the MODU with DP, the results of the modelling studies indicate the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h} ; R_{max}) for LF cetaceans are predicted to be within 110 m (PTS) and 1.49 km (TTS) of the MODU (Table 50, Chapter 10, Appendix D.3). The results of the modelling studies also indicated that the maximum distance to the NMFS (2014) marine mammal behavioural response to continuous noise criteria (SPL; R_{max}) is predicted to be within 10.5 km of the MODU.

At the Brecknock location for the MODU with DP, the results of the modelling studies indicate the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h} ; R_{max}) for LF cetaceans are predicted to be within 110 m (PTS) and 1 km (TTS) of the MODU. The results of the modelling studies also indicated the maximum distance to the NMFS (2014) marine mammal behavioural response to continuous noise criteria (SPL; R_{max}) are predicted to be within 8.84 km of the MODU.

The above ranges to PTS and TTS do not incorporate animal movement and behaviour are based on the assumption the marine mammal is stationary within these ranges for a 24-hour period, which is highly unlikely to occur.

At the Torosa TRD location, MODU with DP noise levels of 120 dB re 1 μPa (SPL) are predicted to reach the reef edge of North and South Scott Reef, as well as within the channel between North and South Scott Reef, along the southern edge of North Scott Reef (Figure 6-19), whereas at Brecknock, noise levels of 120 dB re 1 μPa (SPL) are not predicted to reach the reef edge of South Scott Reef.

At the Torosa TRD location, the area ensonified from the MODU within the marine mammal behaviour criteria (120 dB re 1 μPa) is predicted to overlap 0.9% of the pygmy blue whale possible foraging area, leaving 99% of the possible foraging area available to pygmy blue whales and uninterrupted foraging.

At the Brecknock location, the area ensonified from the MODU within the marine mammal behaviour criteria (120 dB re 1 μPa) is predicted to overlap 1.5% of the pygmy blue whale possible foraging BIA leaving ~98% of the possible foraging BIA available to pygmy blue whales and uninterrupted foraging.

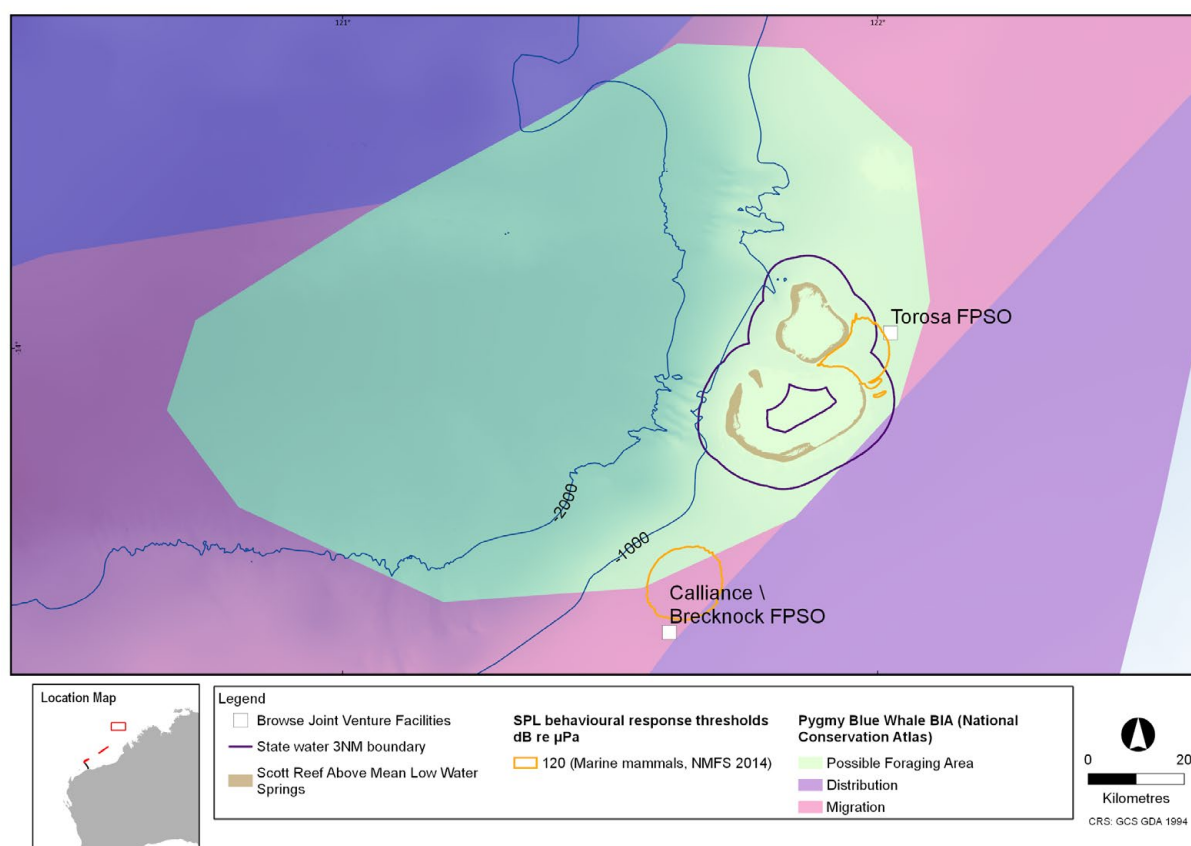


Figure 6-19 MODU SPL: Sound level contour map showing maximum-over-depth results. Isopleths for marine mammal (120 dB re 1 μPa) behavioural criteria are shown

Marine turtles

At the Torosa TRD location the results of the modelling studies in Table 6-56 indicate the maximum distance to the Finneran et al. (2017) PTS and TTS criteria ($\text{SEL}_{24\text{h}}; R_{\text{max}}$) for marine turtles are predicted to be associated with the MODU with DP within 60 m and 130 m, respectively (Table 6-56; McPherson et al., 2019).

As previously described above, radii that correspond to $\text{SEL}_{24\text{h}}$ typically represent an unlikely worst-case scenario for SEL-based exposure that doesn't incorporate animal movement or behaviour. Therefore, the reported radius of $\text{SEL}_{24\text{h}}$ criteria does not mean that any animal travelling within this radius of the source will

be impacted, but rather that it could be impacted if it remained stationary in that range for a 24-hour period.

Fish

Sound produced by the MODU operations on DP could cause physiological effects, and recoverable injury, to some fish species, but only if the animals are in very close proximity to the sound sources—within a planar distance of 60 m, for 48 hours (McPherson et al., 2019). Temporary impairment due to TTS could occur at similar short distances if fish remain at the same point within the sound field for long periods of time (12 h) (Table 6-57).

Table 6-56 MODU with DP, $\text{SEL}_{24\text{h}}$: Maximum-over-depth distances (in km) to PTS and TTS turtles (Finneran et al. 2017)

$\text{SEL}_{24\text{h}}$ ($L_{E,24\text{h}}; \text{dB re } 1 \mu\text{Pa}^2 \cdot \text{s}$)	Distance R_{max} (km)
	MODU with DP
Torosa (TRD)	
PTS - 220 ⁺	0.06
TTS - 200 ⁺	0.13
Brecknock	
PTS - 220 ⁺	0.06
TTS - 200 ⁺	0.13

A dash indicates the level is not reached.

Table 6-57 MODU with DP SPL, fish effect thresholds: maximum (R_{max}) horizontal distances (km) from the vessels to modelled maximum-over-depth SPL thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014)

SPL (L_p : dB re 1 μ Pa)	MODU with DP	
	R_{max} (km)	$R_{95\%}$ (km)
Torosa (TRD)		
170 [†]	0.06	0.06
158 [#]	0.06	0.06
Brecknock		
170 [†]	0.06	0.06
158 [#]	0.06	0.06

[†] Recoverable injury

[#] TTS

6.3.8.2.5 Well VSP Modelling Results

Cetaceans

At the Torosa TRD Well location the results of the VSP modelling studies indicate the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h}) for LF cetaceans (Table 6-58) are predicted to be within 200 m and 1.69 km, respectively, for 150 impulses. PTS levels will not be reached until there has been > 9 impulses, i.e. after 10 impulses the modelling study predicts PTS within 40 m of the source. TTS levels will be reached after 1 impulse at 90 m from the source.

At the Brecknock well location the results of the VSP modelling studies indicate the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h}) for LF cetaceans (Table 6-59) are predicted to be within 200 m and 1.69 km, respectively for 150 impulses. Correspondingly, PTS levels will not be reached until there has been > 9 impulses, i.e. after 10 impulses the modelling study predicts PTS within 40 m of the source. TTS levels will be reached after 1 impulse at 90 m from the source.

The results for the criteria applied for marine mammal PTS (NMFS, 2018), consider both metrics within the criteria (PK and SEL_{24h}), and a range of impulses within 24 hours, from 1 to 150. The applicable metric from the criteria, associated with the longest distance associated with either metric, depends upon the number of impulses within 24 hours. The ranges presented are based upon no more than 150 impulses within 24 hours.

PTS and TTS are not predicted to occur in mid-frequency cetaceans. For PTS in high-frequency cetaceans, the PK metric is always associated with the longest range (68 m; Torosa and Brecknock), while for PTS in low-frequency cetaceans, for less than 10 impulses the range is greater due to the PK metric (12 m; Torosa and Brecknock), but otherwise the range is determined by SEL_{24h} , with the maximum distance of 200 m being associated with 150 impulses at either Torosa TRD Well or Brecknock.

For TTS in high-frequency cetaceans the PK metric is always associated with the longest range (141 m), while for TTS in low-frequency cetaceans the range for five or more impulses is determined by SEL_{24h} , with the maximum distance of 1.69 km for 150 impulses at both the Torosa and Brecknock well locations (Table 6-60).

As previously described above, radii that correspond to SEL_{24h} typically represent an unlikely worst-case scenario for SEL-based exposure that doesn't incorporate animal movement or behaviour. Therefore, the reported radius of SEL_{24h} criteria does not mean that any animal travelling within this radius of the source *will* be impacted, but rather that it *could* be impacted if it remained stationary in that range for the entire period of VSP.

At both the Torosa TRD and Brecknock well locations, the results of the VSP modelling studies indicate that the maximum distances to the NMFS (2014) marine mammal behavioural response criterion of 160 dB re 1 μ Pa (SPL; impulsive noise) are predicted within 1.60 km and 1.70 km of the well location, respectively (Figure 6-20; Figure 6-21).

For VSP activities at the Torosa TRD Well location, behavioural response noise levels of 160 dB re 1 μ Pa (SPL) are not predicted to reach the reef edge of Scott Reef, or within the channel between North and South Scott Reef (Figure 6-20).

Noise levels predicted from well evaluation using VSP demonstrate that potential behaviour impacts may occur within 1.6 - 1.7 km from the well location; however, these would be limited to a very short duration as this type of activity will only occur for up to 10 hours per well. If VSP is conducted at a drill centre, it will be subject to pre-start marine fauna observations and procedures to ensure sensitive marine fauna are not in the vicinity.

Table 6-58 Torosa VSP, multiple-pulse SEL: Maximum (R_{max}) horizontal distances to frequency-weighted SEL_{24h} based marine mammal PTS and TTS thresholds NMFS (2018) from VSP operations, assuming different numbers of impulses during a 24 h period

Hearing group	Effect	Threshold for SEL_{24h} ($L_{E,24h}$; dB re $1 \mu Pa^2 \cdot s$)	Number of impulses							
			1 R_{max} (km)	5 R_{max} (km)	10 R_{max} (km)	15 R_{max} (km)	25 R_{max} (km)	50 R_{max} (km)	100 R_{max} (km)	150 R_{max} (km)
LF cetaceans	PTS	183	-	-	0.04	0.06	0.08	0.11	0.17	0.20
	TTS	168	0.09	0.22	0.29	0.36	0.46	0.65	1.10	1.69
MF cetaceans	PTS	185	-	-	-	-	-	-	-	-
	TTS	170	-	-	-	-	-	-	-	-
HF cetaceans	PTS	155	-	-	-	-	-	-	-	-
	TTS	140	-	-	-	-	-	0.04	0.06	0.09

A dash indicates the level is not reached.

Table 6-59 Brecknock VSP, multiple-pulse SEL: Maximum (R_{max}) horizontal distances to frequency-weighted SEL_{24h} based marine mammal PTS and TTS thresholds NMFS (2018) from VSP operations, assuming different numbers of impulses during a 24 h period

Hearing group	Effect	Threshold for SEL_{24h} ($L_{E,24h}$; dB re $1 \mu Pa^2 \cdot s$)	Number of impulses							
			1 R_{max} (km)	5 R_{max} (km)	10 R_{max} (km)	15 R_{max} (km)	25 R_{max} (km)	50 R_{max} (km)	100 R_{max} (km)	150 R_{max} (km)
LF cetaceans	PTS	183	-	-	0.04	0.06	0.08	0.11	0.16	0.20
	TTS	168	0.09	0.22	0.29	0.36	0.46	0.64	1.10	1.69
MF cetaceans	PTS	185	-	-	-	-	-	-	-	-
	TTS	170	-	-	-	-	-	-	-	-
HF cetaceans	PTS	155	-	-	-	-	-	-	-	-
	TTS	140	-	-	-	-	-	0.04	0.06	0.09

A dash indicates the level is not reached.

Table 6-60 VSP, PTS and TTS PK thresholds: Maximum (R_{max}) horizontal distances from the 750 in³ VSP array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for cetaceans at the modelled sites

Hearing group	PK threshold (L_{pk} ; dB re $1 \mu Pa$)	Distance R_{max} (m)	
		Torosa TRD Well	Brecknock
Low-frequency cetaceans (PTS)	219	12	12
Low-frequency cetaceans (TTS)	213	21	21
Mid-frequency cetaceans (PTS)	230	-	-
Mid-frequency cetaceans (TTS)	224	-	-
High-frequency cetaceans (PTS)	202	68	68
High-frequency cetaceans (TTS)	196	141	139

A dash indicates the level is not reached.

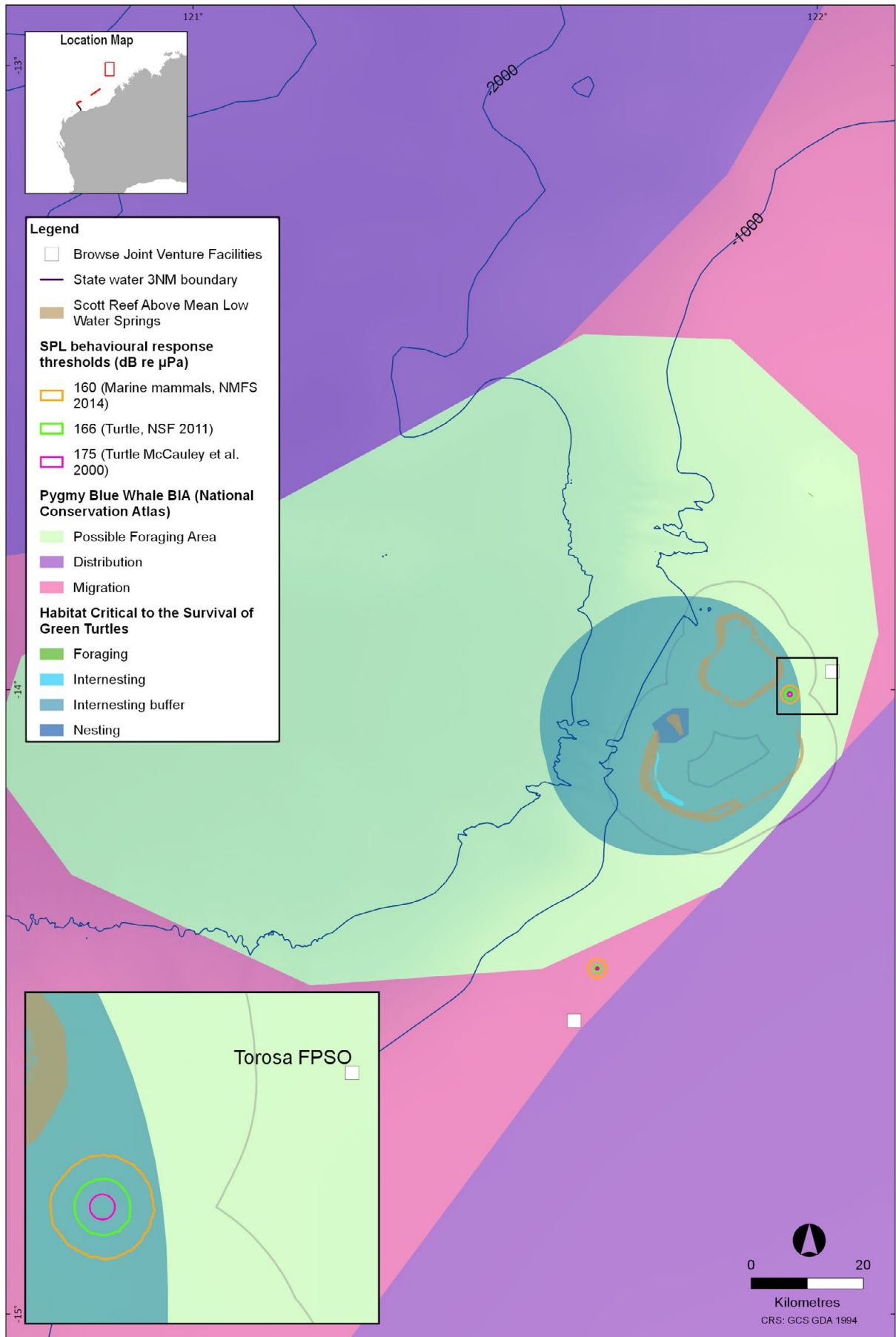


Figure 6-20 Torosa - VSP sound level contour map showing isopleths for marine mammal and turtle behavioural criteria

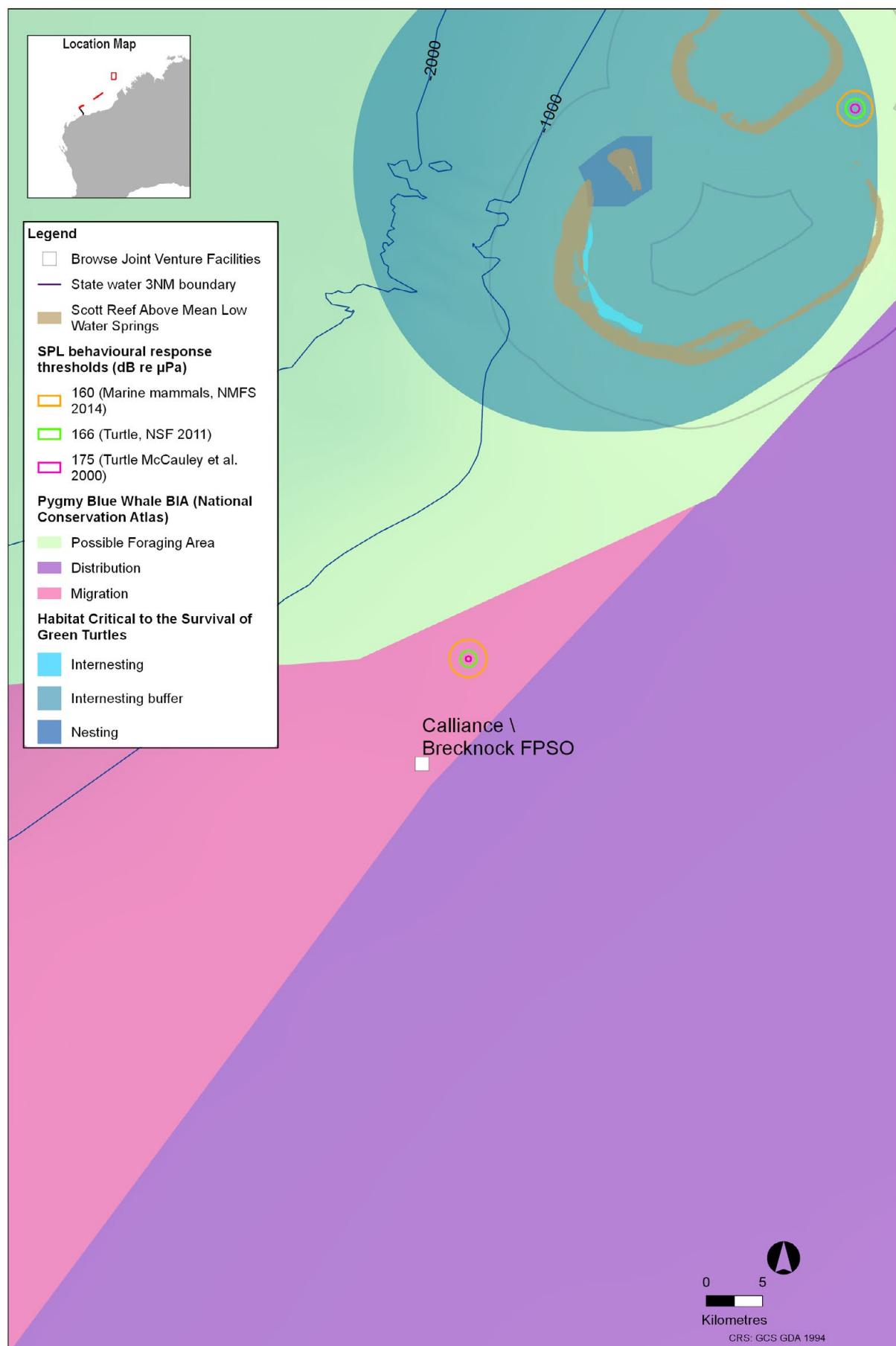


Figure 6-21 Brecknock - VSP sound level contour map showing isopleths for marine mammal and turtle behavioural criteria

Marine turtles

At the Torosa TRD and Brecknock well locations the results of the VSP modelling studies indicate the maximum distance to the Finneran et al. (2017) TTS criteria (SEL_{24h}) for marine turtles (Table 6-61;

Table 6-62) are predicted to be within 160 m, for 150 impulses. PTS levels will not be reached for the modelled 150 impulses. TTS levels will be reached after 10 impulses at 40 m from the source (Table 6-63).

Table 6-61 Torosa VSP, multiple-pulse SEL: maximum (R_{max}) horizontal distances to frequency-weighted SEL_{24h} based turtle PTS and TTS thresholds (Finneran et al., 2017) from VSP operations, assuming different numbers of impulses during a 24 h period

Hearing group	Effect	Threshold for SEL_{24h} ($L_{E,24h}$; dB re $1 \mu Pa^2 \cdot s$)	Number of impulses							
			1 R_{max} (km)	5 R_{max} (km)	10 R_{max} (km)	15 R_{max} (km)	25 R_{max} (km)	50 R_{max} (km)	100 R_{max} (km)	150 R_{max} (km)
Turtles	PTS	204	-	-	-	-	-	-	-	-
	TTS	189	-	-	0.04	0.04	0.06	0.09	0.13	0.16

A dash indicates the level is not reached.

Table 6-62 Brecknock VSP, multiple-pulse SEL: maximum (R_{max}) horizontal distances to frequency-weighted SEL_{24h} based turtle PTS and TTS thresholds (Finneran et al., 2017) from VSP operations, assuming different numbers of impulses during a 24 h period

Hearing group	Effect	Threshold for SEL_{24h} ($L_{E,24h}$; dB re $1 \mu Pa^2 \cdot s$)	Number of impulses							
			1 R_{max} (km)	5 R_{max} (km)	10 R_{max} (km)	15 R_{max} (km)	25 R_{max} (km)	50 R_{max} (km)	100 R_{max} (km)	150 R_{max} (km)
Turtles	PTS	204	-	-	-	-	-	-	-	-
	TTS	189	-	-	0.04	0.04	0.06	0.09	0.13	0.16

A dash indicates the level is not reached.

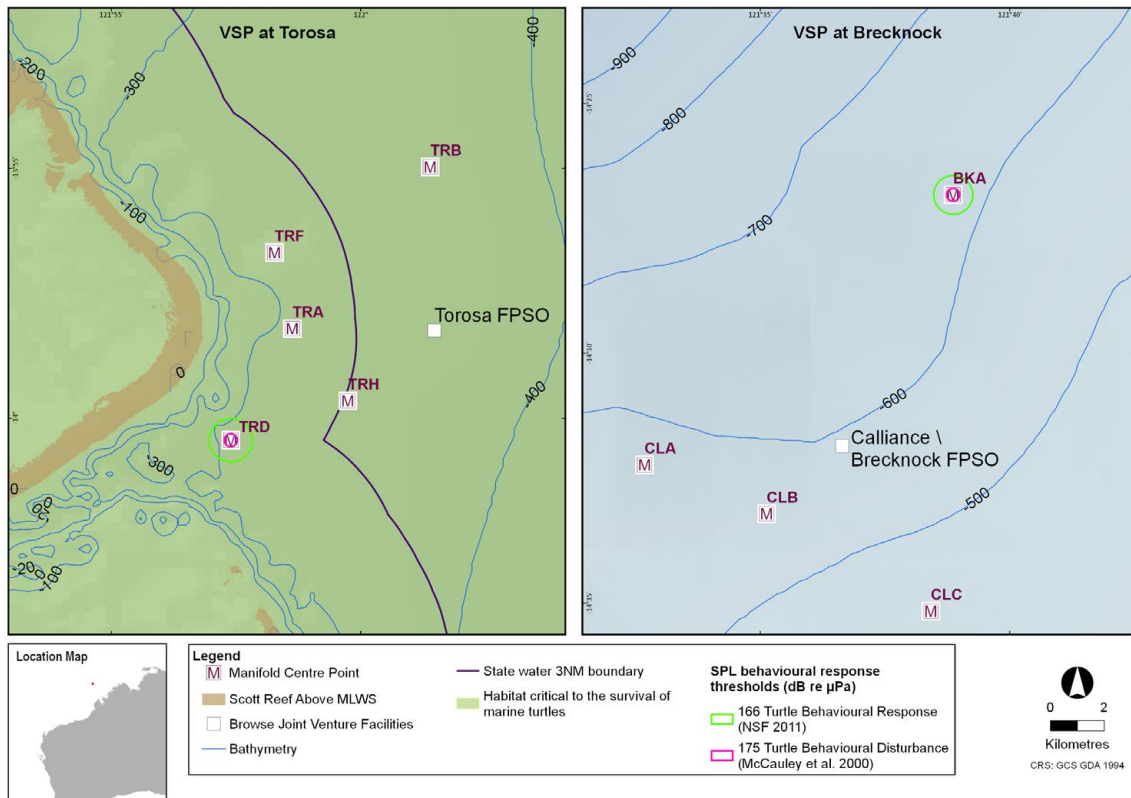


Figure 6-22 Torosa and Brecknock VSP: sound level contour map, showing marine turtle behaviour response thresholds

Table 6-63 VSP, PTS and TTS PK thresholds: maximum (R_{max}) horizontal distances from the 750 in³ VSP array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the Finneran et al. (2017) for turtles, at the modelled sites

Hearing group	PK threshold (L_{pk} ; dB re 1 μ Pa)	Distance R_{max} (m)	
		Torosa TRD Well	Brecknock
Turtles (PTS)	232	-	-
Turtles (TTS)	226	-	-

A dash indicates the level is not reached.

For both the Torosa TRD and Brecknock well locations the VSP source is not predicted to cause PTS in turtles, as it doesn't result in an exceedance of either the PK or SEL_{24h} criteria from Finneran et al. (2017) at a distance greater than the horizontal modelling resolution (20 m) from the source.

As with marine mammals, the SEL_{24h} considers a range of impulses within 24 h, from 1 to 150. While the TTS criteria due to the PK metric isn't exceeded, depending upon the number of impulses, the TTS SEL_{24h} criteria can be exceeded at up to 160 m for 150 impulses at Torosa TRD Well or Brecknock respectively.

At the Torosa TRD well location the results of the VSP modelling studies indicate that the maximum distances to the NSF (2011) and turtle behavioural response and behavioural disturbance criterion of 166 and 175 dB re 1 μ Pa (SPL; impulsive noise) are predicted within 810 m and 230 m of the well, respectively (Table 6-64; McPherson et al., 2019). For VSP activities at the Torosa TRD Well location, noise levels of 166 or 175 dB re 1 μ Pa (SPL) are not predicted to reach the reef edge of Scott Reef, or within the channel between North and South Scott Reef (Figure 6-22).

Table 6-64 Distances to turtle behavioural response criteria for VSP

SPL (L_p ; dB re 1 μ Pa)	Torosa TRD Well		Brecknock	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
175† (Behavioural Disturbance)	0.23	0.23	0.23	0.23
166‡ (Behavioural Response)	0.81	0.77	0.72	0.69

† (Moein et al. 1995).

‡ (NSF 2011).

Fish

At the Torosa TRD and Brecknock well locations the maximum-over-depth (MOD) results of the VSP modelling studies indicate the maximum distance to the Popper et al. (2014) criteria for mortality and potential mortal injury and impairment thresholds (PK) are predicted to be within 21 m for fish with no swim bladder and sharks, and 39 m for fish; swim bladder not involved in hearing; swim bladder involved with hearing (Table 6-65). Therefore, at these distances, for VSP activities at both the Torosa TRD and Brecknock well locations, noise levels of 213 and 207 dB re 1 μ Pa (PK) are not predicted to reach the reef edge of Scott Reef, or within the channel between North and South Scott Reef.

Received sound levels at the seafloor do not exceed any of the criteria (Table 6-66).

Plankton

At the Torosa TRD and Brecknock well locations the MOD results of the VSP modelling studies indicate the maximum distance to the Popper et al. (2014) criteria for mortality and potential mortal injury and impairment thresholds (PK) are predicted to be within 39 m and 40 m respectively for fish eggs and larvae (Table 6-65). Therefore, at these distances, for VSP activities at the both well locations, noise levels of 207 dB re 1 μ Pa (PK) are not predicted to reach the reef edge of Scott Reef.

Received sound levels at the seafloor do not exceed any of the criteria for impacts to fish eggs and larvae (Table 6-66).

Table 6-65 VSP, PK thresholds: Maximum (R_{max}) horizontal distances from the 750 in³ VSP array to modelled maximum-over-depth peak pressure level (PK) thresholds (Popper et al., 2014)

Hearing group	PK threshold (L_{pk} , dB re 1 μ Pa)	Distance R_{max} (m)	
		Torosa TRD Well	Brecknock
Fish: No swim bladder (also applied to sharks)	213	21	21
Fish: Swim bladder not involved in hearing; Swim bladder involved in hearing	207	39	40
Turtles, fish eggs, and larvae			

Table 6-66 VSP, seafloor PK: Maximum (R_{max}) horizontal distances from the 750 in³ VSP array to modelled seafloor peak pressure level thresholds (PK) at the modelled sites

Hearing group/animal type	PK threshold (L_{pk} , dB re 1 μ Pa)	Distance R_{max} (m)	
		Torosa TRD Well	Brecknock
Fish: No swim bladder (also applied to sharks)	213	-	-
Fish: Swim bladder not involved in hearing; Swim bladder involved in hearing	207	-	-
Turtles, fish eggs, and larvae			

A dash indicates the level is not reached.

Coral and benthic organisms

To assist with assessing the potential effects on sponges and coral receptors, the PK sound level at the seafloor directly underneath the VSP source was estimated in the modelling studies. For both Torosa TRD and Brecknock well locations, it was found that the sound

level of 226 dB re 1 μ Pa PK, a sound level associated with no effect (Heyward et al., 2018) was not reached ([Table 6-67](#)). Therefore, for VSP activities at both well locations, noise levels of 226 dB re 1 μ Pa (PK) are not predicted to reach the reef edge of Scott Reef.

Table 6-67 VSP, seafloor PK: Maximum (R_{max}) horizontal distances from the 750 in³ VSP array to modelled seafloor peak pressure level thresholds (PK) for sponges and corals at the modelled sites

Hearing group/animal type	PK threshold (L_{pk} ; dB re 1 μ Pa)	Distance R_{max} (m)	
		Torosa TRD Well	Brecknock
Sound levels for sponges and corals [†]	226	—	—

[†] Heyward et al. (2018)

A dash indicates the level is not reached.

6.3.8.2.6 FPSO Offtake Aggregate Modelling Scenario Results

Cetaceans

At the Torosa location during FPSO offtake, the results of the modelling studies indicate the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h} ; R_{max}) for LF cetaceans are predicted to be within 120 m (PTS) and 1.74 km (TTS) (McPherson et al., 2019a). The results of the modelling studies also indicated the maximum distance to the NMFS (2014) marine mammal behavioural response to continuous noise criteria (SPL; R_{max}) are predicted to be within 8.89 km of the FPSO offtake.

At the Brecknock location during FPSO offtake, the results of the modelling studies indicate the maximum distance to the NMFS (2018) PTS and TTS criteria (SEL_{24h} ; R_{max}) for LF cetaceans are predicted to be within 120 m (PTS) and 1.68 km (TTS) (McPherson et al., 2019a). The results of the modelling studies also indicated that the maximum distance to the NMFS (2014) marine mammal behavioural response to continuous noise criteria (SPL; R_{max}) are predicted to be within 8.89 km of the FPSO offtake.

The above ranges to PTS and TTS do not incorporate animal movement and behaviour and are based on the assumption the marine mammal is stationary within these ranges for a 24-hour period, which is highly unlikely to occur.

During FPSO offtake operations at the Torosa location, noise levels of 120 dB re 1 μ Pa (SPL) are not predicted to reach the reef edge of Scott Reef, or within the channel between North and South Scott Reef and only 1.5% of the pygmy blue whale possible foraging area is expected to exceed the behavioural response threshold. Offtake operations are unlikely to displace any individuals from the possible foraging area given only a small portion of this area overlaps with the potential for behavioural response. Furthermore, offtake activities are temporary in nature and expected to take place for approximately 30 hours (total activity time – i.e. including mooring operations) every 2 to 4 weeks.

At the Brecknock location during offtake operations noise levels of 120 dB re 1 μ Pa (SPL) are not predicted to reach the reef edge of Scott Reef or overlap into the pygmy blue whale possible foraging area ([Figure 6-23](#)).

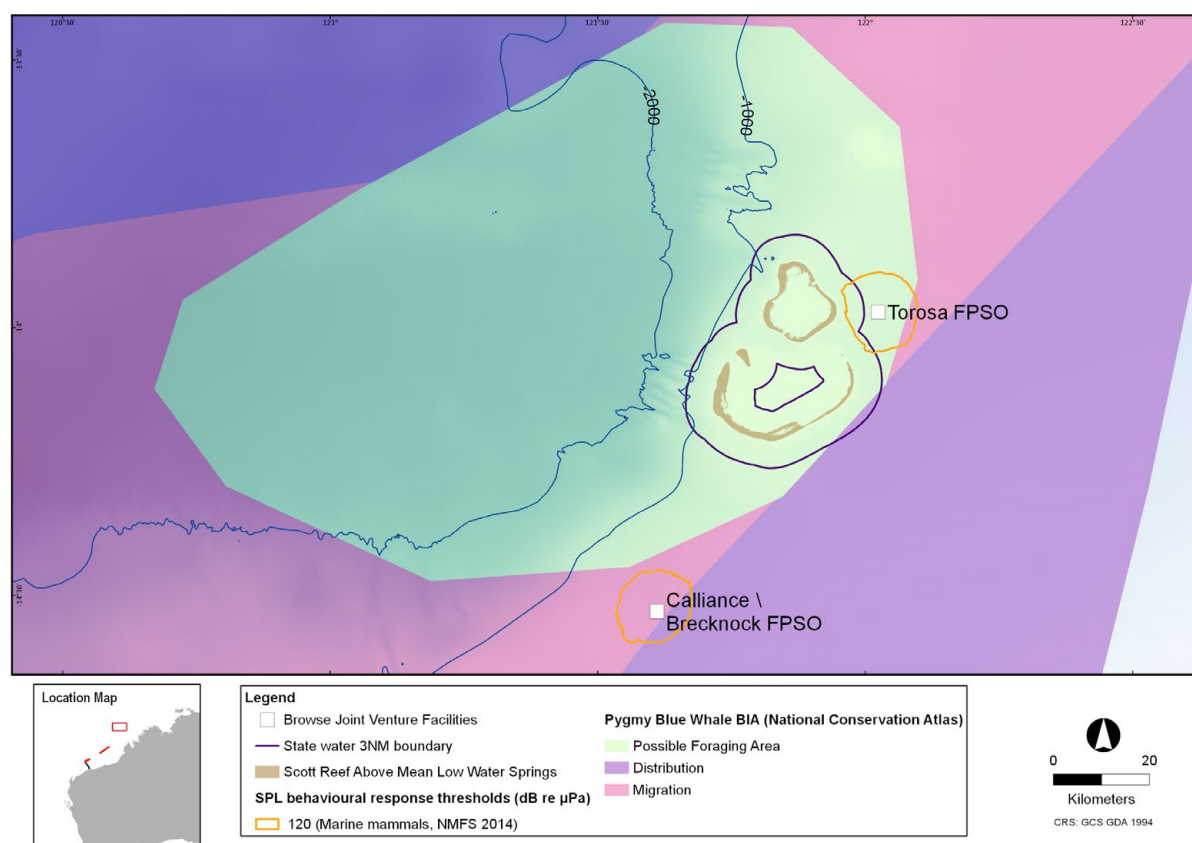


Figure 6-23 Torosa FPSO, tanker, and OSV maximum-over-depth (SPL) aggregate noise results

Marine turtles

For the Torosa location, the maximum distance to the Finneran et al. (2017) PTS and TTS criteria ($SEL_{24h}; R_{max}$) for marine turtles are predicted to be associated with the FPSO offtake within <20 m (Table 6-68).

As described above, radii that correspond to SEL_{24h}

typically represent an unlikely worst-case scenario for SEL-based exposure that doesn't incorporate animal movement or behaviour. Therefore, the reported radius of SEL_{24h} criteria does not mean that any animal travelling within this radius of the source *will* be impacted, but rather that it *could* be impacted if it remained stationary in that range for a 24-hour period.

Table 6-68 FPSO Offtake aggregate, SEL_{24h} : maximum-over-depth distances to PTS and TTS threshold criteria for turtles (Finneran et al. 2017)

SEL_{24h} ($L_{E,24h}; r; dB re 1 \mu Pa^2 \cdot s$)	Distance R_{max} (km)			
	OSV	FPSO on DP	FPSO without DP	FPSO Offtake
Torosa				
PTS - 220 ⁺	0.06	<0.02	-	<0.02
TTS - 200 ⁺	0.05	<0.02	-	<0.02
Brecknock				
PTS - 220 ⁺	0.06	<0.02	-	<0.02
TTS - 200 ⁺	0.06	<0.02	<0.02	0.06

A dash indicates the level is not reached.

Fish

Sound produced by the vessel operations could cause physiological effects, and recoverable injury, to some fish species, but only if the animals are in very close proximity to the sound sources—within a planar distance of 60 m, for 48 hours (McPherson et al., 2019a). For offtake operations at both the Torosa and Brecknock

locations, recoverable injury and temporary impairment could happen if fish remain within planar distances of <20 m and 40 m, respectively, from the FPSO or the OSV thrusters (Table 6-69). There is no increased risk to fish from aggregate scenarios, with ranges to thresholds from the individual sources unchanged.

Table 6-69 FPSO Offtake aggregate, SPL, fish effect thresholds: Maximum (R_{max}) horizontal distances from the vessels to modelled maximum-over-depth SPL thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014)

SPL (L_p ; dB re 1 μ Pa)	OSV		FPSO on DP		FPSO without DP		FPSO Offtake	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
Torosa								
170 [†]	0.05	0.05	<0.02	<0.02	-	-	0.04	0.04
158 [#]	0.05	0.05	0.04	0.04	-	-	0.06	0.06
Brecknock								
170 [†]	0.06	0.06	<0.02	<0.02	<0.02	<0.02	0.04	0.04
158 [#]	0.06	0.06	0.04	0.04	<0.02	<0.02	0.06	0.06

[†] Recoverable injury

[#] TTS FPSO offtake includes an FPSO under DP, a noiseless condensate tanker and an OSV.

6.3.8.2.7 Cumulative Modelling Scenario - FPSO Offtake and MODU Results

Representative cumulative scenario

In order to assess the potential cumulative impacts associated with multiple noise sources operating concurrently during the proposed Browse to NWS Project, a representative cumulative scenario was modelled. The scenario considers both FPSO facilities during offtake along with operations of a MODU under DP at either a Torosa TRD well or Brecknock. The FPSO operational noise during offtake includes: the FPSO under DP; and an OSV near each FPSO (presented in isolation also). It should be noted that this scenario, will only occur at times where drilling of wells within the State Proposal Area, and offtake activities are occurring simultaneously (i.e. only 30 hours, every 2-4 weeks and only during drilling activities). During offloading, the main engines of the condensate tankers will not typically be operating.

Cetaceans

During the representative cumulative scenario of an FPSO offtake operations at both locations with the MODU operating at Torosa TRD well, the results of the modelling studies indicate noise levels of 120 dB re 1 μ Pa (SPL) (the NMFS (2014) marine mammal behavioural response threshold) are predicted to reach the reef edge of North and South Scott Reef, and within the channel between North and South Scott Reef. The

modelling indicates that the NMFS (2018) PTS and TTS criteria (SEL_{24h} ; R_{max}) for LF cetaceans are predicted to be reached within an area of 160 m² (PTS) and 30.05 km² (TTS). These PTS and TTS predictions represent up to 0.3% of the possible pygmy blue foraging area and do not incorporate animal movement and behaviour and are based on the assumption the marine mammal is stationary within these ranges for a 24-hour period, which is highly unlikely to occur.

The modelling studies also indicate the NMFS (2014) marine mammal behavioural response to continuous noise criteria (120 dB re 1 μ Pa L_p) are predicted to be reached within an area of 481.9 km² (Figure 6-24). Of this area, 274.6 km² overlaps the pygmy blue whale possible foraging area. This corresponds to 2.2% of the possible foraging area. In comparison, during normal operations, i.e. the FPSO without DP, results of the modelling studies also indicated the NMFS (2014) marine mammal behavioural response to continuous noise criteria (120 dB re 1 μ Pa L_p) are predicted to be within an area of 1 km² (all of which is located within the pygmy blue whale possible foraging area).

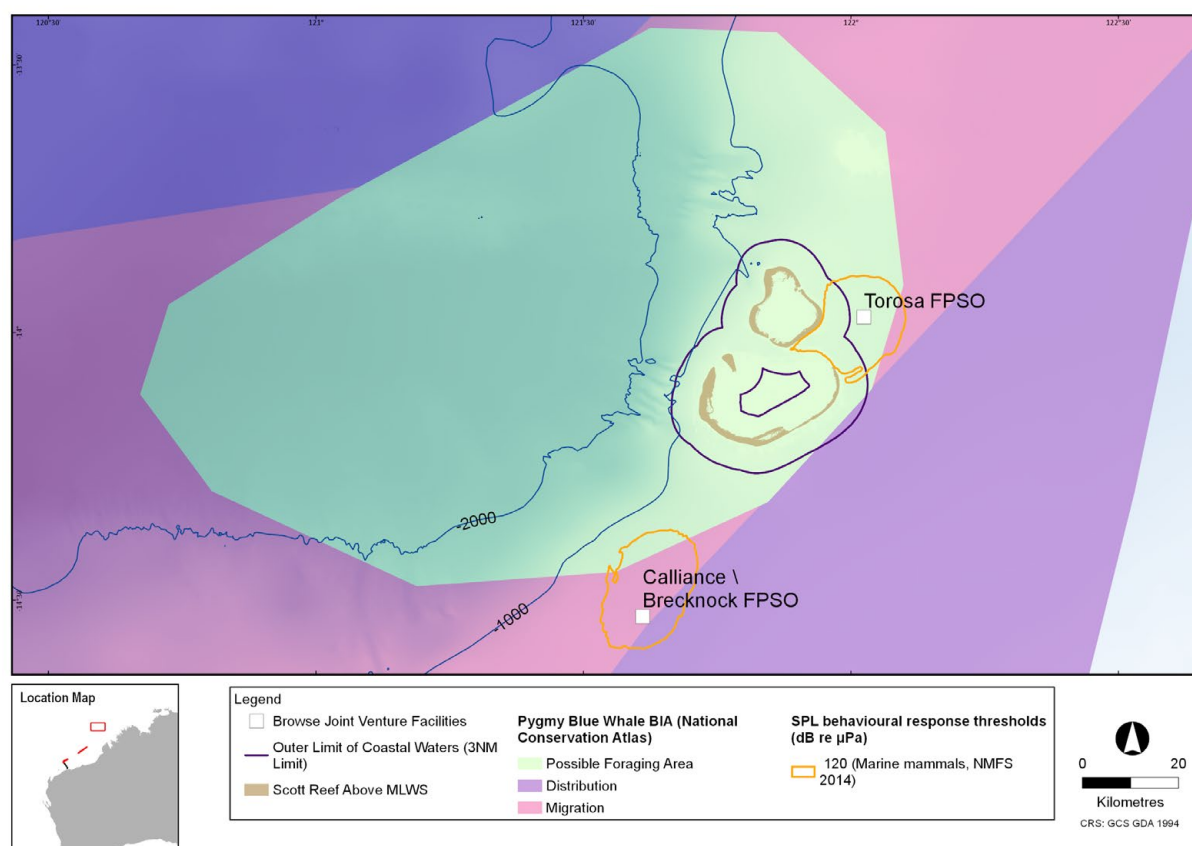


Figure 6-24 FPSO offtake at both Torosa and Brecknock and MODU at Torosa maximum-over-depth (SPL) aggregate noise results

Marine turtles

During FPSO offtake operations at both locations with the MODU at Torosa TRD well, the results of the modelling studies indicate the Finneran et al. (2017) PTS and TTS criteria (SEL_{24h} ; R_{max}) for marine turtles are predicted to be reached within an area of 17 m² (PTS) and 130 m² (TTS). This corresponds up to 0.00008% of the Scott Reef (Sandy Islet) 20 km habitat critical interesting buffer area.

As previously described above, radii that correspond to SEL_{24h} typically represent an unlikely worst-case scenario for SEL-based exposure that doesn't incorporate animal movement or behaviour. Therefore, the reported radius of SEL_{24h} criteria does not mean that any animal travelling within this radius of the source *will* be impacted, but rather that it *could* be impacted if it remained stationary in that range for a 24-hour period.

Fish

The modelling of the representative cumulative scenario indicated that the ranges to the threshold was unchanged from the modelled individual scenarios.

6.3.8.2.8 Wellhead Noise Modelling Results

Subsea choke valve noise propagation was undertaken as part of a previously proposed Development Concept. The modelling was undertaken based on the previously proposed locations of the TRD and TRE drill centres

(). Underwater noise from subsea wellheads was modelled to determine the geographical range over which noise from the Browse subsea wellheads might be expected to occur (Duncan, 2011). The source level recorded by McCauley (2002) from an oil producing wellhead associated with the Cossack Pioneer FPSO was used in the modelling. The modelling was based on configurations of seven wellheads at the TRD drill centre and six wellheads at the TRE drill centre, spaced 20 to 40 m apart and 4.5 m above the seabed in a water depth of approximately 400 m.

Received levels were calculated for cross-sections of the channel at the TRD and TRE drill centres (Figure 6-25). The modelling indicated that noise levels will fall below 120 dB re 1 µPa (SPL) within approximately 500 m of the wellheads and are not expected to propagate more than 1 km under optimal conditions. It is noted that the operating state of the Cossack Pioneer FPSO wellhead was not known at the time of measurement. However, in the absence of measured data at the Browse reservoirs, the Cossack Pioneer wellhead data is considered a reasonable proxy. In recognition of the absence of data for Browse reservoirs Section 6.3.8.2.4 presents the risk of the subsea wellhead noise being higher than that predicted within this section.

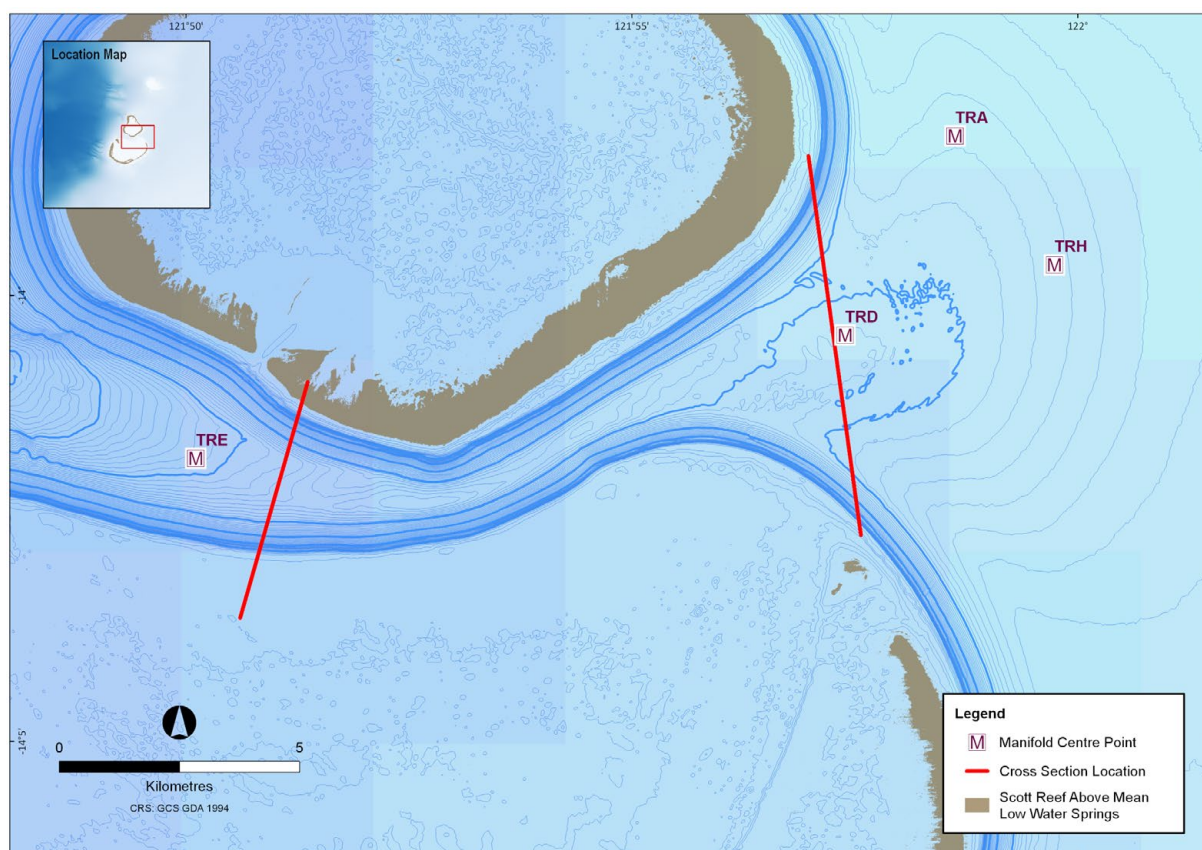


Figure 6-25 Previously proposed locations of the TRD and TRE drill centres for modelling of subsea choke valve noise propagation

6.3.8.3 Environmental Impact

Impacts on receptors associated with the predicted underwater noise emissions outlined in [Section 6.3.8.2.2](#) are discussed below. In considering such impacts several factors have been considered, including:

- + predicted source levels generated by an activity
- + the spectral characteristics of the noise emissions (i.e. frequency)
- + the distance a receptor is likely to be from the noise source (i.e. range)
- + the level of transmission loss between the noise source and the receptor
- + the hearing threshold and frequency sensitivity of the receptor.

Each of these factors has been considered in determining the likely environmental impact associated with the predicted underwater noise emissions.

Ambient noise

Change in ambient noise

Given the temporary nature of the primary noise sources during construction (such as piling), and the highly localised nature of the operations-based noise emissions, impacts to underwater ambient noise as a result of underwater noise emissions from the proposed Browse to NWS Project are considered negligible.

Plankton communities

Injury or mortality to fauna

The modelling indicates that mortality and potential mortal injury to plankton will be highly localised near the sound source (in the order of 170 m for piling, and 40 m for VSP). Plankton are expected to rapidly recover once the activity ceases, as they are known to have high levels of natural mortality and a rapid replacement rate (ITOPF, 2011). As impacts to plankton will be highly localised, they are not expected to have a significant impact on plankton communities in a region.

Benthic Habitats

Injury or mortality to fauna - Corals

As discussed in [Section 6.3.8.2.2](#) Woodside's Maxima Study on seismic noise on Scott Reef estimated that corals would require received levels of PK-PK exceeding 260 dB re 1 μ Pa (SPL) to induce injury (Hastings, 2010). The modelling indicates that sound levels reaching Scott Reef from the proposed activities do not reach these levels and as such no impact to corals from underwater noise resulting from the proposed activities is predicted to occur.

Likewise modelling of the VSP activities indicates that the sound level associated with no effect (Heyward et al., 2018) was not reached. As such, no impacts to corals are expected to occur.

Furthermore, studies on the dispersion of coral larvae at Scott Reef (Done et al., 2015; Foster and Gilmour, 2018) demonstrates that while there is significant movement of larvae within the reef system itself (particularly for spawning corals), there is no evidence to suggest the coral larvae travel outside the reef system (i.e. off the reef) before re-settling on the reef. Therefore, impacts to coral larvae as a result of noise emissions are not likely to impact the recruitment of corals within the Scott Reef system as any affect coral larvae would not have been available to resettle on the reef regardless of if the impact had occurred or not.

Injury or mortality to fauna - Epifauna and infauna

Although sparsely distributed, epifauna and infauna in the deepwater habitats of the Project Area consists of invertebrates including small burrowing worms and crustaceans. Few marine invertebrates have sensory organs that can perceive sound pressure, but many have organs or elaborate arrays of tactile 'hairs', called mechanoreceptors, that are sensitive to hydro-acoustic disturbances. Close to an impulsive noise source, the mechano-sensory system of many benthic crustaceans will perceive the 'sound' of compressed air pulses. However, for most species such stimulation would only occur within the near-field or closer, perhaps within distances of several metres from the source (McCauley, 1994).

Decapod crustaceans have a variety of external and internal sensory receptors that are potentially responsive to sound and vibration. However, the exoskeleton and body plan of aquatic decapods are more capable of responding to particle displacement components of an impinging sound field than pressure changes. The limited acoustic sensitivity of decapods is also related to their lack of any gas-filled spaces such as those associated with pressure detection in fishes. However, many decapods have extensive arrays of hair-like receptors both on and inside their exoskeleton that most probably respond to water- or substrate-borne displacements. They also have many

proprioceptive organs that may perceive vibrations (Christian et al., 2003).

Although previous studies observed little effect of impulsive noise on invertebrate behaviour and population (as inferred from commercial catch rates), Day et al., (2016) found evidence of behavioural responses and sub-lethal effects from repeated exposure to impulsive noise. Therefore, it is possible that a small number of individuals may present similar effects. However, given the relative sparsity of marine invertebrates in the Browse Development Area, and the short-term nature of the piling activities, no lasting impacts are expected, and these impacts are not considered to be significant.

Marine fauna

Change in fauna behaviour and injury or mortality to fauna - cetaceans

As detailed in [Section 5.3](#), 27 cetacean species were identified by the PMST search as potentially occurring within the Project Area. Of these species, the humpback whale, pygmy blue whale, sei whale, fin whale, Bryde's whale, and spinner dolphin are expected to occur within the Project Area. Additionally, the Project Area overlaps the humpback whale migration BIA; the pygmy blue whale migration BIA and possible foraging area located at Scott Reef. Noise interference is identified as a key threat to pygmy blue whales in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b) and in the conservation advice for humpback, sei and fin whales.

While humpback and pygmy blue whales are known to occur within the Browse Development Area during their annual migrations, studies indicate that these species occur in relatively low numbers within the area. The Browse Development Area is >140 km away from the humpback whale calving BIA on the Kimberley coastline. In addition, the proposed BTL route is located outside of the humpback whale migration BIA (approximately 40 km distance at closest point) and as such impacts to humpback whales are likely to be limited to individuals transiting through the Browse Development Area during noise generating activities.

The Browse Development Area and BTL are both within the pygmy blue whale possible foraging and migration BIA, with individuals observed and recorded (McCauley, 2011) within the vicinity of Scott Reef; however, the majority of pygmy blue whales are expected to migrate within deep waters to the west of Scott Reef.

As discussed in [Section 6.3.8.2.2](#) incorporation of animal behaviour and exposure into the acoustic modelling of piling activities at both Torosa and Brecknock indicates that with exclusion zones in place, exposures to injury threshold criteria (PTS) for pygmy blue whales were reduced to zero.

During piling activities exposure to TTS is estimated to be limited to a few individuals, however given the precautionary way in which these exposures are calculated, specifically; they do not incorporate migratory travel direction, behavioural avoidance or industry standard pre-start observations and soft starts, the likelihood of actual TTS exposure is very low. Furthermore, the potential reduction of cumulative sound exposure associated with pausing and restarting piling to account for potential shutdowns also will significantly reduce potential TTS exposure to individuals. The currently adopted cumulative SEL approach for quantifying TTS onset also assumes that exposures with equal SEL result in equal effects, regardless of the duration or duty cycle of the sound (i.e. continuous or impulsive) (Fineran et al. 2015). It is well-known that this 'equal energy' rule over-estimates the effects of intermittent noise such as piling, since the quiet periods between piling pulses will allow some recovery of hearing compared to noise that is continuously present with the same total SEL (Ward, 1997)

Modelling also indicates that for other activities including the MODU on DP and FPSO offtake activities using DP the maximum distance to the NMFS (2018) PTS criteria is 120 m and the maximum distance to the NMFS (2018) TTS criteria (SEL_{24h} ; R_{max}) for LF cetaceans is predicted to be within 1.74 km. For the scenarios of FPSO under offtake at Torosa and Brecknock, the area ensonified within the marine mammal behavioural response criteria of 120 dB re 1 μ Pa (SPL) is estimated to overlap 1.4% to 1.5% of the pygmy blue whale possible foraging BIA, leaving ~98% of the foraging BIA available to pygmy blue whales and uninterrupted foraging. Given these results do not incorporate animal movement and behaviour, and they are based on the assumption the marine mammal is stationary within this distance for a 24 hour period (which is highly unlikely to occur), it is considered highly unlikely that marine mammals will be exposed to underwater noise levels above the PTS or TTS threshold as a result of these activities associated with the proposed Browse to NWS Project.

Furthermore, for the aggregate scenario of FPSOs under offtake at both locations and the MODU at Torosa TRD well location the area ensonified within the marine mammal behavioural response criteria of 120 dB re 1 μ Pa (SPL) is estimated to overlaps 2.2% of the pygmy blue whale possible foraging area, leaving ~98% of the potential foraging area available to pygmy blue whales

and uninterrupted foraging. In comparison, at the Torosa TRD well location during normal operations (FPSO, no DP) the area ensonified within the 120 dB re 1 μ Pa (SPL) is estimated to be 1 km².

The onset and severity of behavioural responses in cetaceans depends on a number of factors, such as whether the frequencies and characteristics of the noise are of any biological significance to the animal; the animals' activities at the time it is heard (e.g. feeding, resting, migrating, socialising); and their motivation to remain, approach or avoid. These factors can vary further between each individual or group. Another key consideration involves differentiating brief, minor, biologically unimportant reactions from profound, sustained, and/or biologically meaningful responses that may influence survival (Southall et al., 2007). For example, Croll et al. (2001) did not observe any response from feeding blue and fin whales receiving noise levels between 140 and 150 dB re 1 μ Pa (SPL) from continuous, low frequency sonar transmissions. The sound spectrum of the sonar within this study is comparable to the dominant frequency band associated with vessel DP noise (130 – 160 Hz and 260 – 320 Hz). Results showed whale movements were instead found to be influenced by the distribution and movement of prey, indicating that the generated noise levels were not a direct significant disturbance to the whales during feeding.

The North West Shelf Project has been operating for more than 30 years, and offshore activities such as seismic exploration, piling, drilling, and well operations have been conducted within the humpback whale migratory corridor. During this time the humpback whale population continues to recover exponentially, and data from aerial surveys conducted in 2000, 2001, 2006, 2007, and 2008, shows no avoidance of the area nor has the migration route changed (Jenner and Jenner, 2010; Salgado Kent et al., 2012).

The most discernible behavioural reactions in cetaceans tend to occur at the sudden onset of noise, when noise sources change or increase suddenly, or when they occur unexpectedly (Richardson et al., 1995). Stationary and continuous industrial noise sources are typically observed to result in less dramatic avoidance reactions than moving noise sources, and in numerous cases cetaceans have been known to approach the noise source. For example, whales are often observed in close proximity to operating offshore infrastructure such as platforms and vessels that emit underwater noise.

Whales have been recorded and reported to DoEE by Woodside in close proximity to operating facilities such as the Nganhurra FPSO on numerous occasions. The noise source level of the Nganhurra FPSO has been recorded to be 172 dB re 1 μ Pa (Erbe et al., 2013), which is comparable to predicted operational noise levels at

the FPSO facilities (without DP) and higher than the expected source level of the subsea wellheads (Duncan, 2014, 2011)¹¹.

Elevated underwater noise can result in changes to marine fauna behaviour by masking or interfering with other biologically important sounds, including vocal communication, echolocation, signals and sounds produced by predators or prey, and through disturbance leading to behavioural changes or displacement from important areas (Richardson et al., 1995). The sensitivity of fauna behaviour to elevated noise levels vary both inter- and intra-specifically, with individual responses often being influenced by the present behaviour, such as reproductive behaviours, foraging or migration.

Startle responses from vessel and drilling activities are unlikely as source levels at the higher end of the potential range (e.g. from operation of bow thrusters or drilling) are not likely to occur suddenly in isolation. Project vessels and the MODU will already be operating and emitting noise at lower levels prior to commencement of potentially noisier activities.

ANIMAT modelling (Section 6.3.8.2.3) of the pile driving activities indicates that with a 2000 m exclusion zone:

- + behavioural impact thresholds for pygmy blue whales are not exceeded in the possible foraging area during Brecknock piling when using a smaller IHC S-600 hammer
- + behavioural impact thresholds for pygmy blue whales are exceeded within 0.07% of the possible foraging area during Brecknock piling when using a smaller IHC S-1200 hammer with exposure to 0.08 individuals per pile predicted
- + behavioural impacts to 0.32 individual migrating pygmy blue whales per pile are predicted during Brecknock piling when using a smaller IHC S-600 hammer
- + behavioural impacts to 1.65 individual migrating pygmy blue whales per pile are predicted during Brecknock piling when using a smaller IHC S-1200 hammer
- + behavioural impact thresholds for pygmy blue whales are exceeded within 1.2% of the possible foraging area during Torosa piling when using a smaller IHC S-600 hammer with exposure to 0.43 individuals per pile predicted
- + behavioural impact thresholds for pygmy blue whales are exceeded within 2.84% of the possible foraging area during Torosa piling when using a larger IHC S-1200 hammer with exposure to 1.28 individuals per pile predicted

- + behavioural impacts to 0.32 individual migrating pygmy blue whales per pile are predicted during Torosa piling when using a smaller IHC S-600 hammer
- + behavioural impacts to 1.22 individual migrating pygmy blue whales per pile are predicted during Torosa piling when using a smaller IHC S-1200 hammer.

These estimates do not include individual's behavioural avoidance, or industry standard pre-start observations or soft starts, and as such the actual number of individuals will likely be less. These impacts are expected to be limited to temporary avoidance behaviour, are not expected to be significant and have been demonstrably minimised.

Behavioural impacts may also occur as a result of the MODU on DP and the FPSO offtake activities using DP. Modelling indicates that behavioural impacts may occur during offtake and MODU DP to a distance of 8.9 km and 10.5 km, respectively. As with the piling noise, these impacts are expected to be limited to temporary avoidance behaviour and would only occur during MODU activities or offtake activities requiring DP.

Noise levels predicted from well evaluation using VSP demonstrate that potential behaviour impacts may occur within 1.6-1.7 km from the well; however, these would be limited to a very short duration as this type of activity will only occur for up to 10 hours per well. Due to the temporary and localised nature of these behavioural impacts, they are not considered to be significant.

Underwater noise levels from subsea wellheads will likely fall below the 120 dB re 1 µPa (SPL) cetacean behavioural response threshold within approximately 500 m of the wellheads at the TRD and TRE drill centres and are not predicted to reach the top 100 m of the water column, even directly above the wellheads. Potential impacts to whales and other cetaceans from increased noise levels in the vicinity of the wellheads are therefore expected to be minor and highly localised and are not expected to cause disturbance to individuals.

Migrating humpback and pygmy blue whales may occur along the proposed BTL route and as such behavioural responses may occur to a small number of individuals during installation of the BTL. Such behavioural responses will likely be limited to avoidance and will be localised around the pipelay vessel which will be continually moving at a slow speed.

¹¹ AIMS (2014) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

Given the width of the migration BIAs of the pygmy blue whales; and the fact that the proposed BTL route is outside of the humpback whale BIA, the operation of the pipelay vessel is unlikely to present a barrier to migration. As any disturbance that does occur will be temporary and localised at the individual level, these impacts are not considered to be significant.

Other sources of noise include helicopters used for crew transfers. Depending on the final method chosen for crew transfers, helicopter transfers may occur during all phases of the proposed Browse to NWS Project. In general, helicopter noise is of short duration, peaking as the helicopter passes directly overhead. Received levels are expected to be low during transit when helicopter altitude is greatest. The highest received levels will occur at lower altitudes on approach to landing. Some behavioural disturbance may occur for short periods if marine mammals are present near the surface in the vicinity of landing helicopters. These impacts are not considered to be significant.

In summary, predicted underwater noise emissions associated with key activities for the proposed Browse to NWS Project may result in localised avoidance and/or behavioural disturbance of marine mammals within the vicinity of the project activities. Given that relatively low numbers of transient marine mammals are expected to seasonally occur within the Project Area, only slight behavioural impacts are expected to occur, with no long-term effects at a species population level. These impacts are not considered to be significant, based on the MNES significant impact criteria for listed endangered species (Table 6-5), have been demonstrably minimised, and are not inconsistent with the recovery objectives within the Conservation Management Plan for the Blue Whale (2015-2025) (Commonwealth of Australia, 2015c).

Change in fauna behaviour and Injury or mortality turtles

Sandy Islet and the surrounding waters (20 km interneresting buffer) have been identified as habitat critical to the survival of green turtles in the Recovery Plan for Marine Turtles 2017-2027 (Commonwealth of Australia, 2017a) (Figure 5-29). In addition, a BIA exists for interneresting green turtles around Sandy Islet with interneresting occurring just offshore in waters 4-15 m deep (Commonwealth of Australia, 2017a). The recovery plan identifies noise interference (acute and chronic) as a key threat to the recovery of turtles.

As discussed in Section 6.3.8.2.3 when incorporating representative green turtle animal movement and behaviour into the impact piling propagation model for both migratory and interneresting turtles (as described in Section 6.3.8.2.3) during the Torosa piling the injury PTS threshold is not exceeded, with no individual turtles exposed to injury levels. Additionally, when incorporating representative migratory green turtle animal movement and behaviour, the 95th percentile exposure ranges to the recoverable auditory fatigue

(TTS) threshold are 1.79 km and 1.65 km for the IHC S-1200 and IHC S-600 hammer, respectively. It should be noted that these results do not incorporate potential behavioural avoidance and soft starts.

The results of the animal movement and behaviour modelling also demonstrated that no migrating or interneresting green turtles within the habitat critical are likely to be exposed to injury (PTS), auditory fatigue (TTS) or behavioural response or disturbance during the Brecknock piling activities.

Modelling shows that for other key activities associated with the proposed Browse to NWS Project, the turtle injury PTS threshold is either not reached, or only extends a distance in the order of 100 m. Given these results do not incorporate animal movement and behaviour is based on the assumption the marine turtle is stationary within this distance for a 24 hour period (which is highly unlikely to occur), therefore it is considered highly unlikely that marine turtles will be exposed to underwater noise levels above the PTS threshold as a result of activities associated with the proposed Browse to NWS Project.

Modelling indicates that the recoverable auditory fatigue (TTS) threshold extends in the order of 1.50 to 2.0 km for other modelled activities including the MODU on DP, VSP and FPSO offtake activities on DP. For the aggregate scenario of FPSOs under offtake at both locations and the MODU at Torosa TRD well location the area ensonified within the marine turtle PTS and TTS criteria ($SEL_{24h}^+; R_{95\%}$) is estimated to be 17 m² (PTS) and 130 m² (TTS), respectively.

It should be noted again that these results do not incorporate animal movement and behaviour is based on the assumption the marine turtle is stationary within this distance for a 24-hour period (which is highly unlikely to occur). Given this, the planned mitigation measures (including exclusion zones and shut downs during piling), the small exposure area, the temporary nature of the piling activities and the likely avoidance behaviour of marine turtles, it is not considered that these impacts will be limited to behavioural (avoidance) impacts and would not result in any lasting effect. The avoidance activities are likely to be most evident in relation to the MODU on DP, FPSO offtake activities on DP and piling. While some of the proposed noise generating activities (drilling activities including the MODU on DP, MODU anchor piling and subsea choke valve noise) will occur within the interneresting critical habitat buffer (20 km radius) surrounding Sandy Islet, the temporary nature of the piling and drilling activities as well as the predicted noise attenuation means that any potential behavioural impacts are not expected to result in a significant impact to nesting success, interneresting or migrating marine turtles based on the MNES significant impact criteria for listed vulnerable species (Table 6-5).

Therefore, it is determined that the underwater noise activities associated with the proposed project activities are not inconsistent with the recovery objectives within the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Migrating marine turtles may occur along the BTL route and as such behavioural responses may occur to a small number of individuals during installation of the BTL. Such behavioural responses are likely limited to avoidance and will be localised around the pipelay vessel which will be continually moving at a slow speed. Given the low number of individuals that are likely to be impacted, these behavioural impacts are not considered to be significant.

Turtles may be exposed to helicopter noise when on the sea surface (e.g. when basking or breathing). Hearing in marine turtles is adapted for the perception of sound underwater (Popper et al., 2014), where they spend most of their time. As such, turtles are not expected to perceive noise levels from helicopters; impacts may consist of 'startle' responses such as diving, which are exhibited when turtles are exposed to other disturbances such as the passage of vessels. Given the nature of the impact and the low number of marine turtles likely to be affected, these impacts are not considered to be significant.

Change in fauna behaviour and Injury or mortality to fauna - fish

The modelling indicates that for the most sensitive fish groups (fish with swim bladder involved in hearing) sounds levels from the piling activities could exceed mortality levels within 200-210 m of the noise source. For fish species including sharks sound levels could exceed TTS threshold are predicted to extend to in the order of 9 km at Torosa and 6 km at Brecknock. However, for these impacts to occur, exposure would be required to occur for a 24 hours period. Given the mobility of fish species and the likely avoidance behavior, it is considered highly unlikely that such exposure would occur or that significant impacts will occur to fish species as a result of the piling activities.

The modelling indicates that the sound levels from the piling, VSP, MODU with DP and FPSO offtake using DP activities expected to reach the south Scott Reef lagoon are not expected to result in any impacts to site attached fish.

For the other modelled activities including the MODU on DP, VSP and the FPSO Offtake activities, the modelling indicates that fish will not be exposed to sound levels that could cause permanent injury or mortality. Physiological effects, and recoverable injury, to some fish species, could occur but only if the animals are in very close proximity to the sound sources (within a planar distance of 60 m) for a 48-hour period which as discussed above, is considered highly improbable.

Temporary impairment due to TTS could occur at similar short distances if fish remain at the same point within the sound field for long periods of time (12 hours) which is also considered highly improbable.

As such, it is considered that any impacts to fish will be limited to temporary avoidance behaviour. Most pelagic and open water fish species (including whale sharks) are expected to swim away when impulsive noise reaches levels at which it might cause physiological effects. BPM (2008) recorded no exposure mortality from the Woodside Maxima 3D MSS Phase I and Phase II survey of fish species such as mackerel (*Decapterus macarellus*), barracuda (*Sphyraena barracuda*), large billfish (sailfish or marlin), schooling bait fish and a number of species of rays and sharks. Behavioural responses are expected to be short-lived, with duration of effect less than or equal to the duration of exposure. For some fish, strong 'startle' responses have been observed at sound levels of 200 to 205 dB re 1 μ Pa, indicating that sounds at or above this level may cause fish to move away from the sound source. Other studies (McCauley et al., 2003) have found that active avoidance may occur in some fish species at sound levels of -161-168 dB re 1 μ Pa SPL (-186-193 PK). While fish may initially be startled and move away from the sound source, once the source moves on fish would be expected to move back into the area. As such these behavioural impacts are not considered to be significant.

There is a paucity of data about responses of sharks, including whale sharks, and rays to underwater noise. It is expected that the potential impacts to whale sharks associated with impulsive noise will be the same as for other fish. Given whale sharks do not have swim bladders, they are categorised as fish that are less sensitive to noise and therefore, unlikely to be impacted by impulsive noise unless at close distances to the source location (Popper et al., 2014).

Fish, including migrating whale sharks, may occur along the BTL route. Given the above regarding potential effects of noise emission on fish; and the temporary nature of the pipelay activities, no noise related impacts are expected to occur to fish as a result the pipelay activities.

Change in fauna behaviour and Injury or mortality to fauna - sea snakes

As discussed in [Section 6.3.8.1](#), there is limited information available on hearing in sea snakes, but they are known to be capable of detecting pressure changes (Mick Guinea pers. comm.). Due to this and as quantifiable distances for assessing impacts from continuous sounds only exist for fish, fish have been used as a surrogate for this assessment. As discussed above, no significant impacts to fish are expected to occur as a result of noise emissions from the proposed Browse to NWS Project. Given this, no significant impacts to sea snakes are expected to occur as a result of underwater noise emissions from proposed Browse to NWS Project.

Summary

Table 6-70 provides an assessment of the underwater noise emissions from the proposed activities in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-70 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – underwater noise

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The potential impact of underwater noise emissions resulting from the proposed Browse to NWS Project have been assessed. Given the low numbers and infrequent nature of whale shark presence in the Project Area, there is a high level of confidence that underwater noise will not result in and adverse impact to whale sharks.
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival	The potential impact to marine turtles from underwater noise emission has been assessed as minor given: + the predicted extent of underwater noise emissions affects a very small portion of the offshore waters, limited to hundreds of metres from the source + low risk of any injury to marine turtles from vessel noise (the only credible impact is expected to be behavioural). + behavioural changes, e.g. avoidance and diving, are only predicted within a very small portion (0.004% to 0.0004%) of the area identified as habitat critical to the survival of green turtles. As such, displacement of marine turtles from identified habitat critical to the survival, is not predicted. As such, it is considered that the activity is not inconsistent with the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Anthropogenic noise and acoustic disturbance have been identified as a threat for the recovery of these species.	Displacement of pygmy blue whales from the potential foraging area is not predicted, as only 2.2% of the potential foraging area is predicted to be ensonified at levels above behaviour response thresholds for the governing scenario - Offtake activities with a MODU present. This leaves 98% of the potential foraging area available to pygmy blue whales for uninterrupted foraging.
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area.	Potential impacts are therefore likely to be restricted to a small number of individuals that may be travelling through the area.
Sei whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale		Therefore, the impacts from underwater noise emissions to pygmy blue whales has been assessed as minor.
Fin whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale		Brecknock and Torosa piling animal movement modelling simulation results demonstrate that incorporation of shutdowns eliminate any potential for injury to both migrating and possible foraging pygmy blue whales within the migratory and possible foraging BIAs. Furthermore, for vessel related noise as it is not credible that a whale would remain within the required close proximity to a either the FPSO or a MODU for a continuous 24-hour duration, it is not considered credible for continuous noise sources to result in injury to pygmy blue whales. This is not inconsistent with the Blue Whale Conservation Management Plan that assessed shipping and industrial noise as 'minor - individuals are affected but no affect at the population level'. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.

Key Ecological Features

Change in fauna behaviour and Injury or mortality to fauna

Underwater noise emissions will occur in the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF and the Continental slope demersal fish communities KEF during all phases of the proposed Browse to NWS Project. The sources of these noise emissions are detailed in [Section 6.3.8.1](#). These KEFs are recognised for their high species richness and for the high diversity of demersal fish respectively. The Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012) recognises noise pollution as a pressure ‘of less concern’ in the relation to the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF and a pressure ‘not of concern’ in relation to the Continental slope demersal fish communities KEF.

As described above, no significant impacts to marine fauna including fish and plankton are expected to occur and as such; subsequent impacts to the conservation

values of these KEFs are not expected.

Underwater noise emissions will also occur within Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF (depending on the final route of the BTL) and the Ancient coastline at 125 m depth contour KEF. The Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012) recognises noise pollution as a pressure ‘not of concern’ in relation to these KEFs. Underwater noise emissions in these KEFs will be temporary and limited to noise related to the installation of the BTL and vessel noise associated with intermittent IMR activities. These underwater noise emissions are considered highly unlikely to affect marine fauna or the conservation values of these KEFs.

[Table 6-71](#) provides an assessment of the proposed underwater noise emissions in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-71 Alignment with protection of conservation values of KEFs – underwater noise

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Noise pollution - currently identified as 'less of concern'	Underwater noise emissions from the proposed project activities within these KEFs will be low level, temporary and transient in nature and therefore there is a high level of confidence that such emissions will not result in an adverse impact to marine ecosystem function or integrity with in the KEFs; or any reduction in to the conservation values of the KEFs will occur.
Continental slope demersal fish communities		Noise pollution - currently identified as 'not of concern'	
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals			
Ancient coastline at 125 m depth contour			

Australian Marine Parks

Change in fauna behaviour

Noise emissions will occur from vessels associated with the installation of the BTL and intermittent IMR activities within the Argo-Rowley Terrace and Kimberley AMPs. The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park.

The Argo-Rowley Terrace and Kimberley AMP protects a variety of values that could be potentially impacted by underwater noise. The Marine bioregional plan for the North-west Marine Region places noise pollution as a priority for conservation effort in this region because it is of potential concern for multiple conservation values and the pressure in increasing in the region (Commonwealth of Australia, 2012). This plan recognises that anthropogenic noise poses a significant threat to cetaceans in particular because it may mask sounds that are vital for their essential activities and behaviour.

Given the distance from the source activities (>100 km to the boundary of the Kimberly AMP and >180 km to the boundary of the Argo-Rowley Terrace AMP), underwater noise emissions generated at the Browse Development Area are not predicted to have any impacts on the values or users of the AMPs.

Due to the short duration and temporary nature of the underwater noise emissions associated with the installation of the proposed BTL and IMR activities within the AMPs, no significant impacts are expected from these proposed activities.

Table 6-72 provides an assessment of the proposed underwater noise emissions in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018)

Table 6-72 Alignment with the North-west Marine Parks Network Management Plan – underwater noise

Australia Marine Park	Relevant plan(s)	Australian Marine Park Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	Underwater noise emissions from the proposed project activities within these AMPs will be low level, temporary and transient in nature and therefore unlikely to disturb marine turtles or seabirds in these AMPs. There is a high level of confidence that ambient light will not result in an adverse impact to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced.
Kimberley Marine Park Multi Use Zone (VI)			As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, underwater noise emissions associated with the installation of the BTL and occasional IMR activities are not considered a credible source of significant impact and no effect on ecosystems, habitats or native species in the AMP will occur. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

State Marine Parks and Nature Reserves

Change in fauna behaviour and Injury or mortality to fauna

The Scott Reef Nature Reserve is utilised by fauna including turtles. Sandy Islet in particular is used by nesting green turtles. As described above, no injury or mortality to marine turtle is predicted, with impacts restricted to temporary behavioural impact to a very small portion of the population. As such, not adverse impact to the conservation values of the Scott Reef Nature Reserve is predicted.

Other Protected Places

Change in fauna behaviour and Injury or mortality to fauna

The Scott Reef and Surrounds - Commonwealth Area Commonwealth Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef. The Commonwealth Heritage Place is utilised by seabirds, marine mammals and marine turtles; and supports diverse fish and coral communities. As described above no injury or mortality to marine fauna is predicted, with impacts restricted to temporary behavioural impact to a very small of the population. Given this, it is considered that the identified conservation values of these other protected places will not be detrimentally impacted by underwater noise associated with the proposed Browse to NWS Project

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that the impacts from underwater noise emissions to marine fauna including fish are not expected to be significant, no significant subsequent impact to fisheries is expected.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

Scott Reef is used for tourism and recreation (primarily fishing charters) and scientific studies at low levels. Given the underwater noise modellings predictions demonstrate noise emissions will attenuate significantly prior to reaching Scott Reef, impacts to tourism/recreation and scientific studies are expected to be negligible.

6.3.8.4 Environmental Risk

Risk event: Displacement of pygmy blue whales from Scott Reef channel as a result of subsea choke valve noise

There is a risk that the number of individuals that would be impacted may be higher than predicted. It should be noted however that the simulated impacts to each individual would remain unchanged.

The assessment presented within the draft EIS/ERD is based on current available information and indicated no significant impact is expected to occur to marine fauna (such as pygmy blue whales) utilising the channel between north and south Scott Reef as a result of subsea choke valve noise. In the event that subsea choke valve noise is significantly higher than predicted, there is the potential for this noise to result in an increased behavioural response to whales within the channel. Further, as the drill centres planned for within the Scott Reef channel will not be developed as part of phase one RFSU, underwater noise monitoring of RFSU operational wells will be undertaken prior the development of any wells within the channel which will allow for adaptive management and mitigation to be applied prior to the development of any wells within the channel. As such, it is considered highly unlikely that subsea choke valve noise significantly above predicted resulting in significant impacts to pygmy blue whales will occur.

6.3.8.5 Cumulative Impacts

Underwater noise during the drilling, installation and commissioning phases of the project will be temporary and localised to the source of the activity. Therefore, the risk of cumulative impacts resulting from the generation of underwater noise associated with the drilling, installation and commissioning phases of the proposed Browse to NWS Project is low when considering other potential sources within the broader Project Area or region.

The results indicated that underwater noise emissions during offloading activities at Torosa and Brecknock with the MODU at Torosa TRD well predicted noise emissions to exceed 120 dB re 1 µPa (SPL) within an area of 274.6 km² of the pygmy blue whale possible foraging area. This corresponds to 2.2% of the possible foraging area, leaving -98% of the possible foraging area available to pygmy blue whales and uninterrupted foraging.

These noise levels are sufficiently distant from other oil and gas infrastructure (i.e. Prelude and Ichthys developments) so as no cumulative impacts are anticipated.

6.3.8.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact and risk assessment for the underwater noise emission is provided in [Table 6-73](#) and [Table 6-74](#) respectively. The acceptability assessment is provided in [Table 6-75](#).

Table 6-73 Impact assessment summary and adopted controls – underwater noise

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Ambient noise (medium value (open water))	Change in ambient noise	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health	<u>Project vessel operations</u> + Vessels will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale and Dolphin Watching whereby: + Vessels will not knowingly travel greater than six knots within 300 m of a whale or 100 m of a dolphin. + Vessels will not knowingly approach closer than 100 m to a whale or 50 m to a dolphin (except if bow riding). + Vessels will not knowingly restrict the path of cetaceans. + Interactions between support vessels and whale sharks will be not inconsistent with the Whale Shark Code of Conduct	Slight	Slight (E)
Plankton communities (medium value (open water))	Change in fauna behaviour	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No lasting effect	Negligible (F)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Injury or mortality to fauna	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the S Scott Reef shallow water benthic habitat (<75 m bathymetry).		No impact predicted	
Deepwater communities and habitats (>75 m depth) (medium value habitat)	Injury or mortality to fauna	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.	<u>Operations</u> + VSP operations will have trained vessel crew as a marine fauna observer ¹² and will be subject to pre-start up visual observations, operational, and shut-down procedures, as follows: + 500 m shut down zone for whales + 500 m shut down zone for marine turtles. + Impact pile driving activities will have trained vessel crew as a marine fauna observer and will be subject to pre-start up visual observations, soft start, operational, and shut-down procedures, as follows: + 2 km shut down zone for whales + 500 m shut down zone for marine turtles. + During impact piling, thermal imaging will be used during night time / times of low visibility to assist in detecting whales within the shutdown zones. + Underwater noise monitoring of an operational well will be undertaken to inform an adaptive management approach for noise management for the TRD and TRE wells if required.	No lasting effect	Negligible (F)
Fish (high value species)	Change in fauna behaviour and injury or mortality to fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No lasting effect	Slight (E)
Marine mammals (high value species)	Change in fauna behaviour and injury or mortality to fauna	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		Slight	Minor (D)
Marine reptiles (high value species)	Change in fauna behaviour and injury or mortality to fauna	Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population		Slight	Minor (D)

¹² Marine fauna observer – a dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations for whale and marine turtles

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
KEFs (medium value)	Change in fauna behaviour and Injury or mortality to fauna	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
AMPs (medium value (multiple use zones))	Change in fauna behaviour	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Negligible (F)
State Marine Parks and nature reserves (high value)	Change in fauna behaviour and Injury or mortality to fauna			No lasting effect	Slight (E)
Other protected places (high value)	Change in fauna behaviour and Injury or mortality to fauna			No lasting effect	Slight (E)
Managed fisheries (high value marine user)	Changes to the function interests or activities of others	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies (high value users)	Changes to the function interests or activities of others	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Table 6-74 Risk assessment summary and adopted controls – Underwater Noise

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Ambient noise (medium value (open water))	Displacement of pygmy blue whales from Scott Reef Channel as a result of subsea choke valve noise	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health	No further controls (in addition to those described in Table 6-73 adopted).	No increase to significance/consequence		
Plankton (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No increase to significance/consequence		
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		No increase to significance/consequence		
Deepwater communities and habitats (>75 m depth) (medium value habitat)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No increase to significance/consequence		
Fish (high value species)		Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No increase to significance/consequence		
Marine mammals (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		Minor (C)	Highly Unlikely (I)	Moderate (CI)
Marine reptiles (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population		No increase to significance/consequence		
KEFs (medium value)		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No increase to significance/consequence		
AMPs (medium value (multiple use zones))		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
State Marine Parks and nature reserves (high value)				No increase to significance/consequence		
Other protected places (high value)				No increase to significance/consequence		
Managed fisheries (high value marine user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		
Other users including tourism and recreation and scientific studies (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is necessary for the execution of the Browse to NWS Project.		No increase to significance/consequence		

Table 6-75 Acceptability Assessment – Underwater Noise

Acceptability Assessment
<i>Certainty in Assessment</i> Woodside have a high level of certainty with respect to the assessment of the potential impacts associated with underwater noise emissions as: + A robust underwater noise modelling study has indicated that there would be minimal impact to sensitive receptors. + The proposed controls are likely to effectively mitigate the potential impacts associated with the underwater noise emissions. The available pygmy blue whale and green turtle data, 2002 to 2017, were determined to be adequate for the purposes of impact assessment and management planning purposes based on the lack of significantly altered regional cumulative impacts since collection (Chapter 9), ability to extrapolate population trends using existing literature, and conservative interpretation of available data where applied. The existing data will be updated by targeted monitoring programs to verify impact predictions and inform adaptive management approaches at relevant times throughout the project life cycle.
<i>Principles of ESD</i> With the application of the proposed controls it is predicted that the nominated environmental objectives for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
<i>Significant Impacts as defined by the MNES Significant Impact Guidelines</i> <i>Listed threatened species and ecological communities / listed migratory species</i> As described in Table 6-73, no lasting effect is predicted to occur as a result of underwater noise emissions to listed threatened and migratory fish with the impact significance level determined to be Slight (E). Slight impacts are predicted to occur to listed threatened and migratory marine mammals (pygmy blue whales) and marine turtles with the impact significance level determined to be Minor (D). As described in Table 6-74, potential risk events associated with underwater noise present a Moderate risk to marine mammals (pygmy blue whales) noting that the identified risk event is considered highly unlikely to occur. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <i>Commonwealth Marine Environment</i> As described in Table 6-73, the potential impacts resulting from underwater noise emissions to plankton, deepwater communities and habitats (>75 m depth), KEFs and AMPs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to ambient noise, fish, other protected places, managed fisheries and other users. Minor (D) impacts are predicted to marine mammals (pygmy blue whale) and marine turtles, while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth). As described in Table 6-74, potential risk events associated with underwater noise present a Moderate risk to marine mammals (pygmy blue whales) noting that the identified risk event is considered highly unlikely to occur. Given this, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of underwater noise against the WA EPA Objective is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Marine environmental quality

As described in [Table 6-73](#), the potential impact from underwater noise emissions to plankton and deepwater water benthic communities and habitats (>75 m depth) has been as Negligible (F). Slight (E) impacts are predicted to fish. Minor (D) impacts are predicted to occur to marine mammals (pygmy blue whales) and marine turtles, while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-74](#), potential risk events associated with underwater noise present a Moderate risk to marine mammals (pygmy blue whales) noting that the identified risk event is considered highly unlikely to occur.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to maintain the quality of water, sediment and biota so that environmental values are protected” will be achieved.

Marine Fauna

As described in [Table 6-73](#), no lasting effect is predicted to occur as a result of underwater noise emissions to fish with the impact significance level determined to be Slight (E). Slight impacts are predicted to occur to marine mammals (pygmy blue whales) and marine turtles with the impact significance level determined to be Minor (D).

As described in [Table 6-74](#), potential risk events associated with underwater noise present a Moderate risk to marine mammals (pygmy blue whales) noting that the identified risk event is considered highly unlikely to occur.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “To protect marine fauna so that biological diversity and ecological integrity are maintained” will be achieved.

Benthic communities and habitats

As described in [Table 6-73](#), the potential impacts resulting from underwater noise emissions to deepwater benthic communities and habitats (>75 m depth) has been assessed as Negligible (F), while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth).

No risk event associated with underwater noise emissions that may potentially impact benthic habitats have been identified.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained” will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders regarding underwater noise emissions from activities associated with the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

There are no specific Woodside internal environmental requirements, including policies, procedures and standards regarding underwater noise emissions.

Conclusion: Acceptable

Acceptability Assessment

Other requirements

As detailed in [Table 6-70](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + Conservation Management Plan for the Blue Whale: A recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* 2015-2025 (Commonwealth of Australia, 2015b)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation Advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee, 2015b)
- + Conservation Advice *Balaenoptera borealis* sei whale (Threatened Species Scientific Committee, 2015c)
- + Conservation Advice *Balaenoptera physalus* fin whale (Threatened Species Scientific Committee, 2015d).

KEFs

As detailed in [Table 6-71](#) proposed underwater noise emissions will not materially increase existing relevant pressures on the conservation values of KEFs.

AMPs

As detailed in [Table 6-72](#) the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Conclusion: Acceptable

6.3.9 Marine Discharges: Sewage and Sullage

6.3.9.1 Impact and Risk Overview

[Table 6-76](#) presents an overview of the potential impacts and risks from sewage and sullage discharges associated with the proposed Browse to NWS Project.

Table 6-76 Sewage and sullage impact and risk overview

Aspect	Marine discharges: sewage and sullage
Description	Sewage and sullage (grey water generated from domestic processes such as dish washing, laundry and showers) associated with the operation of MODU(s), project vessels and the FPSO facilities will be discharged during all phases of the proposed Browse to NWS Project.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to sewage and sullage discharges associated with the proposed Browse to NWS Project are Objectives 3, 6, 7, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21. These objectives are detailed in Table 6-7 .
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-77). + Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983. This is the primary federal legislative instrument for Australia's implementation of the International Convention for the Prevention of Pollution from Ships (MARPOL). + Commonwealth Navigation Act 2012 + Marine Order 96 (Marine pollution prevention—sewage) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016d) + North-west Marine Parks Network Management Plan (Director of National Parks, 2018) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Aspect	Marine discharges: sewage and sullage		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <i>Physical</i> + water quality (medium value (open water)) <i>Ecological</i> + plankton communities (low value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + fish (high value species) + marine reptiles (high value species) + marine mammals (high value species) + KEFs (high value) + AMPs (high value) + other protected places (high value) <i>Socio-economic</i> + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value user) + scientific studies (high value user)		
Potential impacts	+ change in water quality + change in fauna behaviour + injury or mortality to fauna + changes to the functions, interests or activities of other users		
Risk	unplanned discharge significantly above discharge specifications		
Summary of governing impact evaluation	Magnitude	Impact significance level	Confidence
	No lasting effect	Slight (E)	High
Summary of governing risk evaluation	Consequence	Likelihood	Risk rating
	Slight	Remote	Low (E0)

6.3.9.2 Source of Aspect

Sewage and sullage (grey water generated from domestic processes such as dish washing, laundry and showers) will be generated on the MODU, project vessels and the FPSO facilities throughout the various proposed Browse to NWS Project phases. Sewage and sullage volumes generated will vary depending on the number of people on board each FPSO facility, vessel and MODU. There are no planned discharges of untreated sewage or sullage within the State Proposal Area; however, discharges of treated sewage and sullage from the MODU and vessels within the State Proposal Area will occur.

Approximate sewage and sullage volumes for the largest sources have been determined using a rate of 0.375 m³/person/day (NERA, 2017) as a guide, and are as follows:

- + Vessels – The number of vessels and persons on board (POB) will peak during construction and commissioning. The largest construction vessel is the pipelay vessel for the BTL installation, which may have approximately 700 POB, and therefore have the largest discharge volume (262 m³/day). Note that the pipelay vessel is only expected to be present during installation and commissioning. Support vessels for anchoring, towage, installation, and commissioning are expected to have between 20 and 60 POB each vessel.
- + MODUs – MODUs typically have up to approximately 180 people, depending on the type of MODU selected. During these peak times a MODU would be expected to generate around 67.5m³/day of waste water per day.
- + FPSO facilities – Sewage and sullage generation is dependent on the number of POB. The routine operational workforce will number up to approximately 60 people onboard each FPSO facility. During peak times only (e.g. hookup and major shutdown events), additional people may be required and each FPSO facility will have the capacity to accommodate approximately 180 people. During operations, the FPSO will discharge between 20 - 70 m³/day depending on manning. A support vessel may also be present which may discharge approximately 9.4 m³/day.

The FPSOs are located in deep oceanic Commonwealth waters away from sensitive receiving environments such as Scott Reef (the closest being the Torosa FPSO facility approximately 8 km from the reef). The FPSOs will have a Sewage Treatment Plant onboard to process sewage, which as per MARPOL73/78 is required for discharge within 3 nm of land despite their location being greater than 3 nm from land.

Discharges of treated sewage and sullage in proximity to Scott Reef will be primarily related to the drilling and

completion activities and the installation of the subsea infrastructure, with no permanent vessel presence in the State Proposal Area during operations. Under normal operating conditions, drilling and completion and vessel activity (and associated marine discharges) will be limited to the deep waters in proximity to the location of the proposed development wells and subsea infrastructure.

6.3.9.3 Environmental Impact

Water quality

Change in water quality

Discharged sewage and sullage has the potential to alter the physical characteristics of local marine water quality, primarily through eutrophication as a result of increased nutrient levels (e.g. ammonia, nitrite, nitrate and orthophosphate). Eutrophication occurs when the addition of nutrients, such as nitrates and phosphates, causes adverse changes to the ecosystem, such as increased growth of primary producers (e.g. phytoplankton) which can deplete oxygen in the water column and result in changes in biological processes.

Sewage and sullage may also include some particulate matter which can cause an increase in the turbidity of the receiving waters close to the point of discharge. Discharges will disperse and dilute rapidly, with concentrations of wastes significantly dropping with distance from the discharge point. Several studies have quantified the high levels of dilution, including Loehr et al. (2006). A study by the US EPA (2002) found that discharge plumes behind cruise ships moving at between 9.1 and 17.4 knots are diluted by a factor of between 200,000:1 and 640,000:1. The discharges and level of effluent dilution in the studies did not present significant localised toxicity impacts to marine biota from any changes in water quality.

The effects of sewage and sullage discharges on the water quality at Scott Reef were investigated during the drilling campaign for the Torosa-6 well in 2008. The drilling rig was operating near the edge of the deepwater lagoon area at South Scott Reef (ERM and SKM, 2008). The rig was equipped with a MARPOL approved sewage treatment plant producing approximately 10 m³/day of sewage/sullage during operations, which is likely to be comparable to the rates estimated for routine operations on the MODU and FPSO facilities. Water quality sampling at stations 50, 100 and 200 m downstream of the platform at different water depths determined that discharges were rapidly diluted in the upper (less than 10 m) water layer to 1% of its original concentration within 50 m, with no elevations above background in nutrients or metals recorded at any sampling station.

Plankton communities

Change in fauna behaviour

Although organic materials from the discharges will likely exert biological oxygen demand on the receiving waters, this is unlikely to reach levels below background ambient dissolved oxygen concentrations. Similarly, while the nutrient inputs from discharged effluent will rapidly be taken up by phytoplankton, pronounced increases in productivity as evidenced by increased chlorophyll a concentration are not expected. This is largely due to the assimilative capacity of the open ocean, with any potential additive nutrients not expected to accumulate in the vicinity of the discharge location. As such no lasting impacts to plankton communities are expected.

Benthic habitats

Change in water quality

Given the minimum water depth at the discharge locations (i.e. 125 m at the NRC tie-in), it is not predicted that changes in water quality resulting from the discharge of sewage and sullage will affect the deepwater benthic habitats of the Project Area.

Given the distance from the main sewage and sullage discharge location in relation to Scott Reef (FPSO > 8 km away) impacts to high value benthic habitats at Scott Reef are not anticipated. Furthermore, studies on the dispersion of coral larvae at Scott Reef (Done et al., 2015; Foster and Gilmour, 2018)we examine distance decay among coral communities in a common habitat on northwestern Australian reefs, seeking to better understand the roles of disturbance and coral life history strategies in the changing reefscape. In established communities in 1997, when coral cover and generic richness were uniformly high, there was high similarity (~81 % demonstrates that while there is marked movement of larvae within the reef system itself (broadcast spawning corals), there is no evidence to suggest that those coral larvae that initially dispersed off the reef return to Scott Reef to settle. Therefore, sewage and sullage discharge is not likely to impact the recruitment of corals within the Scott Reef system.

Marine fauna

Injury or mortality to fauna – fish, marine mammals, marine turtles

Chemicals within sewage and sullage discharges may include organics (e.g. volatile and semi-volatile organic compounds, oil and grease, phenols, endocrine disrupting compounds) and inorganics (e.g. hydrogen sulphide, metals and metalloids, surfactants, phthalates, residual chlorine). There is also the potential for biological pathogens, such as bacteria, viruses, protozoa and parasites.

Discharge will also occur from project vessels, the MODU and the Torosa FPSO facility in a possible foraging area and a migration BIA for pygmy blue whales as identified in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c). This plan identified chronic chemical pollution as a potential risk to pygmy blue whales. Conservation advices for other EPBC listed marine mammals that may occur in the Project Area do not identify chemical pollution as a key threat ([Table 5-19](#)).

Marine fauna such as fish, marine mammals and marine turtles may come into contact with these discharges, however given that the discharges will disperse rapidly close to the discharge point and that any contact with the discharge with marine fauna will be of extremely short duration, it is not considered credible that toxic affects to marine fauna will occur and therefore, in summary, it is not predicted that adverse impacts would occur to marine fauna as a result of sewage and sullage discharge.

Assessment against EPBC Act recovery and conservation plans and advices

[Table 6-77](#) provides an assessment of the sewage and sullage discharge from the proposed activities in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-77 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – sewage and sullage

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice objectives and actions	Assessment
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The potential impact of sewage and sullage discharges resulting from the proposed Browse to NWS Project have been assessed. Given the low numbers and infrequent nature of whale shark presence in the Project Area, there is a high level of confidence that sewage and sullage discharges will not result in adverse impact to whale sharks.
Green turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival.	Potential impacts to turtles have been assessed and will be managed in accordance with the Recovery Plan for Marine Turtles in Australia (2017-2027) which includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a).
Hawksbill turtle		Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Given the nature, volume and dispersion of the sewage or sullage drainage discharges, adverse impacts to marine turtles are not expected. As such, in relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival is predicted to be met. Likewise, it is not predicted that sewage and sullage discharge will adversely affect the breeding cycle of marine turtles in the BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice objectives and actions	Assessment
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Chronic chemical pollution is identified as a potential risk to pygmy blue whales, however there are no specific actions identified	Occasional exposure of individuals of these species to the sewage and sullage discharge may occur. However, given the nature, volume and dispersion of the predicted discharges, and the highly mobile nature of marine mammals, exposure would be temporary and is not expected to have any lasting impacts on the listed whale species. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Marine discharges have not been identified as a direct threat to these whale species; however, habitat degradation	
Sei whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale	has been identified as a threat and unmanaged discharges may contribute to this threat. The conservation advice relevant for this threat –	
Fin whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale	identifies modification to the coastal region in areas of importance to listed whales may result in reduced occupancy, compromised reproductive success and even mortality.	

KEFs

Change in water quality

The Continental slope demersal fish communities KEF and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs overlap with the Browse Development Area. Sewage and sullage discharges will occur within these KEFs from project vessels, MODU and the FPSO facilities. The BTL traverses the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF (depending on the final BTL route) and the Ancient coastline at 125 m depth contour KEF. Discharge of sewage and sullage will occur within these KEFs from project vessels during the BTL installation and intermittent IMR activities. The conservation values of these KEFs are described in [Section 5.3.3.1](#).

As described above, changes to water quality as a result of sewage and sullage discharge are predicted to be temporary and highly localised. As such no lasting impacts to the conservation values of these KEFs is predicted. No impact is predicted to the reefs associated with the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF.

[Table 6-78](#) provides an assessment of the proposed sewage and sullage discharges in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-78 Alignment with protection of conservation values of KEFs – sewage and sullage

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Chemical pollution / contaminants and nutrient pollution - currently identified as 'not of concern'.	Given that any sewage and sullage discharges will occur in surface waters with changes in water quality predicted to be temporary and highly localised, there is a high level of confidence that such discharges will not result in an adverse impact to marine ecosystem function or integrity within the KEFs; or any reduction in to the conservation values of the KEFs will occur.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Ancient coastline at 125 m depth contour			
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals		Chemical pollution / contaminants and nutrient pollution - currently identified as 'data deficient or not assessed'	

Australian Marine Parks

Change in water quality

Vessels associated with the installation of the BTL, IMR vessels during operations and transiting project vessels will discharge sewage and sullage within the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley AMPs. Discharges from vessels operating within the AMPs will be temporary and transient in nature (e.g. the slowest moving Project vessel will be the pipelay vessel, which will move at a rate of up to 5 km/day). In addition, vessels operating along the BTL will discharge sewage and sullage in accordance with the approved allowed activities of the multiple use zoning (IUCN VI), which permits the disposal of waste from the normal operations of vessels in accordance with MARPOL requirements. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park and it is unlikely that the effluent would reach this AMP from the discharge point.

The Kimberley Marine Park ranges in water depth from less than 15 m to 800 m, providing protection for habitats and ecological communities in waters offshore of the Kimberley coastline. Fauna that utilise this AMP include seabirds, marine turtles, inshore dolphins, humpback whales, pygmy blue whales, dugongs and whale sharks. The Argo-Rowley Terrace AMP provides protection for the ecological communities and habitats of the deeper offshore waters, and key features include Mermaid, Clerke and Imperieuse Reefs. This AMP also protects threatened, migratory, marine and cetacean species as well as BIAs for seabirds and migratory pathways for the pygmy blue whale (Director of National Parks, 2018).

The release of effluents that could locally affect the quality of receiving marine waters is recognised as pressure in the North-west marine region (Commonwealth of Australia, 2012). The Marine Bioregional Plan for the North West Marine Region recognises that fauna and ecosystems may be vulnerable to marine discharges that include chemicals and toxins (Director of National Parks, 2018).

As described above, it is expected that the sewage and sullage effluent will disperse in very close proximity to the discharge point. Given the water depths along the BTL route >250 m, it is not predicted that the effluent will impact on the deepwater benthic habitats in the AMPs.

As described above, marine fauna within the AMPs are unlikely to be adversely impacted due to the dispersive action on the effluent and the transient nature of the fauna that could potentially be exposed to the discharge.

Given this, it is considered that the identified conservation values of these AMPs will not be adversely impacted by the discharge of sewage and sullage from project vessels associated with the proposed Browse to NWS Project.

Table 6-79 provides an assessment of the proposed sewage and sullage discharges in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018)

Table 6-79 Alignment with the North-west Marine Parks Network Management Plan – sewage and sullage discharge

Australia Marine Park	Relevant plan(s)	Australian Marine Park Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	As outlined above, sewage and sullage discharges from vessels operating within these AMPs will be of a small volume (highest discharge is approximately 262 m ³ /day from the pipelay vessel), temporary and transient in nature and therefore unlikely to impact marine fauna or benthic habitats in these AMPs. Therefore, there is a high level of confidence that sewage and sullage discharges will not result in any adverse impacts to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018)
Kimberley Marine Park Multi Use Zone (VI)			
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, the sewage and sullage discharges associated with the installation of the BTL and occasional IMR activities are not considered a credible source of impact and no effect on ecosystems, habitats or native species in the AMP will be predicted. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

Other protected places

Change in water quality

The Scott Reef and Surrounds - Commonwealth Area Commonwealth Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef. The Commonwealth Heritage Place is utilised by seabirds, marine mammals and marine turtles; and supports diverse fish and coral communities. Project vessels will not operate within this area under normal operations.

Given this, and the dispersive nature of the effluent in close proximity to the discharge point, no impacts is predicted to occur to this Commonwealth Heritage Place as a result of sewage and sullage discharge. The same applies with respect to the potential for marine discharge impacts on the Mermaid Reef - Rowley Shoals Commonwealth Heritage Place.

As such, it is considered that the identified conservation values of these other protected places will not be adversely impacted by sewage and sullage discharge associated with the proposed Browse to NWS Project.

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no lasting effect to fish have been predicted, no significant subsequent impact to fisheries is expected.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

Activities such as tourism and recreation and scientific studies at Scott Reef are unlikely to be impacted due to the distance between Scott Reef and the discharge locations and the rapid dispersal of the discharges.

6.3.9.4 Environmental Risk

Risk event: Unplanned discharge of sewage and sillage significantly above discharge specifications

Though unlikely, discharges of sewage and sillage at levels significantly above the discharge specifications resulting from human error or equipment failure may occur. This would potentially result in a larger area being impacted (a temporary larger mixing zone), although the plume would still be expected to rapidly disperse. As per [Section 6.3.9.3](#), it would remain unlikely that exposure to marine fauna would be sufficient to elicit a toxic response. As such no change to the significance of the impact to water quality, plankton communities, benthic habitat, marine fauna, KEFs, AMPs, other Protected Places, managed fisheries or other users would be expected.

In the event that the discharge of sewage and sillage at levels significantly above the indicative discharge specifications occurs from the MODU or vessels operating near Scott Reef at a time where the prevailing conditions result in the plume moving towards Scott Reef, there is a risk of resultant impacts to the Scott Reef habitats shallow water benthic habitats. This impact would be expected to be temporary and localised in nature. Given the controls in place and the distance from the closest source (i.e. MODU during drilling at TRE), the likelihood of such an event occurring and resulting in adverse effects on Scott Reef shallow water benthic habitat (<75 m bathymetry) is considered remote, with the subsequent risk assessed to be low.

6.3.9.5 Cumulative Impacts

Cumulative impacts resulting from the discharge of sewage and sillage from the two FPSO facilities, project vessels, MODU(s), other marine users or other operating facilities within the region are not expected, given the predicted volumes of waste, the highly localised nature of impacts and the large geographic spread of the facilities and activities.

6.3.9.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact and risk assessment for the discharge of sewage and sillage is provided in [Table 6-80](#) and [Table 6-81](#) respectively. The acceptability assessment is provided in [Table 6-82](#).

Table 6-80 Impact assessment summary and adopted controls – marine discharges: sewage and sillage

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Water quality (medium value (open water))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	<u>Project vessel and FPSO operations</u> + Project vessels will comply with MARPOL 73/78 Annex IV: Sewage – (as applied in Australia under Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983) and Marine Orders 96 (Marine pollution prevention—sewage).	Slight	Slight (E)
Plankton (medium value (open water))	Change in fauna behaviour	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No lasting effect	Negligible (F)
Deepwater benthic communities and habitats (>75 m depth) – (medium value)	Change in water quality	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No impact expected	No impact expected
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in water quality	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	+ The FPSO facilities will be equipped with sewage treatment systems compliant with the MARPOL 73/78 9.1.1 requirements required for discharge within 3 nm of land despite their location being greater than 3 nm from land.	No impact expected	No impact expected
Fish (high value species)	Injury or mortality to fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.	<u>Installation of the BTL and inter-field spur line</u> + Sewage discharge will be conducted in a manner not inconsistent with the objectives, values and principles of the multi-use zones of the AMPs, which are traversed by the proposed BTL route.	No lasting effect	Slight (E)
Marine turtles (high value species)	Injury or mortality to fauna	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No lasting effect	Slight (E)
Marine mammals (high value species)	Injury or mortality to fauna	Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.	<u>Operations</u> + Discharge of sewage will occur in accordance with the WA Department of Transport sewage strategy within State waters.	No lasting effect	Slight (E)
KEFs (Medium value)	Change in water quality	Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population. Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.	+ There will be no discharge of untreated sewage within 3 nm of Scott Reef.	No lasting effect	Negligible (F)
AMPs (Medium value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Negligible (F)
Other protected places (high value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Slight (E)
State and Commonwealth managed fisheries (high value marine user)	Changes to the functions, interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies (high value users)	Changes to the functions, interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Water quality (medium value (open water))	Unplanned discharge significantly above discharge specifications	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	No further controls (in addition to those described in Table 6-80) adopted.	No increase to significance/consequence		
Plankton (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No increase to significance/consequence		
Deepwater benthic communities and habitats (>75 m depth) – (medium value)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No increase to significance/consequence		
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		Slight	Remote	Low (EO)
Fish (high value species)		Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No increase to significance/consequence		
Marine turtles (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No increase to significance/consequence		
Marine mammals (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No increase to significance/consequence		
KEFs (medium value)		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No increase to significance/consequence		
AMPs (medium value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
Other protected places (high value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
State and Commonwealth managed fisheries (high value marine user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		
Other users including tourism and recreation and scientific studies (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is necessary for the execution of the Browse to NWS Project.		No increase to significance/consequence		

Table 6-82 Acceptability assessment – marine discharges: sewage and sullage

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts and risks associated with sewage and sullage discharges as: + Studies of the effects of sewage and sullage discharges on the water quality at Scott Reef were undertaken during the drilling campaign for the Torosa-6 well in 2008 which showed sewage and sullage discharges were rapidly diluted in the upper (less than 10 m) water layer to 1% of its original concentration within 50 m. + Controls listed in Table 6-80, including the implementation of MARPOL 73/78 Annex IV: Sewage – (as applied in Australia under Commonwealth Protection of the Sea (<i>Prevention of Pollution from Ships</i>) Act 1983) and <i>Marine Orders</i> 96 (Marine pollution prevention—sewage), will be implemented to mitigate potential impacts. + In consideration of the lack of significant potential impacts, it is considered that studies have adequately characterised the marine fauna populations and distributions that may potentially be impacted by such discharges.
Principles of ESD With the application of the proposed controls in Table 6-80 it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-80, no lasting effect is predicted to occur from sewage and sullage discharge to listed threatened and migratory species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E). As described in Table 6-81, potential risk events associated with sewage and sullage discharge are not predicted increased the significance/consequence of impacts to listed threatened and migratory species. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted <u>Commonwealth Marine Environment</u> As described in Table 6-80, the potential impact from sewage and sullage discharge to plankton, KEFs and AMPs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to water quality, marine fauna, other protected places, managed fisheries and other users, while no impact is predicted to occur to deepwater benthic communities and habitats (>75 m depth) and shallow water benthic communities and habitats (<75 m depth). As described in Table 6-81, potential risk events associated with sewage and sullage discharge present a Low risk to shallow water benthic communities and habitats (<75 m depth). As such, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of sewage and sullage against the WA EPA Objective is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Marine environmental quality

As described in [Table 6-80](#), the potential impact from sewage and sullage discharge to plankton, has been assessed as Negligible (F). Slight (E) impacts may potentially occur to water quality.

As described in [Table 6-81](#), potential risk events associated with sewage and sullage discharge are not predicted increased the significance/consequence of impacts to plankton or water quality.

Given this, it is considered that with the application of the proposed controls, the environmental objectives for these receptors, and the WA EPA environmental objective “*To maintain the quality of water, sediment and biota so that environmental values are protected*” will be achieved.

Marine Fauna

As described in [Table 6-80](#), no lasting effect is predicted to occur from sewage and sullage discharge to marine fauna such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

As described in [Table 6-81](#), potential risk events associated with sewage and sullage discharge are not predicted increased the significance/consequence of impacts to marine fauna species.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*To protect marine fauna so that biological diversity and ecological integrity are maintained*.” will be achieved.

Benthic communities and habitats

As described in [Table 6-80](#) no impact is predicted to occur as a result of sewage and sullage discharge to deepwater benthic communities and habitats (>75 m depth) or shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-81](#), potential risk events associated with sewage and sullage discharge present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls in [Table 6-80](#), the environmental objectives for these receptors, and the WA EPA environmental objective “*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*” will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders, regarding discharge of sewage and sullage in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)) The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside’s chemical selection and assessment process and approved prior to use. Woodside will implement its internal requirement “*Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.*”

Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-77](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d).

KEFs

As detailed in [Table 6-78](#), the proposed discharges will not materially increase existing relevant pressures on the conservation values of KEFs.

AMPs

As detailed in [Table 6-79](#) the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other Protected Places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.10 Marine Discharges: Treated Utility Water, Chemical and Deck Drainage

6.3.10.1 Impact and Risk Overview

[Table 6-83](#) presents an overview of the potential impacts and risks from treated utility water, chemical and deck drainage discharges associated with the proposed Browse to NWS Project.

Table 6-83 Treated utility water, chemical and deck drainage impact and risk overview

Aspect	Marine discharges: treated utility water, chemical and deck drainage
Description	Treated utility water, chemical and deck drainage discharges will occur from the FPSO facilities, project vessels and MODU and comprise: + discharge from drains and bilges + non-process chemicals (e.g. clearing chemicals) + fire suppression systems + chemical storage drains + desalination brine.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to treated utility water, chemical and deck drainage associated with the proposed Browse to NWS Project are Objectives 3, 6, 7, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21. These objectives are detailed in Table 6-7 .

Aspect	Marine discharges: treated utility water, chemical and deck drainage		
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-84). + Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Part II Prevention of pollution from oil) (which applies MARPOL 74/78) + Marine Orders 91 (Marine pollution prevention – Oil) + WA Pollution of Waters by Oil and Noxious Substances Act 1987 + Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016d) + WA EPA Technical Guidance – Protecting the Quality of Western Australia’s Marine Environment (EPA, 2016b). + North-west Marine Parks Network Management Plan (Director of National Parks, 2018) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <u>Physical</u> + water quality (medium value (open water)) <u>Ecological</u> + plankton communities (low value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + fish (high value species) + marine reptiles (high value species) + marine mammals (high value species) + KEFs (high value) + AMPs (high value) + other protected places (high value) <u>Socio-economic</u> + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value user) + scientific studies (high value user)		
Potential impacts	+ change in water quality + change in fauna behaviour + changes to the functions, interests or activities of other users		
Risk	+ unplanned discharge significantly above discharge specifications		
Summary of governing impact evaluation	Magnitude	Impact significance level	Confidence
	No lasting effect	Slight (E)	High
Summary of governing risk evaluation	Consequence	Likelihood	Risk rating
	Slight	Remote	Low (EO)

6.3.10.2 Source of Aspect

Treated utility water will be generated from three main sources, the project vessels, MODU(s) and FPSO facilities.

The MODU and FPSO facilities will have open and closed drainage systems. The open system collects deck drainage (firewater, stormwater, and wash down water), drip trays, and sample returns. Deck drainage typically contains particulate matter and residual chemicals such as cleaning chemicals, oil and grease in small volumes. The open system is routed through slop tanks for treatment prior to discharge. Deck drainage is equipped with an overflow arrangement, which allows heavy rainfall and testing/operation of the fire deluge system to be discharged directly overboard.

Bilge water (drainage) from within machinery spaces will be captured in bilge drains and also routed to slops tank, where treated water (below 15 ppm in accordance with MARPOL 73/78 Annex 1¹³, will be discharged overboard. The recovered oil will likely be recovered into the Process and exported as condensate.

Closed drain systems collect liquids drained directly from the process, as opposed to the machinery spaces or the deck. The closed drain systems are returned to process and not discharged.

Chemical drains and amine drains systems are also provided. The chemical drains systems route chemicals to a waste tank for onshore disposal. During heavy rainfall the chemical drains will be routed to the open drains system. The amine drains systems routes to the amine slops tank. During heavy rainfall the bulk of the water will be directed overboard to prevent filling the amine slops tank.

Fire-fighting foams which contain organic and fluorinated surfactants can deplete dissolved oxygen in water. In the event that firefighting foam is required (in the event of an emergency or for infrequent testing), the foam systems mix the concentrates (~3%) with water (~97%) prior to application. There is then further dilution and dispersion following discharge to the open-water environment around the facility. Its expected ~5 m³ could be discharged to the surface during infrequent testing, which would rapidly disperse.

Desalinisation brine will also be generated through the production of freshwater for potable and other uses on the FPSO facilities, MODU and project vessels. The FPSO reverse osmosis units will result in a supply of fresh and demineralised water at a total rate of 21.5 m³/h. The MODU and vessels may either produce fresh water by means of reverse osmosis or thermal desalination or load fresh water at port.

The discharge of desalination brine, which consists of water with elevated salinity (typically 20 to 50% higher than the intake seawater) and low concentrations of anti-scale chemicals, is expected to be continuous throughout the life of the proposed Browse to NWS Project, although volumes will vary depending on potable water requirements on each FPSO facility, MODU and project vessels. Discharge of desalination brine from the FPSO facilities will likely occur below sea level. The FPSO facilities represent the most significant sources of desalination brine for the proposed Browse to NWS Project.

6.3.10.3 Environmental Impact

Water Quality

Change in water quality

Collected drainage water will be treated onboard prior to discharge to meet regulatory requirements (15 ppm oil in water). Considering the composition of the drain discharges (i.e. small quantities of residual hydrocarbons and detergents), and assimilative capacity of the receiving environment at the discharge points, it is expected that drain discharges will rapidly dilute within the surrounding waters. As such, these discharges will result in temporary (lasting a few minutes) change in water quality in the immediate vicinity of the discharge.

Firefighting foams containing organic and fluorinated surfactants are unlikely to be used and as such no impacts to water quality would be expected.

Desalination brine discharge is expected to be 20 to 50% more saline than the intake seawater (depending on the desalination process used) and therefore only a small number of dilutions will be required to achieve ambient salinity levels. Studies undertaken by the US EPA (Frick et al., 2001) determined that brine discharges from the surface dilute 40-fold approximately 4 m from the source. This modelling can be used as an indicator for predicting horizontal attenuation and diffusion of brine discharges. Given the proposed discharge volumes from the FPSO facilities (21.5 m³/hr), which is the largest source of such discharges, dilution to ambient levels is likely to be achieved within a very short distance from the discharge point (<100 m). Therefore, owing to the likely high number of dilutions achieved following discharge from the proposed sources (i.e. FPSO, vessels and MODU), elevated salinity levels (above ambient) will be highly localised at the discharge point and unlikely to have a perceptible effect on ambient salinity concentrations in the water column.

¹³ as applied in Australia under the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Part II Prevention of pollution from oil); Marine Orders 91 (Marine pollution prevention – Oil) as applicable to vessel class; and the WA Pollution of Waters by Oil and Noxious Substances Act 1987.)

Plankton communities

Injury or mortality to fauna

Plankton in close proximity to the discharge point may be exposed to the discharges. However, given the predicted dilutions, resulting in a very localised mixing zone, the proportion of the plankton population affected will be negligible. In addition, the wide spread nature and rapid turn-over of plankton populations leading to relatively quick recovery times, ensures that any impact on local communities would be expected to recover relatively quickly (within weeks or months) (ITOPF, 2011).

Benthic habitat

Change in water quality

Given the minimum water depth at the discharge locations (i.e. ~125 m at the NRC tie-in), it is not predicted that change in water quality resulting from the discharge of treated utility water, chemical and deck drainage will affect the deepwater benthic habitats of the Project Area.

Given the distance from the main discharge location in relation to Scott Reef (FPSO > 8 km away) and the expected rapid dilution of the discharge within 100 m, adverse impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) are not anticipated.

Studies on the dispersion of coral larvae at Scott Reef (Done et al., 2015; Foster and Gilmour, 2018) we examine distance decay among coral communities in a common habitat on northwestern Australian reefs, seeking to better understand the roles of disturbance and coral life history strategies in the changing reefscape. In established communities in 1997, when coral cover and generic richness were uniformly high, there was high similarity (~81 % demonstrates that while there is marked movement of larvae within the reef system itself (broadcast spawning corals), there is no evidence to suggest that those coral larvae that initially dispersed off the reef return to Scott Reef to settle. Therefore, the discharges are not likely to impact the recruitment of corals within the Scott Reef system.

Marine fauna

Injury or mortality to fauna – fish, marine mammals, marine turtles

While marine fauna (including fish, marine mammals and marine turtles) are known to be present within the Project Area, it is unlikely that large numbers of individuals will occur within close proximity to the discharge locations on the facilities, vessels or MODU. While marine fauna may come into contact with these discharges, any contact with the discharge with marine fauna will be of extremely short duration as the discharges are expected to be rapidly diluted in the prevailing currents, and due to the small volume and the short, intermittent nature of the discharge

Further, the potential for toxicity effects to marine biota from chemicals such as anti-scale and biocides is unlikely as these chemicals have low inherent toxicity (i.e. fit for human consumption in potable water) and will be consumed and neutralised in the desalination system, with any residual chemicals rapidly diluted following discharge.

As such it is not considered credible that toxic affects to marine fauna will occur as a result of the discharge of treated utility water, chemical and deck drainage associated with the proposed Browse to NWS Project.

With respect to desalination brine, studies have demonstrated that most marine species are able to tolerate short-term fluctuations in salinity of 20 to 30% (Walker and McComb, 1990), and can move away from discharge locations. Therefore temporary, localised salinity increases in the immediate vicinity of the discharge (diluted to ambient levels within meters) are not expected to have a lasting impact on marine biota.

It is noted that acute and chronic effects of chemical discharges are highlighted within the Recovery Plan for Marine Turtles in Australia (2017-2027) as a threat to green turtles within the Scott Reef and Browse Island area (Commonwealth of Australia, 2017a). Treated utility water, chemical and deck drainage discharge from the Torosa FPSO facility, project vessels and the MODU will occur in the green turtle BIA around Sandy Islet. Discharge will occur from vessels and the MODU in an area defined as habitat critical to the survival of green turtles in the Recovery Plan for Marine Turtles in Australia (2017-2027). The recovery plan includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a).

Discharge from project vessels, MODU and the Torosa FPSO facility will also occur in the potential foraging area and a migration BIA for pygmy blue whales as identified in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c). This plan identified chronic chemical pollution as a potential risk to pygmy blue whales. Conservation advices for other EPBC listed marine mammals that may occur in the Project Area do not identify chemical pollution as a key threat (Table 5-19). Given the above and the low numbers of pygmy blue whales and other marine mammals in the Project Area, it is not predicted that adverse impacts would occur to marine mammals as a result of treated utility water, chemical and deck drainage discharges.

Assessment against EPBC Act recovery and conservation plans and advices

Table 6-84 provides an assessment of the discharge of treated utility water, chemical and deck drainage from the proposed activities in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-84 Alignment with EPBC Act recovery and conservation plans and advices for protect – treated utility water, chemical and deck drainage

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice objectives and actions	Assessment
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The impact of treated utility water, chemical and deck drainage discharges resulting from the proposed Browse to NWS Project have been assessed. Given the low numbers and infrequent nature of whale shark presence in the Project Area, there is a high level of confidence that treated utility water, chemical and deck drainage discharges will not result in adverse impact to whale sharks.
Green turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival.	Impacts to turtles have been assessed and will be managed in accordance with the Recovery Plan for Marine Turtles in Australia (2017-2027) which includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a).
Hawksbill turtle		Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Given the nature, volume and dispersion of the treated utility water, chemicals and deck drainage discharges, adverse impacts to marine turtles are not expected. As such, in relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival is predicted to be met. Likewise, it is not predicted that treated utility water, chemical and deck drainage discharge will adversely affect the breeding cycle of marine turtles in the BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice objectives and actions	Assessment
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Chronic chemical pollution is identified as a potential risk to pygmy blue whales, however there are no specific actions identified	Occasional exposure of individuals of these species to the that treated utility water, chemical and deck drainage discharge may occur. However, given the nature, volume and dispersion of the predicted discharges, and the highly mobile nature of marine mammals, exposure would be temporary and is not expected to have any lasting impacts on the listed whale species. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Marine discharges have not been identified as a direct threat to these whale species; however, habitat degradation has been	
Sei whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale	identified as a threat and unmanaged discharges may contribute to this threat. The conservation advice relevant for this threat – identifies	
Fin whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale	modification to the coastal region in areas of importance to listed whales may result in reduced occupancy, compromised reproductive success and even mortality.	

Key Ecological Features

Injury or mortality to fauna and Change in water quality

The Continental slope demersal fish communities KEF and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs overlap with the Browse Development Area. Treated utility water, chemical and deck drainage discharges will occur within these KEFs from project vessels, MODU and the FPSO facilities. The BTL traverses the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF (depending on the final BTL route) and the Ancient coastline at 125 m depth contour KEF. Treated utility water, chemical and deck drainage discharges will occur within these KEFs from project vessels during the BTL installation and

intermittent IMR activities. The conservation values of these KEFs are described in [Section 5.3.3.1](#).

As described above, changes to water quality as a result of treated utility water, chemicals and deck drainage discharge are predicted to be temporary and highly localised. As such no lasting impacts to the conservation values of these KEFs is predicted. No impact is predicted to the reefs associated with the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF.

[Table 6-85](#) provides an assessment of the proposed treated utility water, chemical and deck drainage discharge in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-85 Alignment with protection of conservation values of KEFs – treated utility water, chemical and deck drainage discharges

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Chemical pollution / contaminants - currently identified as 'not of concern'	Given that any treated utility water, chemical and deck drainage discharges will occur in surface waters with changes in water quality predicted to be temporary and highly localised, there is a high level of confidence that such discharges will not result in an adverse impact to marine ecosystem function or integrity with in the KEFs; or any reduction in to the conservation values of the KEFs will occur.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Ancient coastline at 125 m depth contour		Chemical pollution / contaminants - currently identified as 'data deficient or not assessed'	
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals			

Australian marine parks

Change in water quality

Vessels associated with the installation of the BTL and transiting project vessels will discharge treated utility water, chemicals and deck drainage within the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley AMPs. Discharges from vessels operating within the AMPs will be temporary and transient in nature (e.g. the slowest moving Project vessel will be the pipelay vessel, which will move at a rate of up to 5 km/day). In addition, vessels operating along the BTL will discharge in accordance with the approved allowed activities of the multiple use zoning (IUCN VI), which permits the disposal of waste from the normal operations of vessels in accordance with MARPOL requirements as applied in Australia under the Commonwealth Protection of the Sea (*Prevention of Pollution from Ships) Act 1983 (Part II Prevention of pollution from oil)*; Marine Orders 91 (Marine pollution prevention – Oil) as applicable to vessel class; and the *WA Pollution of Waters by Oil and Noxious Substances Act 1987*). It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park and it is not expected that the effluent would reach this AMP from the discharge point.

The Kimberley Marine Park ranges in water depth from less than 15 m to 800 m, providing protection for habitats and ecological communities in waters offshore of the Kimberley coastline. Fauna that utilise this AMP include seabirds, marine turtles, inshore dolphins, humpback whales, pygmy blue whales, dugongs and whale sharks. The Argo-Rowley Terrace AMP provides protection for the ecological communities and habitats of the deeper

offshore waters, and key features include Mermaid, Clerke and Imperieuse Reefs. This AMP also protects threatened, migratory, marine and cetacean species as well as BIAs for seabirds and migratory pathways for the pygmy blue whale (Director of National Parks, 2018).

The release of effluents that could locally affect the quality of receiving marine waters is recognised as pressure in the North-west marine region (Commonwealth of Australia, 2012). The Marine Bioregional Plan for the North West Marine Region recognises that fauna and ecosystems may be vulnerable to marine discharges that include chemicals and toxins (Director of National Parks, 2018).

As described above, it is expected that discharges from vessels will disperse in very close proximity to the discharge point. Given the water depths along the BTL route >250 m, it is not predicted that the discharges will impact on the deepwater benthic habitats in the AMPs. As described above, marine fauna within the AMPs are unlikely to be adversely impacted due to the dispersive action on the effluent and the transient nature of the fauna that could potentially be exposed to the discharge.

Given this, it is considered that the identified conservation values of these AMPs will not be adversely impacted by treated utility water, chemical or deck discharges associated with the proposed Browse to NWS Project.

Table 6-86 provides an assessment of the proposed discharge of treated utility water, chemical and deck drainage in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Table 6-86 Alignment with the objectives of AMPs – treated utility water, chemical and deck drainage

Australia Marine Park	Relevant plan(s)	Australian Marine Park Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	Treated utility water, chemical and deck drainage discharges from vessels operating within these AMPs will be of a small volume, temporary and transient in nature and therefore unlikely to impact marine fauna or benthic habitats in these AMPs. Therefore, there is a high level of confidence that such discharges will not result in any adverse impacts to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
Kimberley Marine Park Multi Use Zone (VI)			
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, discharges associated with the installation of the BTL and occasional IMR activities are not considered a credible source of impact and no effect on ecosystems, habitats or native species in the AMP is predicted. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

Other protected places**Change in water quality**

The Scott Reef and Surrounds - Commonwealth Area Commonwealth Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef. The Commonwealth Heritage Place is utilised by seabirds, marine mammals and marine turtles; and supports diverse fish and coral communities. Project vessels will not operate within this area under normal operations.

Given this, and the dispersive nature of the effluent in close proximity to the discharge point, no impact is predicted to occur to this Commonwealth Heritage Place as a result of treated utility water, chemicals and deck drainage discharge. The same applies with respect to the potential for marine discharge impacts on the Mermaid Reef - Rowley Shoals Commonwealth Heritage Place.

As such, it is considered that the identified conservation values of these other protected places will not be adversely impacted by treated utility water, chemicals and deck drainage discharge associated with the proposed Browse to NWS Project.

Other users**Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries**

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no lasting effect to fish have been predicted, no significant subsequent impact to fisheries is expected.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

Activities such as tourism and recreation and scientific studies at Scott Reef are unlikely to be impacted by discharges from the FPSO facilities given the distance from Scott Reef (Torosa FPSO is approximately 8 km away). Similarly, discharge from project vessels and the MODU are unlikely to have any impact on other marine users at Scott Reef given the distance and the small volumes, low toxicity, and temporary nature of these discharges in the context of the open ocean receiving environment.

6.3.10.4 Environmental Risk

Risk event: Unplanned discharge of treated utility water, chemical and deck drainage significantly above discharge specifications

Though unlikely, unplanned discharges of treated utility water, chemical and deck drainage resulting from human error or equipment failure on project vessels, MODU or FPSO facilities may occur. This would potentially result in a larger area being impacted (a temporary larger mixing zone), although the plume would still be expected to rapidly disperse. As per [Section 6.3.10.3](#), it would remain unlikely that exposure to marine fauna would be sufficient to elicit a toxic response. As such no change to the significance of the impact to water quality, plankton communities, benthic habitat, marine fauna, KEFs, AMPs, other protected places, managed fisheries or other users would be expected.

In the event that the discharge of treated utility water, chemical and deck drainage at levels significantly above the indicative discharge specifications occurs from the MODU or project vessels operating near Scott Reef at a time where the prevailing conditions result in the plume moving towards Scott Reef, there is a risk of resultant impacts to the Scott Reef habitats shallow water benthic habitats. This impact would be expected to be temporary and localised in nature. Given the controls in place and the distance from the closest source (i.e. MODU during drilling at TRE) to Scott Reef, the likelihood of such an event occurring and resulting in adverse effects on Scott Reef shallow water benthic habitat (<75 m bathymetry) habitats is considered remote, with the subsequent risk assessed to be low.

6.3.10.5 Cumulative Impacts

Cumulative impacts resulting from the discharge of treated utility water, chemical and deck drainage from the two FPSO facilities, project vessels, MODU(s), other marine users or other operating facilities within the region are not expected, given the predicted volumes of waste, the highly localised nature of impacts and the large geographic spread of the facilities and activities.

6.3.10.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact and risk assessment for the discharge of treated utility water, chemical and deck drainage is provided in [Table 6-87](#) and [Table 6-88](#). The final acceptability assessment is provided in [Table 6-89](#).

Table 6-87 Impact assessment summary and adopted controls – marine discharges: treated utility water, chemical and deck drainage

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Water quality (medium value (open water))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	<i>Protect vessels, MODU and FPSO operations</i>	Slight	Slight (E)
Plankton (medium value (open water))	Injury or mortality to fauna	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	+ Areas of potential contamination such as machinery and bulk liquid storage areas will be banded to capture any spilled chemicals or oil residues. Drainage from these areas will be directed to holding tanks for treatment prior to discharge, subject to overflow arrangements.	No lasting effect	Negligible (F)
Deepwater benthic communities and habitats (>75 m depth) – (medium value)	Change in water quality	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No impact expected	
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in water quality	Objective 10: To avoid changes beyond natural variation in ecosystem processes; biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		No impact expected	
Fish (high value species)	Injury or mortality to fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No lasting effect	Slight (E)
Marine turtles (high value species)	Injury or mortality to fauna	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.	+ An oil-in-water separator will be available onboard the FPSO facilities, MODU and vessels (as applicable to vessel class), which will be maintained and operated so that bilge water is treated to reduce hydrocarbon concentrations below 15 ppm in accordance with MARPOL 73/78 Annex I, as applied in Australia under the Commonwealth	No lasting effect	Slight (E)
Marine mammals (high value species)	Injury or mortality to fauna	Objective 14: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No lasting effect	Slight (E)
KEFs (medium value)	Change in water quality	Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No lasting effect	Negligible (F)
AMPs (medium value)	Change in water quality	Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No lasting effect	Negligible (F)
Other protected places (high value)	Change in water quality	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.	<i>Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Part II Prevention of pollution from oil); Marine Orders 91</i>	No lasting effect	Slight (E)
State and Commonwealth managed fisheries (high value marine user)	Changes to the functions, interests or activities of other users	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies (high value users)	Changes to the functions, interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing.		No lasting effect	Slight (E)
		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	<i>Pollution of Waters by Oil and Noxious Substances Act 1987.</i>	No lasting effect	Slight (E)

Table 6-88 Risk assessment summary and adopted controls – Treated Utility Water, Chemical and Deck Drainage

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Water quality (medium value (open water))	Unplanned discharge significantly above discharge specifications	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	+ Discharges from FPSO slops holding tanks will be monitored to ensure specifications are met. Where discharge specification cannot be met for FPSO facility discharges, the discharge stream will be reprocessed or sent onshore for disposal.	No increase to significance/consequence		
Plankton (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No increase to significance/consequence		
Deepwater benthic communities and habitats (>75 m depth) – (medium value)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No increase to significance/consequence		
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		Slight	Remote	Low (EO)
Fish (high value species)		Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.	+ FPSO facility hazardous open drains systems integrity will be maintained, and open hazardous and closed drain caisson sump pumps will be available to support hydrocarbon recovery.	No increase to significance/consequence		
Marine turtles (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No increase to significance/consequence		
		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.				
Marine mammals (high value species)		Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No increase to significance/consequence		
KEFs (medium value)		Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No increase to significance/consequence		
		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No increase to significance/consequence		
AMPs (medium value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
Other protected places (high value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
State and Commonwealth managed fisheries (high value marine user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing.		No increase to significance/consequence		
		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		
Other users including tourism and recreation and scientific studies (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is necessary for the execution of the proposed Browse to NWS Project.		No increase to significance/consequence		

Table 6-89 Acceptability Assessment – treated utility water, chemical and deck drainage

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts and risks associated with treated utility water, chemical and deck drainage discharges as: + In consideration of the lack of significant potential impacts, it is considered that studies have adequately characterised the marine fauna populations and distributions that may potentially be impacted by such discharges. + Studies have demonstrated that such discharges from project infrastructure and vessels will rapidly dilute within the immediate vicinity of the discharge point, with no impact to sensitive receptors or species. + Controls, including the implementation of MARPOL 73/78 Annex I, as applied in Australia under the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Part II Prevention of pollution from oil); Marine Orders 91 (Marine pollution prevention – Oil) as applicable to vessel class; and the WA Pollution of Waters by Oil and Noxious Substances Act 1987, will be implemented to mitigate potential impacts.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-87, no lasting effect is predicted to occur from the discharge of treated utility water, chemical and deck drainage to listed threatened and migratory species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E). As described in Table 6-88, potential risk events associated with the discharge of treated utility water, chemical and deck drainage are not predicted increased the significance/consequence of impacts to listed threatened and migratory species. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted <u>Commonwealth Marine Environment</u> As described in Table 6-87, the potential impact from the discharge of treated utility water, chemical and deck drainage to plankton, KEFs and AMPs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to water quality, marine fauna, other protected places, managed fisheries and other users, while no impact is predicted to occur to deepwater benthic communities and habitats (>75 m depth) and shallow water benthic communities and habitats (<75 m depth). As described in Table 6-88, potential risk events associated with the discharge of treated utility water, chemical and deck drainage present a Low risk to shallow water benthic communities and habitats (<75 m depth). As such, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of treated utility water, chemical and deck drainage discharges against the WA EPA Objective is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Marine environmental quality

As described in [Table 6-87](#), the potential impact from the discharge of treated utility water, chemical and deck drainage to plankton has been assessed as Negligible (F). Slight (E) impacts may potentially occur to water quality.

As described in [Table 6-88](#), potential risk events associated with the discharge of treated utility water, chemical and deck are not predicted increased the significance/consequence of impacts to plankton or water quality

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective *"To maintain the quality of water, sediment and biota so that environmental values are protected"* will be achieved.

Marine Fauna

As described in [Table 6-87](#), no lasting effect is predicted to occur from the discharge of treated utility water, chemical and deck drainage to marine fauna such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

As described in [Table 6-88](#), potential risk events associated with the discharge of treated utility water, chemical and deck drainage are not predicted increased the significance/consequence of impacts to marine fauna species.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective *"To protect marine fauna so that biological diversity and ecological integrity are maintained."* will be achieved.

Benthic communities and habitats

As described in [Table 6-87](#) no impact is predicted to occur as a result of the discharge of treated utility water, chemical and deck drainage to deepwater benthic communities and habitats (>75 m depth) or shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-88](#), potential risk events associated with the discharge of treated utility water, chemical and deck drainage present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective *"to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained"* will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders, regarding discharge of treated utility water in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)) The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System.

Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside's chemical selection and assessment process and approved prior to use. Woodside will implement its internal requirement *"Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints."*

Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-84](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d).

KEFs

As detailed in [Table 6-85](#), the proposed discharges will not materially increase existing relevant pressures on the conservation values of KEFs.

AMPs

As detailed in [Table 6-86](#), the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other Protected Places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.11 Marine Discharges: Putrescible Waste

6.3.11.1 Impact and Risk Overview

[Table 6-90](#) presents an overview of the potential impacts and risks from putrescible waste discharges associated with the proposed Browse to NWS Project.

Table 6-90 Putrescible waste impact and risk overview

Aspect	Marine discharges: putrescible waste
Description	Food scraps and other putrescible waste will be discharged from the: + FPSO facilities (approximately 1L/person/day) + MODU + project vessels.
Area	Project Area, Browse Development Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to putrescible waste associated with the proposed Browse to NWS Project are Objectives 3, 6, 10, 11, 12, 13, 14, 17, 18, 19, 20 and 21. These objectives are detailed in Table 6-7 .

Aspect	Marine discharges: putrescible waste						
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. + Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983. This is the primary federal legislative instrument for Australia’s implementation of the International Convention for the Prevention of Pollution from Ships (MARPOL) + Commonwealth Navigation Act 2012 (Cth) + Marine Order 95 (Marine pollution prevention – garbage) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016d) + North-west Marine Parks Network Management Plan (Director of National Parks, 2018) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).						
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <u>Physical</u> + water quality (medium value (open water)) <u>Ecological</u> + plankton communities (low value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + seabirds and migratory shorebirds (high value species) + fish (high value species) + KEFs (high value) + AMPs (high value) + other protected places (high value) <u>Socio-economic</u> + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value user) + scientific studies (high value user)						
Potential impacts	+ change in water quality + change in fauna behaviour + changes to the functions, interests or activities of other users						
Risk	+ there are no anticipated environmental risks in relation to this aspect associated with unplanned project activities						
Summary of governing impact evaluation	<table><tr><th>Magnitude</th><th>Impact significance level</th><th>Confidence</th></tr><tr><td>Slight</td><td>Slight (E)</td><td>High</td></tr></table>	Magnitude	Impact significance level	Confidence	Slight	Slight (E)	High
Magnitude	Impact significance level	Confidence					
Slight	Slight (E)	High					
Summary of governing risk evaluation	<table><tr><th>Consequence</th><th>Likelihood</th><th>Risk rating</th></tr><tr><td>n/a</td><td>n/a</td><td>n/a</td></tr></table>	Consequence	Likelihood	Risk rating	n/a	n/a	n/a
Consequence	Likelihood	Risk rating					
n/a	n/a	n/a					

6.3.11.2 Source of Aspect

Putrescible waste will be generated from three main sources:

- + FPSO facilities
- + MODUs
- + project vessels.

FPSO facilities, MODU and vessel operations used for the proposed Browse to NWS Project include accommodation facilities for crew and passengers. The crew and passengers will generate waste including putrescible waste which will be discharged to the marine environment in a controlled manner, in accordance with the Navigation Act 2012, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. The average volume of food waste discharged overboard will vary depending on the number of personnel on board at any time, and the types of meals prepared. This is estimated to be in the order of 1–2 kg per person per day. Discharged putrescible waste will be restricted to the immediate vicinity of the discharge location and is expected to be undetectable further than 500 m from the discharge source.

Macerated putrescible waste will be discharged throughout all phases of the proposed Browse to NWS Project. The FPSO and MODU will discharge putrescible waste from a stationary point over the term of their operations (months to years). Support vessels and pipelay vessels will typically discharge over short-term operations (weeks to months), possibly while in transit.

It is anticipated that putrescible waste will disperse and break up rapidly in the marine environment, with some of the waste being consumed by marine fauna upon discharge.

6.3.11.3 Environmental Impact

Water quality

Change in water quality

The discharge of macerated putrescible waste has the potential to change the local water quality for a short period through the addition of a temporary nutrient source resulting in potential temporary reduction to biological oxygen demand. However, studies into the effects of nutrient enrichment indicate that the influence of nutrients in open marine areas such as the locations for the proposed Browse to NWS Project, is much less significant than that experienced in enclosed areas (McIntyre and Johnston, 1975). Due to the nature of the open ocean receiving environment and relatively small volumes of discharge, this nutrient loading would rapidly return to background conditions following dispersion through surface currents and wave action. Therefore, the extent of this potential impact will be restricted to the immediate vicinity of the discharge locations.

Plankton communities

Change in fauna behaviour

Plankton in close proximity to the discharge points may be exposed to the macerated putrescible waste. Organic materials from the discharges will likely exert biological oxygen demand on the receiving waters, although this is unlikely to reach levels below background ambient dissolved oxygen concentrations. Similarly, while the nutrient inputs from discharged will rapidly be taken up by phytoplankton, pronounced increases in productivity as evidenced by increased chlorophyll a concentration are not expected. This is largely due to the assimilative capacity of the open ocean, with any potential additive nutrients not expected to accumulate in the vicinity of the discharge locations. As such no lasting impacts to plankton communities are expected.

Benthic habitats

Change in water quality

Given the minimum water depth at the discharge locations (i.e. 125 m at the NRC tie-in), it is not predicted that change in water quality resulting from the discharge of putrescible waste will affect the deepwater benthic habitats of the Project Area.

Given the distance from the putrescible waste discharge locations in relation to nearby sensitive receptors (e.g. >3 nm from Scott Reef and 2 km from the boundary of the Mermaid Reef Marine Park) and the likelihood that such discharges would disperse and break up rapidly in the marine environment, impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) including coral and seagrass are not anticipated.

Marine fauna

Change in fauna behaviour

There is potential that some opportunistic fish and seabirds may be attracted to the discharge of macerated putrescible waste either directly, in response to increased food availability, or indirectly as a result of attraction of prey species. Food waste is not identified as a threat in any EPBC listed threatened species recovery plans or conservation advice. Furthermore, given the small quantities of macerated putrescible waste to be disposed, any attraction of marine fauna is likely to be localised and temporary and is not expected to result in lasting effects to marine fauna.

Key Ecological Features

Change in water quality

The Continental slope demersal fish communities KEF and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs overlap with the Browse Development Area. Putrescible waste discharges will occur within these KEFs from project vessels, MODU and the FPSO facilities. The BTL traverses the Mermaid

Reef and Commonwealth waters surrounding Rowley Shoals KEF (depending on the final BTL route) and the Ancient coastline at 125 m depth contour KEF. Discharge of putrescible waste will occur within these KEFs from project vessels during the BTL installation and intermittent IMR activities. The conservation values of these KEFs are described in [Section 5.3.3.1](#).

As described, change to water quality resulting from the discharge of putrescible waste will be limited, temporary

and localised increase in nutrient levels, and such are not predicted to reduce the conservation values of the KEFs within the Project Area.

[Table 6-91](#) provides an assessment of the proposed putrescible waste discharge in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-91 Alignment with protection of conservation values of KEFs – putrescible waste

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Nutrient pollution - currently identified as 'not of concern'	Given that any putrescible waste discharges will occur in surface waters with changes in water quality predicted to be temporary and highly localised, there is a high level of confidence that such discharges will not result in an adverse impact to marine ecosystem function or integrity within the KEFs; or any reduction to the conservation values of the KEFs.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Ancient coastline at 125 m depth contour			
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals		Nutrient pollution - currently identified as 'data deficient or not assessed'	

Australian Marine Parks

Change in water quality

Vessels associated with the installation of the BTL and transiting project vessels will discharge putrescible waste within the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley AMPs. Discharges from vessels operating within the AMPs will be temporary and transient in nature (e.g. the slowest moving Project vessel will be the pipelay vessel, which will move at a rate of up to 5 km/day). In addition, vessels operating along the BTL will discharge putrescible waste in accordance with the approved allowed activities of the multiple use zoning (IUCN VI), which permits the disposal of waste from the normal operations of vessels in accordance with MARPOL requirements. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park and it is unlikely that the discharge would reach this AMP from the discharge point.

As described above, the discharge of putrescible waste may temporarily change the water quality (on a very localised scale) within the AMP and lead to an alteration to fauna (seabirds and fish) behaviour associated with food and/or prey availability. The release of effluents that could locally affect the quality of receiving marine waters is recognised as pressure in the North-west marine region (Commonwealth of Australia, 2012).

The Argo-Rowley Terrace and Kimberley AMPs protect values including seabirds, marine turtles, inshore

dolphins, humpback whales, pygmy blue whales, dugongs and whale sharks (Director of National Parks, 2018). Additionally, the Kimberley AMP supports benthic habitats including macroalgae (Walker, 1995; Walker et al., 1996) and coral (Veron and Marsh, 1988).

As described above, change in water quality will be temporary and highly localised. Impacts on fauna through a reduction in water quality are not expected due to the small discharge volumes and the ability of the surface currents and wave motion to disperse it. Any alternations in fauna behaviour based on their attraction to food and/or prey availability is likely to be only temporary due also to the rapid dispersion of the waste.

The BTL is located in deep water where inputs at the surface would be unlikely to impact on any deepwater benthic habitats within the AMP. Benthic habitat surveys of the proposed BTL confirmed that there were no sensitive benthic communities present (Advisian, 2019).

Given the above, it is considered that the identified conservation values of the Argo-Rowley Terrace and Kimberley AMPs will not be detrimentally impacted by putrescible waste discharges associated with the proposed Browse to NWS Project.

Summary

[Table 6-92](#) provides an assessment of the proposed discharge of putrescible waste in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018)

Table 6-92 Alignment with the objectives of AMPs – putrescible waste

Australia Marine Park	Relevant plan(s)	Australian Marine Park Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	Putrescible waste discharges from project vessels operating within these AMPs will be of a small volume, temporary and transient in nature and therefore unlikely to impact marine fauna or benthic habitats in these AMPs. Therefore, there is a high level of confidence that putrescible waste discharges will not result in any adverse impacts to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
Kimberley Marine Park Multi Use Zone (VI)			
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, the putrescible waste discharges associated with the installation of the BTL and occasional IMR activities are not considered a credible source of significant impact and no effect on ecosystems, habitats or native species in the AMP will occur. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

Other protected places**Change in water quality**

The Scott Reef and Surrounds - Commonwealth Area Commonwealth Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef. The Commonwealth Heritage Place is utilised by seabirds, marine mammals and marine turtles; and supports diverse fish and coral communities. Project vessels will not operate within this area under normal operations.

Given this, the small discharge volumes and the expected dispersion of the discharge in proximity to the discharge point, no impacts are predicted to occur to this Commonwealth Heritage Place as a result of putrescible waste discharge. The same applies with respect to the potential for marine discharge impacts on the Mermaid Reef - Rowley Shoals Commonwealth Heritage Place.

As such, it is considered that the identified conservation values of these other protected places will not be adversely impacted by putrescible waste discharge associated with the proposed Browse to NWS Project.

Other users**Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries**

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no lasting effect to fish have been predicted, no significant subsequent impact to fisheries is expected.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

Activities such as tourism and recreation and scientific studies at Scott Reef are unlikely to be impacted due to the distance between Scott Reef and the discharge locations (noting no discharges of putrescible waste will occur within State waters and the rapid dispersal of the discharges).

6.3.11.4 Environmental Risk

There are no anticipated environmental risks in relation to this aspect associated with unplanned project activities.

6.3.11.5 Cumulative Impacts

Cumulative impacts resulting from the discharge of putrescible waste from two FPSO facilities, project vessels, MODU(s), other marine users or other operating facilities within the region are not expected, given the predicted volumes of waste, the highly localised nature of impacts and the large geographic spread of the facilities and activities.

Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact assessment for the discharge of putrescible waste is provided in [Table 6-93](#). The acceptability assessment is provided in [Table 6-94](#).

Table 6-93 Impact assessment summary and adopted controls – marine discharges: putrescible waste

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Water quality (medium value (open water))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	<i>MODU and FPSO operations</i> + Putrescible waste will be macerated to a diameter of less than 25 mm prior to disposal overboard, in accordance with MAPOL 73/78 Annex V; Garbage and Section 26F of the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983.	Slight	Slight (E)
Plankton (medium value (open water))	Change in fauna behaviour	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No lasting effect	Negligible (F)
Deepwater benthic communities and habitats (>75 m depth) – (medium value)	Change in water quality	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No impact expected	No impact expected
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in water quality	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No impact expected	No impact expected
Seabirds and migratory shorebirds (high value species)	Change in fauna behaviour	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	<i>Project vessel operations</i> + Vessel discharges will be conducted in a manner not inconsistent with the objectives, values and principles of the multi-use zones of the AMPs, which are traversed by the trunkline route.	No lasting effect	Slight (E)
Fish (high value species)	Change in fauna behaviour	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population. Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.	+ No putrescible waste will be discharged within the 3nm State waters boundary.	No lasting effect	Slight (E)
KEFs (medium value)	Change in water quality	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No lasting effect	Negligible (F)
AMPs (medium value)	Change in water quality	Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
Other protected places (high value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place. Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Slight (E)

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
State and Commonwealth managed fisheries (high value marine user)	Changes to the functions, interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies (high value users)	Changes to the functions, interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is necessary for the execution of the Browse to NWS Project.		No lasting effect	Slight (E)

Table 6-94 Acceptability assessment – marine discharges: putrescible waste

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts and risks associated with putrescible waste discharges as: + The implementation of relevant acts and legislative requirements, including MARPOL 73/78 Annex V: Garbage and the Commonwealth <i>Protection of the Sea (Prevention of Pollution from Ships) Act 1983</i>, will mitigate potential impacts.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-93, no lasting effect is predicted to occur from the discharge of putrescible waste to listed threatened and migratory species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E). Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted <u>Commonwealth Marine Environment</u> As described in Table 6-93, the potential impact from the discharge of putrescible waste to plankton, KEFs and AMPs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to water quality, marine fauna, other protected places, managed fisheries and other users, while no impact is predicted to occur to deepwater benthic communities and habitats (>75 m depth) and shallow water benthic communities and habitats (<75 m depth). As such, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable
WA EPA Environmental Objectives In accordance with MARPOL 73/78 Annex V: Garbage, no putrescible waste will be discharged within the State Proposal Area. Conclusion: Acceptable
External context To date there have been no specific matters raised by stakeholders regarding discharge of putrescible waste in relation to the proposed Browse to NWS Project. Conclusion: Acceptable
Internal context This impact assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline Section 6.2.3.4. The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System. Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

No adverse impacts to species where an EPBC Act management plan of conservation advice applies is predicted to occur as a result of the discharge of putrescible waste.

KEFs

As detailed in [Table 6-91](#), the proposed discharges will not materially increase existing relevant pressures on the conservation values of KEFs.

AMPs

As detailed in [Table 6-92](#) the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other Protected Places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.12 Marine Discharges: Produced Water

6.3.12.1 Impact and Risk Overview

[Table 6-95](#) presents an overview of the potential impacts and risks from produced water (PW) discharges associated with the proposed Browse to NWS Project.

Table 6-95 Produced water impact and risk overview

Aspect	Marine discharges: produced water
Description	When hydrocarbons are recovered from the reservoir a by-product is produced water (PW), which is separated out from the hydrocarbons during the production process and disposed of. This PW may consist of a combination of formation water (water that occurs naturally within the hydrocarbon-bearing geological formations that is drawn into the well during hydrocarbon recovery), and condensed water (water vapour contained in the gaseous phase of the reservoir fluids that condenses out of the gas as the pressure and temperature is reduced when the reservoir fluids are brought up to the surface). PW will be produced during operations where it will be treated on board the FPSO facilities prior to discharge to the marine environment. Low levels of PW may also be discharged from the MODU at the drill centre locations, during well unloading. PW discharged to the marine environment may include: + trace amounts of hydrocarbon compounds + trace amounts of metals + MEG + Naturally occurring radioactive materials (NORMS) + nutrients such as ammonia.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	Drilling and completions, operations
Environmental objectives	The environmental objectives in relation to produced water associated with the proposed Browse to NWS Project are Objectives 3, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20 and 21. These objectives are detailed in Table 6-7 .

Aspect	Marine discharges: produced water
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-99). + Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016d) + WA EPA Technical Guidance – Protecting the Quality of Western Australia’s Marine Environment (EPA, 2016b) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <i>Physical</i> + Sediment quality (medium value (open water)) + water quality (medium value (open water)) <i>Ecological</i> + plankton (medium value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + fish (high value species) + marine reptiles (high value species) + marine mammals (high value species) + KEFs (medium value) + State marine parks and nature reserves (high value) + other protected places (high value) <i>Socio-economic</i> + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value user) + scientific studies (high value user) + aboriginal or indigenous heritage (high value users)
Potential impacts	+ change in water quality + Injury or mortality to fauna + changes to the functions, interests or activities of other users
Risk	+ Unplanned discharge of PW significantly above discharge specifications

Marine discharges: produced water			
Aspect			
Summary of governing impact evaluation	Magnitude	Impact significance level	Confidence
	Minor	Minor	High
Summary of governing risk evaluation	Consequence	Likelihood	Risk rating
	Minor	Remote	Low (D0)

6.3.12.2 Source of Aspect

When hydrocarbons are recovered from the reservoir, PW is a by-product, which is separated out from the hydrocarbons during the production process and disposed of. This PW may consist of a combination of formation water (water that occurs naturally within the hydrocarbon-bearing geological formations that is drawn into the well during hydrocarbon recovery), and condensed water (water vapour contained in the gaseous phase of the reservoir fluids that condenses out of the gas as the pressure and temperature is reduced when the reservoir fluids are brought up to the surface). Formation water is typically expected to be saline, while condensed water is fresh.

PW is typically high temperature, due to the high temperature of the reservoir and other reservoir fluids. Key contaminants of PW discharge are:

- + trace amounts of hydrocarbon compounds remaining in the water after treatment (IOGP, 2005)
- + trace amounts of metals
- + nutrients such as ammonia, which occur naturally within the reservoir
- + MEG, which is commonly used as a hydrate inhibitor within oil and gas developments
- + NORMS, which under certain conditions can become bound to scale deposits within the production wells, pipelines and process equipment on the offshore facilities.

Produced Water in the offshore oil and gas industry

While condensed water is typically present in the gaseous component of the reservoir, formation water is actively avoided during reservoir recovery. However, over

time as hydrocarbons are extracted, formation water is drawn towards the well and it is produced. Formation water (and therefore PW) is therefore generally expected to increase over time and be highest towards the end of the reservoir life. Produced water rates are typically influenced by the reservoir characteristics as well as the capacity of the facility design.

Oil and gas facilities typically have a PW treatment system which removes the contaminants from the PW prior to discharge. The PW treatment system typically focusses on the reduction of oil-in-water to acceptable levels. Accepted industry practice in Australia is to treat PW to below 30 mg/L oil-in-water content (average over a 24-hour period) during steady state operations, which aligns well with the internationally recognised IFC standard of 29 mg/L average over a 30-day period.

Through the environmental impact assessment process, it is typical for proponents to quantify the impact of discharge of PW by describing a mixing zone, defined as the area where the Predicted Environmental Concentration (PEC) exceeds the Predicted No Effect Concentration (PNEC). This mixing zone size can be reduced by increasing the depth at which the PW is discharged to facilitate dispersion, which occurs from mixing action as the buoyant plume rises through the water column.

Examples of PW impact from other proponents summarised in [Table 6-96](#). In each instance the proponents identified a mixing zone based on an acceptable discharge of 30 mg/L oil-in-water content (average over a 24-hour period). This mixing zone is typically verified in Operations using a variety of techniques, including whole of effluent toxicity testing.

Table 6-96 Overview of Produced Water in the offshore oil and gas industry

	Barossa Offshore Project Proposal (OPP)	Ichthys EIS
Disposal Mechanism	Treatment and overboard	Treatment and overboard
Maximum Processing Rates	3,260 m ³ /day	5,000 m ³ /day
99% species protection of condensate	0.007 mg/L (0.456 mg/L ¹⁴)	<i>Not presented</i>
Mixing zone sizes	6.1 km (based on 4,285 dilutions)	3.6 km (based on 5,000 dilutions)

Produced Water from the proposed Browse to NWS Project

For the proposed Browse to NWS Project, the primary source of PW discharges will occur from the FPSO facilities in Commonwealth waters, with low levels also discharged from the MODU. The FPSO facilities have been designed to minimise the impact of PW, both through the treatment system design and the discharge depth of PW from the FPSO hull.

The PW stream discharged from the FPSO facilities will be treated using a tertiary treatment system, such as a Macro Porous Polymer Extraction (MPPE) system that meets Woodside and accepted industry standards prior to being discharged overboard, below the sea surface. The planned use of a tertiary treatment system onboard the FPSO facilities is considered to represent best practice in the management of PW discharge in relation to an offshore gas processing facility. The selection of the tertiary treatment system is subject to further detailed engineering, however will consider MPPE, with the technology proven and commercially operational on a number of facilities within Australia (e.g. Shell Prelude FLNG facility, INPEX Ichthys LNG Project).

For the FPSO facilities a discharge depth of 14 m below mean sea level was selected to facilitate dispersion and reduce the mixing zone size due to the buoyant plume. While the PW arrives at the FPSOs at a high temperature, in order to facilitate tertiary treatment of the PW stream, it is expected it will be cooled to 50°C prior to discharge. The FPSO PW treatment circuit will be designed for a maximum processing capacity of 5,723 m³/day on each FPSO. At Phase 1 RFSU, actual PW rates are expected to be significantly less than the design. PW that does not meet these standards will be stored on board the FPSOs before being blended and processed via the PW treatment system to meet specifications prior to discharge.

While PW rates will vary over the life of the proposed Browse to NWS Project, there are two key scenarios that are applicable:

- + Scenario 1: Maximum processing capacity of the FPSO facilities, which is not expected until late field life. This corresponds to 5,723 m³/day.

- + Scenario 2: Flowrate of the FPSO facility shortly after start-up or on facility restart when MEG is typically expected to be discharged.

Low levels of PW may also be discharged from the MODU (or a well unloading capable vessel) during well unloading at the well locations, including within deep water areas (> 300m). Generation of this PW would result from condensed water in the hydrocarbon gas stream during well unloading. This PW will be discharged as part of the discharge of well clean up fluids, which will include drilling fluids (see [Section 6.3.15](#) for the assessment of drilling or completions discharges). The PW component of the discharge is generally limited to small volumes of condensed water and will constitute a very small proportion of the discharge stream, with the discharge dominated by suspension fluids. Well unloading is anticipated to take 1-2 days per well (i.e. the amount of time that the well is flowing). The PW component of the discharge may contain inorganic salts from geological formations, dissolved organic compounds, dissolved gases (including H₂S and CO₂), dissolved and dispersed hydrocarbons, metals and low levels of NORMs.

Due to the nature, scale and duration of the FPSO discharge compared the MODU discharges, the detailed impact evaluation with modelling has been completed for FPSO facilities.

Constituents of proposed Browse to NWS Project FPSO Produced Water

Similar to the PW discharges of other offshore oil and gas facilities in Australia, the proposed Browse to NWS Project PW discharge is anticipated to contain a number of toxicants, which include:

- + Trace amounts of hydrocarbon compounds remaining in the water after treatment. As hydrocarbon characteristics may vary between oil and gas facilities, the toxicity of the remaining hydrocarbon compounds post treatment also varies. To understand Browse hydrocarbon ecotoxicity better, ecotoxicity testing of Torosa condensate samples has been performed. Based on ecotoxicological studies of Torosa condensate samples the PNEC for chronic exposure at the 99% species protection level is 0.09 mg/L (ESA 2009).

¹⁴ Barossa Offshore Project Proposal based on 0.007 mg/L but acknowledges toxicity of hydrocarbons tested from Barossa is 0.456 mg/L

The laboratory-based ecotoxicology tests used a range of WAF hydrocarbon concentrations on the six species representing six major taxonomic groups of ecological relevance.

In line with Woodside and accepted industry standards in Australia, and the internationally recognised IFC standard, hydrocarbon compounds are discharged at a concentration of 30 mg/L oil-in-water content (average over a 24-hour period) or less during steady state operations. Therefore, to achieve the PNEC identified in ESA 2009 ecotoxicity testing, approximately 333 dilutions are required between the discharge point and the edge of the mixing zone.

- + Mercury in the Browse reservoirs has been studied and there is some inherent uncertainty about the amount of mercury that may be produced. There are only a limited number of reliable mercury measurements taken in samples from the Browse reservoirs. The amount of mercury produced to the FPSOs will be dependent on numerous operational factors, such as how the reservoir pressure changes, the proportional split of condensed water to formation water as well as the chemical composition of the arrival fluids. Once onboard the FPSOs, mercury is expected to partition and preferentially follow gas processing, then condensate processing, with only a remnant being discharged as PW. Operational factors influencing the variability of mercury in PW include processing rates, processing temperature and pressure variation and the chemical composition of the PW stream.

Notwithstanding uncertainty in reservoir production and subsequent partitioning, some mercury in PW streams is expected to occur in the relatively low toxicity form (Hg (0)), with some potential for production of HgII (e.g. mercury chloride and mercury sulphide). Elemental mercury (Hg (0)), which is relatively unreactive, has little tendency to dissolve in water or rapidly deposit, and instead readily volatilises into the atmosphere (Neff, 2002).

Of the different mercury forms, methyl-mercury (MeHg) is of most concern because it is readily bioavailable and can be responsible for toxicological effects at very low doses; however, MeHg is not expected to be produced from the Browse reservoirs.

The 99% species protection limit for mercury is 0.1µg/L (non-bioaccumulating) (ANZG, 2018). Assuming the mixing zone is to be governed by oil in-water content (see previous), a maximum mercury discharge concentration of 0.03 mg/L has been specified (based on 300 dilutions). This approach is inherently conservative as it does not account for the ready volatilisation of Hg (0) into the atmosphere (Neff, 2002), and hence is expected to remain in surface water for much less time than oil-in-water, leading to a smaller mixing zone.

- + MEG will be used as part of the hydrate management strategy, with continuous injection of MEG during steady state operations not required due to the adoption of active heating of the flowlines and risers. However, intermittent MEG injection is still required during start up (when active heating is not effective) and on shut down for components of the subsea infrastructure which do not have active heating.

MEG is listed as 'E' category fluids under the OCNS and considered to 'pose little or no risk to the environment' (PLONOR). In addition, the compound has little or no capacity to bind to particulates and will be mobile in soil (WHO, 2000). Direct toxicity testing of neat MEG, on eight, mainly tropical species, representing seven taxonomic groups, established the lowest no observable effect concentration (NOEC) for sea urchin fertilisation of 130 mg/L (Jacobs 2019). Rapid degradation has been reported in surface waters, with a generally low toxicity to aquatic organisms. As such, and as MEG is an intermittent discharge occurring only when the facility starts up, a 156,000 mg/L limit is proposed.

- + Typically, at other Woodside operating facilities ammonia occurs in the PW stream at concentrations around ~20 mg/L. While no 99% species protection limit has been assigned by ANZECC, the 95% species protection limit is 0.95 mg/L. Given this only ~20-25 dilutions are required to reach the 95% species protection limit. As such ammonia is not a toxicant of concern and is not carried further in this assessment.
- + Maintenance of wells, pipelines and process pipework or equipment may require the disposal of scale if it has built up as a solid. Based on an analysis of the reservoir formation water, the potential for scale deposition containing NORMS has been determined to be low given the low likelihood of NORMS being present within the reservoirs. In addition, the build-up of scale within the subsea and process equipment will be controlled by the use of scale inhibitors if required.

In addition to dissolved and dispersed constituents, it is recognised that there is some potential for inert substances i.e. salts to precipitate into sediment, although these are expected to only occur in very small amounts, with little potential of settling or flocculation due to small particle sizes.

Produced water toxicity uncertainty

For the proposed Browse to NWS project, whole of effluent toxicity data is not currently available as water samples from the appraisal wells are considered unlikely to be representative. Instead the toxicity testing results for Torosa condensate has been identified as the most representative to determine PW toxicity. Oil-in-water content has therefore been used as the governing constituent in PW and has been applied as the basis for impact evaluation for both the Torosa FPSO and the Brecknock/Calliance FPSO PW discharges (for Scenario 1).

This approach has inherent uncertainty as the whole of effluent toxicity of the PW stream has the potential to fluctuate over the life of the field due to varying reservoir characteristics and associated rates of formation water. Therefore, the mixing zone for whole of effluent toxicity may vary from the mixing zone described for the 30mg/L oil-in-water content.

During steady state FPSO operations, an adaptive management process premised on monitoring will be applied to verify that the defined threshold values (i.e. 99% species protection or no effect concentrations) will be met at the edge of the mixing zone and State waters 3 nm boundary, 95% of the time based on dispersion modelling results. The adaptive management process includes:

FPSO PW discharge will be monitored so that its hydrocarbon content is no greater than an average of 30 mg/L over any period of 24 hours during steady-state operations (excluding start-up, shut-downs etc.).

- + Periodic and 'for cause' toxicity testing and characterisation of the physical and chemical composition of the PW stream prior to discharge will be undertaken. This toxicity testing will determine the whole of effluent toxicity used to define the mixing zone, while the chemical characterisation will verify that the discharge limits specified in this draft EIS/ERD are met.
- + In the event the FPSO PW discharge does not meet the defined thresholds in the range predicted for any constituent concentrations, an adaptive management strategy will be implemented (developed during the future Environment Plans).

In addition, baseline and periodic water and sediment quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to detect changes as a result of FPSO PW discharge.

In the event that the mixing zone is larger than anticipated, posing a significant increase in impact than that described in this draft EIS/ERD (below) then corrective actions will be implemented onboard the FPSOs to reduce the risk, such as storing PW on board the FPSOs (i.e. temporarily halting discharge) and additional engineering to produce a change in discharge characteristics.

6.3.12.3 FPSO Produced Water Modelling

Modelling of the PW discharge from the Torosa FPSO (as the closest discharge point to sensitive receptors at Scott Reef) was undertaken to predict the spatial extent of the impact of PW discharge, based on the temperature and toxicity of the plume ((RPS, 2019a); [Chapter 10, Appendix D.4](#)). As PW treatment system and discharge characteristics for the Calliance/Brecknock FPSO are the same as for the Torosa FPSO; and the receiving environment at the FPSO locations are similar, the modelling undertaken at the Torosa FPSO location has been used as a surrogate for the Calliance/Brecknock FPSO facility.

Modelling scenarios and discharge characteristics

The model inputs are provided in [Table 6-97](#), which are based on the current design specification which have been optimised to facilitate dilution outcomes; but remain conservative for modelling purposes.

A summary of the discharge characteristics, as described in [Section 6.3.12.2](#), for the two scenarios is provided in [Table 6-97](#). Scenario 1 is representative of the maximum PW processing capacity of the FPSO facilities during steady state operations (i.e. maximum flow rate), while Scenario 2 represents discharges during start-ups (i.e. lower flow rates, with MEG a key constituent).

Table 6-97 Discharge Characteristics

Parameter	Scenario 1	Scenario 2
Description	Maximum PW processing capacity	Expected PW FPSO Start-Ups (i.e. MEG discharge)
Oil-in-water content (mg/L)	30	30
Flow rate (m ³ /d)	5,723	490
Outlet pipe internal diameter (m)	0.15	0.15
Discharge depth below sea surface (m)	14	14
Salinity (ppt)	9.5	0
Temperature (°C)	50	50

Modelling Thresholds

For the purpose of risk and impact assessment in this draft EIS/ERD, the following thresholds have been adopted for individual toxicants. These thresholds have been derived from ecotoxicological testing and guidelines, and are used as the basis for determining the mixing zone for the FPSO PW discharges:

- + Oil-in-water threshold: 0.09 mg/L which represents the predicted no effect concentration for chronic exposure at the 99% species protection level based on ecotoxicological studies of Torosa condensate samples (ESA, 2009).
- + MEG threshold: 130 mg/L was derived from direct toxicity testing of neat MEG using the lowest no observable effect concentration (NOEC) for sea urchin fertilisation (Jacobs 2019), noting it is not a continuously injected chemical.
- + temperature threshold¹⁵: differential of 3°C above ambient was applied to the modelling based on environmental, health and safety guidelines by the International Finance Corporation (IFC) (IFC, 2007).¹⁶

Modelling studies

To determine the fate, transport and dilution of the PW discharge, both near-field (close range) and far-field (distant range) modelling was undertaken for the Torosa FPSO as these are used to describe different processes and scales of effect¹⁷. The principal aim of the dispersion modelling was to calculate the likely extents of the near-field and far-field mixing zones of discharged PW plumes as they disperse through the water column and are transported away from the source locations. The model was set up to determine the number of dilutions achieved out to the model extent. It allows for determination of plume toxicity anywhere in the model extent by applying a discharge concentration of individual contaminants (i.e. oil-in-water) or whole of effluent toxicity measured during operations. The outcomes of the modelling efforts mean the distances and orientations – relative to the source locations – can be determined at which the concentrations of a variety of discharged contaminants will be below defined environmental threshold concentrations.

It should be noted that the model conservatively assumes that only dilution processes reduce the concentration of various components in PW. Reductions due to weathering processes (e.g. evaporation of volatile compounds) or mixing processes (e.g. wave action in the upper water column) are not taken into account. This results in an overestimation of concentrations in modelling predictions.

The dispersion of the PW discharge will depend, initially, on the geometry and hydrodynamics of the discharges themselves, where the induced momentum and buoyancy effects dominate over background processes. This region is generally referred to as the near-field zone, which ends where the discharged plume reaches the same density as the ambient water. While the far-field modelling expands on the outcomes of the near-field mixing by allowing the time-varying nature of currents to be included, and the potential for recirculation of the plume back to the discharge location to be assessed.

The physical mixing of the discharges was first investigated in the near-field zone under stationary current flows statistically representative of the range of speeds expected at the source locations. The near-field zone limits are defined as the area where levels of mixing and dilution are controlled by a plume's initial jet momentum (lateral or vertical motion of the plume) and buoyancy flux (tendency of the plume to float or sink once initial momentum is lost). Should the plume encounter a physical boundary such as the water surface, near-field mixing is judged to be complete and the plume is considered to have entered the far-field zone.

The near-field mixing and dispersion of the PW discharge was simulated using the Updated Merge (UM3) flow model, with the far-field mixing and dispersion of the PW discharges was predicted using the three-dimensional discharge and plume behaviour model, MUDMAP (Khondaker, 2000; Koh and Chang, 1973). The initial state of the far-field model was tuned to align its predictions against those of the near-field model in terms of plume centreline dilutions, average dilutions and cross-sectional dimensions under three stationary-flow conditions.

The far-field modelling expanded on the near-field work by allowing the time-varying nature of water currents and the potential for recirculation of the plume back to the source location to be assessed. A stochastic modelling procedure, where the characteristics of a single discharge are simulated many times under randomly-selected samples of environmental conditions selected from a long hindcast record of currents and winds, was applied in order to map the potential aggregated spatial distribution of contaminants discharged at any time during a particular season or across the whole year. This methodology ensures that the calculated movement and fate of each discharge is representative of the range of prevailing currents at the discharge location. The same modelling approach was applied to cooling water ([Section 6.3.13](#)) and hydrotest discharge modelling ([Section 6.3.17](#)).

¹⁵ This threshold has been based on the well-established IFC EHS Guidelines for Offshore Oil and Gas Development and has been used a default threshold value for other recent offshore petroleum approvals within Australia and is therefore deemed appropriate for use in this context.

¹⁶ Given the very small mixing zone for thermal impacts resulting from produced water discharge from the FPSO facilities, there is no impact pathway to State waters for this discharge. As such Woodside have used the accepted industry standard used in Environment Plans and OPPs assessed by NOPSEMA.

¹⁷ It is important to note that near-field and far-field modelling are used to describe different processes and scales of effect, and therefore the far-field modelling results will not necessarily correspond to the outcomes at the end of the near-field mixing zone for any given discharge scenario.

Both the near-field and far-field modelling outcomes were expressed conservatively as minimum¹⁸ dilution contours calculated as the ratios of dispersing contaminant concentrations in the receiving waters to the initial concentrations in the discharges. Although indicative initial concentration (based on engineering design advice at a relatively early stage of the proposed Browse to NWS Project) were used as input to the modelling, expressing the results in units of dilution (as a proxy for concentration) allowed the impacts of alternative initial concentrations to be assessed during analysis. The constituents were modelled as conservative tracers, with the assumption that the background concentration of the constituent in the receiving waters is zero¹⁹ and there is no significant biodegradation of the discharged constituent over the short duration of the dispersion process. Furthermore, in order to provide a conservative representative illustration of the spatial extent of potential for impacts, modelling plots and dilution contours are based on 95th percentile values and show the highest value that would be achieved for 95% of the time.

Hydrodynamic Model Validation

The proposed Browse to NWS Project is located within the influence of the Indonesian Throughflow, a large-scale current system characterised as a series of migrating gyres and connecting jets that are steered by the continental shelf. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. On the continental shelf, in shallower waters around Scott Reef and closer to the inshore region of the Kimberley Coast, surface winds and tidal dynamics dominate over the large-scale current flows. In comparison to drift currents, tidal currents generate only relatively short tidal migrations that follow an elliptical path. Hence, tidal currents add variability to the longer-term drift patterns of portions of an effluent discharge. Wind shear on the water surface also generates local-scale currents that can persist for extended periods and result in long trajectories.

The marine discharge dispersion modelling studies required current speeds and directions to be specified over a spatial domain covering the potential migration trajectories of the plumes. The available measured data was not adequate for this purpose and therefore the analysis relied upon hindcasts of the circulation generated by numerical modelling. Predictions of the drift currents, available from mesoscale ocean models, were combined with estimates of the tidal currents generated using RPS's three-dimensional hydrodynamic

model, HYDROMAP, setup for the study area. Two mesoscale ocean current data sets were considered for the study: CSIRO's global ocean model, BRAN (BlueLink Reanalysis); and the HYCOM (Hybrid Coordinate Ocean Model) Consortium's global ocean model, HYCOM. The suitability of the modelled tidal and drift current data products was evaluated by comparing the predicted currents to those measured within the Project Area.

The tidal model validation included an evaluation of both tidal elevations and tidal currents. Visual comparisons of tidal elevations at 20 locations revealed that the model produced a very good match to the known tidal behaviour for a wide range of tidal amplitudes and clearly represented the varying diurnal and semi-diurnal nature of the tidal signal. Statistical analysis of tidal elevation comparisons over the 20 locations also indicated excellent model performance over a wide region. Tidal current comparisons at three selected measurement locations showed that the tidal model produced a good match in the magnitude, timing and direction of the current velocity at two sites, with a reasonable match in timing and direction – albeit some overprediction of magnitude – at the third site. Across all sites, the current magnitudes and directions were well matched by the model and, considering also the good validation of water elevations, the tidal model was considered suitable for use in the marine dispersion modelling studies.

The mesoscale ocean model current predictions were validated through both quantitative and qualitative comparisons between measured and modelled data at a range of depths through the water column at three selected measurement locations. The comparisons revealed that, at two of the sites, both ocean models offered a good match in magnitude and direction of the measured current velocity in the upper water column; however, the magnitudes of the peaks and troughs were often underpredicted at the deeper levels in both ocean models. At the third site, both ocean models captured the range in current magnitude at each depth; however, the timing of peaks and troughs in the measured current velocity and direction was not well-matched. Given the location of this site in close proximity to Scott Reef, with steep gradients in the bathymetry and the relatively coarse resolution of the ocean models (relative to the tidal model), this was not unexpected. Overall, the BRAN model data offered a slightly better correlation to the field measurements within the Project Area than the HYCOM model data. Both models, however, showed a reasonable match with measurements – particularly in the upper water column – and either one could justifiably have been selected for use in this

¹⁸ The minimum dilution is calculated as the lowest value in any individual non-zero grid cell within the specified radial distances (e.g. 100 m), including the buffer zone.

¹⁹ Background concentrations were considered zero based on the water quality results described in Chapter 5, which demonstrated the majority of constituents were below their respective limits of reporting, providing for an essentially pristine receiving environment.

study. Given the stochastic methodology applied in far-field modelling, the use of a ten-year hindcast of BRAN current data allowed a realistic spatial distribution of potential plume trajectories and extents to be captured in aggregate. The BRAN model was considered suitable for use in the marine dispersion modelling studies.

Further details relating to the sources of both the modelled and measured data, the comparison methodologies, and the outcomes of the comparisons for both tidal and drift current components can be found in RPS, (2019a) ([Chapter 10, Appendix D.4](#))

Near-field modelling results

For both scenarios, the results show that due to the momentum of the discharges, a turbulent mixing zone is created in the immediate vicinity of the discharge point.

Within the near-field, the horizontally oriented discharge is predicted to rise towards the water surface after the momentum of the initial discharge is lost, with increased ambient current strengths increasing the horizontal distance travelled by the plume. Near-field average dilution and temperature results for constant medium annualised currents for Scenario 1 and Scenario 2 are provided in [Figure 6-26](#) and [Figure 6-27](#) respectively.

For both scenarios, residual temperature at the point of discharge was assumed to be 50°C. The temperature differential between the discharge and the ambient water is predicted to achieve the threshold level (3°C above ambient temperature) within the near-field (maximum distance of 44 m across all seasons) in all conditions (i.e. current speeds) and therefore no far-field results are portrayed or discussed.

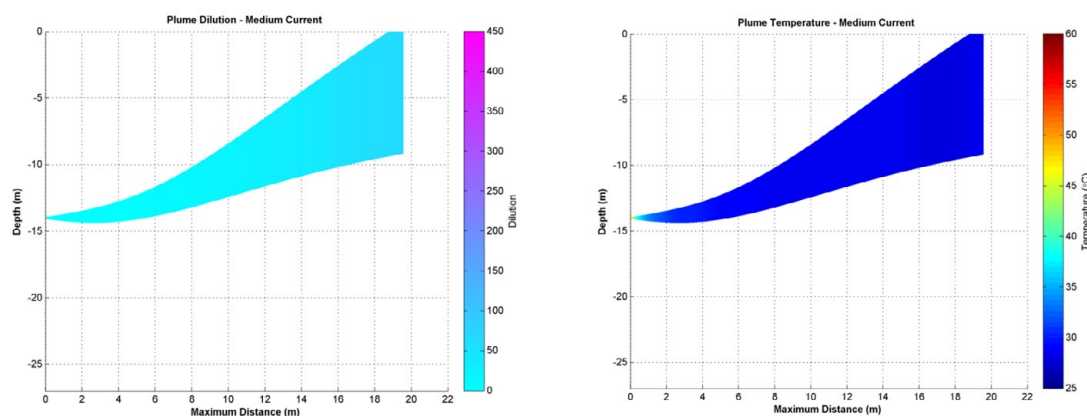


Figure 6-26 Near-field average dilution and temperature results for constant medium annualised currents for Scenario 1 (14 m depth discharge at 5,723 m³/d flow rate).

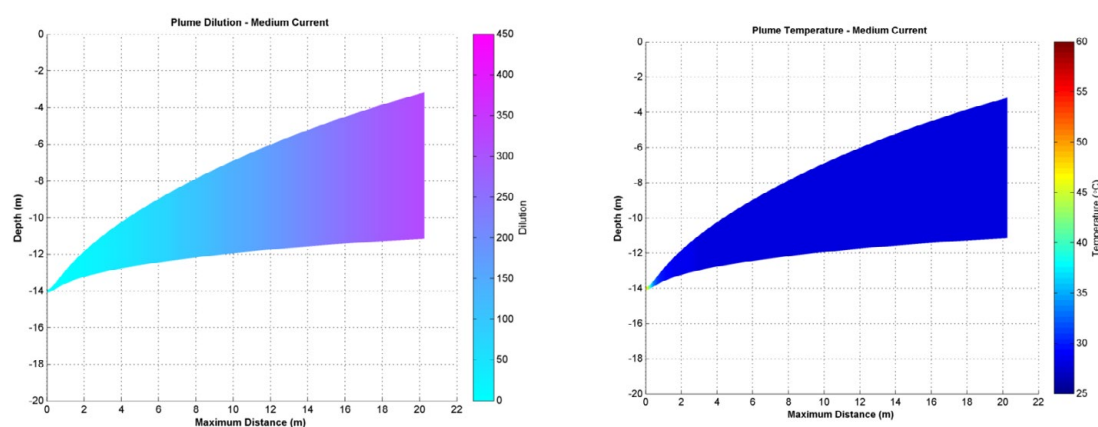


Figure 6-27 Near-field average dilution and temperature results for constant medium annualised currents for Scenario 2 (14 m depth discharge at 490 m³/d flow rate).

Far-field modelling results

Table 6-98 provides a summary of the far field modelling results and demonstrates that the mixing zone for Scenario 1 and 2 PW discharges is achieved well before the 3 nm State waters boundary, with the maximum horizontal distance of 1,200 km from the discharge source (FPSO facility).

Figure 6-28²⁰ illustrates the predicted annualised minimum dilutions at the 95th percentile for Scenario 1, which is the continuous PW discharge representing the maximum PW processing capacity on the FPSO facilities. The figure shows that the point at which the 99% species protection level is met for oil in water (333 dilutions) is a significant distance from Scott Reef. Oil in water was chosen as it represents the highest toxicity constituent in a continuous discharge, particularly in the context of nearby sensitive receptors within the Browse Development Area (i.e. Scott Reef). It should be noted that while the modelling has not taken the degradation process of the hydrocarbons within the receiving environment into consideration, this natural process will occur due to the inherent biological nature

of oil-in-water, further reducing the concentration within the dispersed produced water.

Figure 6-29 illustrates the predicted annualised minimum dilutions at the 95th percentile for Scenario 2, which is the expected rate of the PW discharge during start-up on the FPSO facilities. The figure shows that the 99% species protection level for MEG (1,200 dilutions), which represents the highest toxicity constituent in an intermittent discharge, is met within 200 m of the discharge point (FPSO facility).

To contextualise the stochastic modelling results, **Figure 6-30** shows example time series snapshots of predicted dilutions during a single simulation of Scenario 1 at 3-hour intervals over a nominated period (from 1200 on 29 December 2009 to 0300 on 30 December 2009). These images are representative of typical conditions for the discharge²¹ and demonstrate the spatially-varying orientation of the plume with the currents. The snapshots also show the combined effect of the tide and the drift currents, with a clear tidal oscillation.

Table 6-98 PW Far Field Modelling Results Summary

Parameter	Scenario 1	Scenario 2
Description	Maximum PW Processing Capacity	Expected PW FPSO Start-Ups (i.e. MEG discharge)
Selected governing Constituent	Oil in water	MEG
Indicative discharge specification limit	30 mg/L	156,000 mg/L
Threshold (as described above)	0.09 mg/L	130 mg/L
Minimum dilutions required to achieve threshold	333	1,200
Maximum horizontal distance required to achieve threshold)	1,200 m	200 m
Prevailing direction of mixing zone	NNW - SSE	NNW - SSE
Total area of coverage to achieve threshold	0.94 km ²	0.044 km ²
Maximum depth from sea surface	17	25
Governing mixing zone	Yes	No
Minimum dilution at 3 nm State waters boundary	1,507	17,674
Met at the 3 nm State waters boundary	Yes	Yes

²⁰ Note that the figures do not represent the location of a plume at any point in time; they are a statistical and spatial summary of the percentage of time that dilution values occur across all multiple replicate simulations.

²¹ Based on the 95th percentile annualised predictions.

Typically, the whole of effluent toxicity is considered to be the primary driver of the mixing zone, and therefore the governing modelling scenario on which an impact assessment is based. However whole of effluent toxicity data is not available at this stage of the Project (refer to **Produced Water Toxicity Uncertainty**), and therefore the Scenario 1 oil-in-water mixing zone is considered the governing scenario and the basis of impact evaluation for both the Torosa FPSO and the Brecknock/Calliance FPSO PW discharges. During the operate phase the whole of effluent toxicity may vary from the mixing zone described in this modelling – please refer **Produced Water Toxicity Uncertainty** for how this is managed. Note, the modelled mixing zone for Scenario 1 is similar to the mixing zone established for other operational facilities and provides for a significant distance between the edge of the mixing zone and the 3 nm State waters boundary.

Model verification

Modelling is a predictive tool and as such has a number of inherent uncertainties which are typically compensated through the application of conservatism. As such during steady state FPSO operations, infield verification using a range of monitoring techniques will be completed to verify the model predictions and confirm that the mixing zone, including at the 3 nm State waters boundary is met.

In the event that the mixing zone is larger than anticipated, posing a significant increase in risk than that described in this draft EIS/ERD (below) then corrective actions will be implemented onboard the FPSO to reduce the risk, such as storing PW on board the FPSOs (i.e. halting discharge) and additional engineering to produce a change in discharge characteristics.

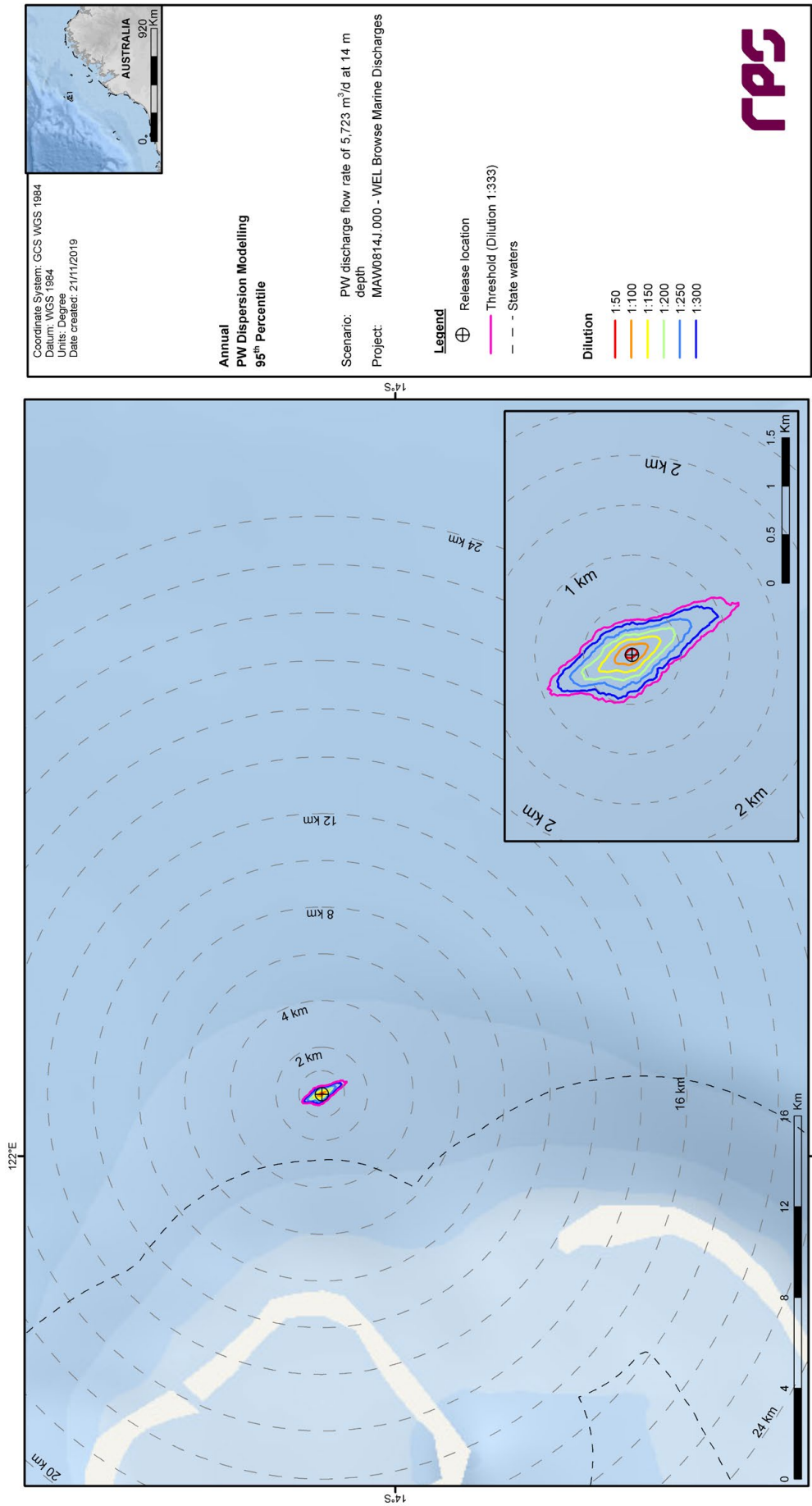


Figure 6-28 Predicted annualised minimum dilutions at the 95th percentile for Scenario 1 (Torosa FPSO release location, 14 m depth discharge at 5,723 m³/d flow rate)

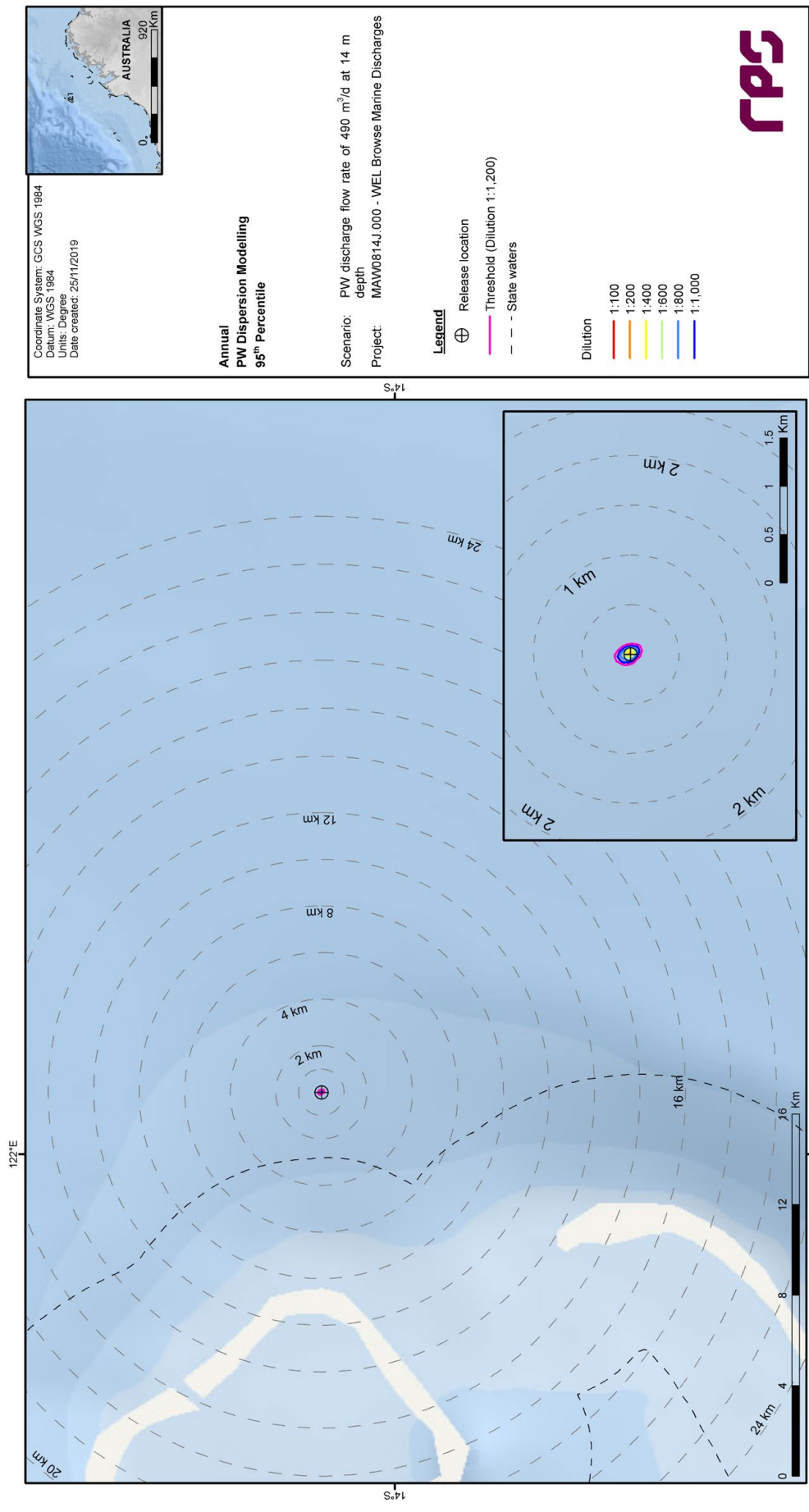


Figure 6-29 Predicted annualised minimum dilutions at the 95th percentile for Scenario 2 (Torosa FPSO release location, 14 m depth discharge at 490 m³/d flow rate)

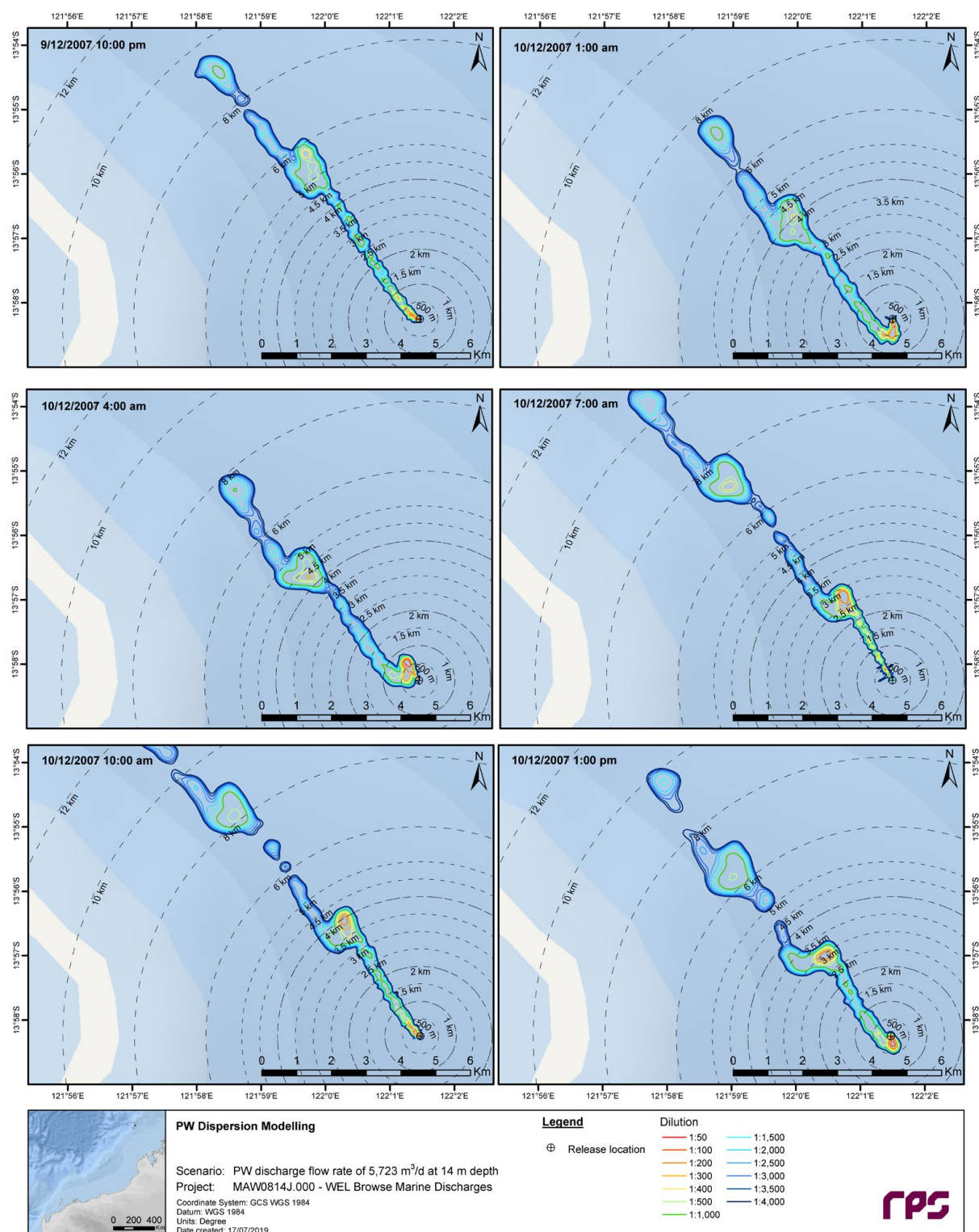


Figure 6-30 Snapshots of predicted dilution levels, at 3-hour intervals from 22:00 on 9th December 2007 to 13:00 on 10th December 2007 (Torosa FPSO release location, 14 m depth discharge at 5,723 m³/d flow rate)

6.3.12.4 Environmental Impact

Water quality

Changes to water quality

PW discharge may change water quality due to thermal impacts (increased water temperature) and toxicity impacts relating to the residual hydrocarbons and chemical concentration within the PW discharge.

Within the immediate area of influence of the discharge, water temperatures will be elevated temporarily impacting water quality. However, as outlined within the modelling results, the temperature differential between the discharge and the ambient water is predicted to achieve the threshold level (3°C above ambient temperature) within the near-field such thermal impacts are not predicted to occur outside of a maximum of 44 m from the discharge location. As such are not further discussed within the impact assessment.

A change in water quality due to residual hydrocarbons and chemical concentration within the PW discharge will occur in the vicinity of the PW discharge point. The change will be relatively localised, limited to the 1, 200 m mixing zone defined by the modelling as described in [Section 6.3.12.3](#), with no predicted impacts to Scott Reef or waters within the State waters boundary (3nm). PW discharges from the FPSO will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection or no effect concentrations) at the State waters 3 nm boundary are met 95% of the time based on dispersion modelling results.

Studies have found significant emission of Hg(O) in surface waters of the marine environment, and that marine environments are typically net emitters of Hg, indicating net reduction of Hg(II) to Hg(O) (Obirst et al., 2018; Rolfhus and Fitzgerald, 2004) including best estimates of Hg concentrations and pool sizes in major environmental compartments and exchange processes within and between these reservoirs. Recent advances include the availability of new global datasets covering areas of the world where environmental Hg data were previously lacking; integration of these data into global and regional models is continually improving estimates of global Hg cycling. New analytical techniques, such as Hg stable isotope characterization, provide novel constraints of sources and transformation processes. The major global Hg reservoirs that are, and continue to be, affected by anthropogenic activities include the atmosphere (4.4–5.3 Gt. It is believed that the process of mercury exchange at the interface between the ocean surface and the atmosphere unfolds relatively quickly (Gworek et al., 2016). It is therefore anticipated that the majority of the discharged elemental mercury will be volatilised to the atmosphere. This is particularly so as elevated concentrations of mercury will occur close to the surface given the buoyant nature of the PW plume.

It is recognised that there is potential for deposition of a small component of the mercury into sediment, particularly if Hg(O) is oxidised to Hg(II).

Of the different mercury forms, methyl-mercury (MeHg) is of most concern because it is readily bioavailable and can be responsible for toxicological effects at very low doses; however, MeHg is not expected to be produced from the reservoirs. Conversion of other mercury forms to MeHg does not occur in well-oxygenated marine waters (J. Neff, 2002) such as those of the Browse Development Area. Generally, methylation of mercury is a natural process mediated by bacterial decomposers in anoxic environments that has the potential to occur in the deep sea (Hamdy and Noyes, 1975; J. Neff, 2002). It should also be noted that in sediments, methylmercury which has formed through methylation typically represents less than 1.5 % of the total quantity of deposited mercury (Gworek et al., 2016). Thus, the risk for bio-accumulation to occur due to trace amounts of mercury in PW discharge is remote.

MODU discharges (i.e. during well unloading) will be significantly smaller in volume compared to the FPSO discharges and will be discharged as a component of the drill discharges (drill cutting and fluids). Given the PW component is a fraction of the overall discharge during well unloading, this discharge is addressed in assessment of drilling or completions discharges ([Section 6.3.15](#)).

Sediment quality

Changes to sediment quality

In addition to dissolved and dispersed constituents, it is recognised that there is some potential for inert substances i.e. salts to precipitate into sediment. These salts will be of an inert nature and will disperse rapidly within the receiving environment, with no lasting effect on sediment quality.

Plankton communities

Injury or mortality to fauna

The change in water quality as a result of PW discharges has the potential to result in the injury or death of plankton species within the water column through toxicity effects. Any potential for acute toxicity impacts to plankton would be expected to be limited to within the modelled mixing zone confined to a small portion of the water column (i.e. surface layer). Early life stages of fish (embryos, larvae) and other plankton would be the most susceptible organisms to exposure from hydrocarbons and chemicals in the PW discharges, as they have limited mobility and are therefore likely to be exposed to the plume within the mixing zone. Communities of these types of organisms are expected to rapidly recover once the activity ceases, as they are known to have high levels of natural mortality and a rapid replacement rate (ITOPF, 2011).

As impacts to plankton will be limited to within the mixing zone, they are not expected to have a lasting impact on plankton communities or ecosystem function locally or regionally.

Benthic habitat

Change in water quality

As described above, the model predicted that the PW plume from the FPSO facilities would disperse to below toxicity threshold concentrations within 1,200 m from the discharge point and well prior to the 3 nm State waters boundary. Therefore, no adverse impact to Scott Reef shallow water benthic habitats (< 75 m water depth) are predicted. This includes high value benthic communities and habitats including coral and seagrass.

Furthermore, studies on the dispersion of coral larvae at Scott Reef (Done et al., 2015; Foster and Gilmour, 2018) we examine distance decay among coral communities in a common habitat on northwestern Australian reefs, seeking to better understand the roles of disturbance and coral life history strategies in the changing reefscape. In established communities in 1997, when coral cover and generic richness were uniformly high, there was high similarity (~81 % demonstrates that while there is marked movement of larvae within the reef system itself (broadcast spawning corals), there is no evidence to suggest that those coral larvae that initially dispersed off the reef return to Scott Reef to settle. Therefore, the PW plume is not likely to impact the recruitment of corals within the Scott Reef system. Furthermore, any coral larvae affected by the PW plume would not have been available to resettle on the reef regardless of if the impact had occurred or not.

The modelling predicts that the PW plume will remain within surface waters and as such will not come into contact with deepwater benthic habitats of the Browse Development Area. While there is the potential for insoluble naturally occurring salts to precipitate out of the PW discharge, these salts will be of an inert nature and will disperse rapidly within the receiving environment, with no lasting effect to benthic habitats or communities. As such no adverse impact to epifauna and infauna in the deepwater habitats of the Browse Development Area are predicted.

Marine fauna

Injury or mortality to fauna – fish, marine reptiles, marine mammals

The model predicted that there is potential for marine organisms present in surface waters (e.g. fish, marine mammals and marine reptiles) to be exposed to PW above threshold concentrations if encountering the plume as it is transported by prevailing currents downstream from the FPSO facilities.

Any potential for toxicity to marine organisms would be expected to be limited to surface waters within the mixing zone in the vicinity of the FPSO, and therefore these concentrations will only potentially affect a limited number of marine fauna individuals. It should be noted that the threshold concentrations and the subsequent mixing zone have been determined through the application of chronic exposure threshold based on ecotoxicological tests on larval marine fauna (i.e. during their most sensitive life stage). Therefore, transient marine fauna (i.e. potentially exposed to toxicity for short periods) within the receiving environment adjacent to the discharge location are unlikely to be exposed to sufficient concentrations or durations of the discharge constituents to result in a toxicological impact.

The predicted toxicity effects on marine fauna within this area of influence is considered conservative given the assumptions included in the model. For example, the actual PW discharge rates are likely to be lower than the those modelled, with the chemical constituents also likely to be subject to weathering and natural degradation following discharge.

Furthermore, the direction of the plume emanating away from the discharge point will change depending on the current direction primarily driven by the tides, such that exposure to the discharges in surrounding waters will not be continuous, with transient marine fauna, such as cetaceans, turtles and fish not likely to be exposed to the discharge for enough time to elicit a toxic response.

Fish

Pelagic fish are likely to be exposed to the PW plume above threshold concentrations (within the mixing zone). However, given the above and the high mobility of pelagic fish species, it is not predicted that fish will be exposed to the discharge constituents in sufficient concentrations or durations to elicit a response.

The whale shark is the only threatened fish species that has the potential to occur within the Browse Development Area. Given the above and the low numbers and infrequent nature of whale shark presence in the Browse Development Area, it is not predicted that adverse impacts would occur as a result of PW discharge.

Marine turtles

Acute and chronic effects of chemical discharges are highlighted within the Recovery Plan for Marine Turtles in Australia (2017-2027) as a threat to green turtles within the Scott Reef and Browse Island area (Commonwealth of Australia, 2017a). Modelling predicts that the PW plume from the FPSO facilities will not reach the area defined as habitat critical to the survival of green turtles in the Recovery Plan for Marine Turtles 2017-2027. However, discharge will occur in an area defined as a green

turtle interesting BIA . The recovery plan includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a).

It should be noted that studies have shown that while interesting areas ranged up to 14 km out from the Sandy Islet, most stayed within 5 km of the islet (Guinea, 2011). As such it is not expected that a large number of marine turtles will be exposed to the Torosa FPSO PW discharge mixing zone. As described above it is not predicted that any marine turtles in the mixing zone will be exposed to the discharge constituents in sufficient concentrations or durations to elicit a response.

Marine mammals

Chronic chemical pollution is identified as a potential risk to pygmy blue whales in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia,

2015c); however, conservation advices for other EPBC listed marine mammals that may occur in the Project area do not identify chemical pollution as a key threat ([Table 5-19](#)). While the maximum mixing zone for PW (1.2 km; [Table 6-98](#)) overlaps with the foraging and migration BIAs for pygmy blue whales, the relatively low densities of pygmy blue whales and other cetaceans within the Browse Development Area, means that it is not predicted that any adverse impacts to marine mammals will occur as a result of PW discharge.

Assessment against EPBC Act recovery and conservation plans and advices

[Table 6-99](#) provides an assessment of the discharge of PW discharge from the proposed activities in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-99 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – PW discharge

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice objectives and actions	Assessment
Whale shark (<i>Rhincodon typus</i>)	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The potential impact of PW discharges resulting from the proposed Browse to NWS Project have been assessed and mitigation measures proposed. Given the low numbers and infrequent nature of whale shark presence in the Project Area, there is a high level of confidence that PW discharges will not result in adverse impact to whale sharks.
Green turtle (<i>Chelonia mydas</i>)	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management actions	Potential impacts to turtles have been assessed and will be managed in accordance with the Recovery Plan for Marine Turtles in Australia (2017-2027) which includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a). In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival is predicted to be met.
Hawksbill turtle (<i>Eretmochelys imbricata</i>)		+ Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice objectives and actions	Assessment
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Chronic chemical pollution is identified as a potential risk to pygmy blue whales, however there are no specific actions identified.	Occasional exposure of individuals of these species to the PW discharge plume may occur. However, given the highly mobile nature of marine mammals, exposure would be temporary. As such, it is unlikely that any exposure will be of sufficient concentration or duration to elicit a toxic response.
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Marine discharges have not been identified as a direct threat to these whale species; however, habitat degradation has been identified as a threat and unmanaged discharges may contribute to this threat. The conservation advice relevant for this threat – identifies modification to the coastal region in areas of importance to listed whales may result in reduced occupancy, compromised reproductive success and even mortality.	Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Sei whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale		
Fin Whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale		

Key Ecological Features

Change in water quality - Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF

Discharge of PW (and subsequent PW mixing zone) from the Torosa FPSO will occur within the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF. The primary values of this KEF relate to high primary productivity, diverse aggregations of marine life and high species richness of the coral reefs. The relevant pressure related to PW discharge (chemical pollution / contaminants) is identified as not being of concern for this KEF within the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

As described above, while a change in water quality is predicted to occur within the modelled mixing zone, subsequent adverse impacts to fauna such as fish, marine mammals and marine turtles are not predicted. Impacts to plankton are predicted to be localised and not expected to have any lasting effect on plankton communities due to the rapid turn-over of plankton populations leading to relatively quick recovery times (within weeks or months) (ITOPF, 2011).

Modelling indicated that the PW plume from the FPSO facilities will remain in surface waters so is not predicted to impact deepwater benthic habitats. Based

on the modelling, the Torosa FPSO PW discharge is not predicted to impact Scott Reef shallow water benthic habitat (<75 m bathymetry). As such adverse impacts to the conservation values of the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF are not predicted.

Change in water quality - Continental slope demersal fish communities KEF

The mixing zone of the PW discharge from the Calliance/Brecknock FPSO is predicted to extend into the Continental slope demersal fish communities KEF. This KEF is recognised mainly for its high diversity of demersal fish. As described above, fish are not likely to be exposed to the discharge for enough time to elicit a toxic response and as such adverse impacts to the values of the Continental slope demersal fish communities KEF are not predicted. The relevant pressure related to PW discharge (chemical pollution / contaminants) is identified as not being of concern for this KEF within the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-100 provides an assessment of the proposed PW discharge in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-100 Alignment with protection of conservation values of KEFs – PW discharge

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Chemical pollution / contaminants - currently identified as 'not of concern'	As described above, PW discharges are not predicted to add to existing or potential pressures or adversely impact the conservation values of these KEFs.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			

State Marine Parks and nature reserves

Change in water quality – Scott Reef nature reserve

PW discharges from the FPSO facilities will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection or no effect concentrations) are met at the edge of the mixing zone and at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results. Given that the Torosa FPSO PW plume is not predicted to reach Scott Reef, no impact to the values of the Scott Reef Nature Reserve are predicted.

Other protected places

Change in water quality – Scott Reef and Surrounds Commonwealth Area National Heritage Place

The Scott Reef and Surrounds - Commonwealth Area National Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef. PW discharges from the FPSOs will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection or no effect concentrations) are met at the edge of the mixing zone and at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results. As such the FPSOs PW discharge plume is not predicted to reach the Scott Reef and Surrounds - Commonwealth Area National Heritage Place and no impacts to the conservation values of the protected place are predicted.

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no adverse impacts to fish from PW discharge have been predicted, subsequent impact to fisheries is also not predicted.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

PW discharges from the FPSO will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection or no effect concentrations) are met at the edge of the mixing zone and at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results. Due to a 500 m petroleum safety zone around the FPSO facilities and their remote location, there will be limited use of the marine waters in close proximity by other users and as such there is not expected to be any significant impact to other users. Activities such as scientific studies, tourism and recreation at Scott Reef are unlikely to be impacted because Scott Reef is approximately 8 km away from the Torosa FPSO facility which is well away from the edge of the FPSOs PW discharge mixing zone.

Aboriginal or indigenous heritage (high value users)

Changes to the functions, interests or activities of other users

Given that no lasting effect to fish from PW discharge have been predicted, subsequent impact to traditional Indonesian fishers is also not predicted.

Environmental Risk

Risk Event: Unplanned discharge of PW significantly above discharge specifications or whole effluent toxicity

Though unlikely, discharges of PW from the FPSOs at levels significantly above the indicative discharge specifications resulting from human error or equipment failure may occur. This would potentially result in a larger area being impacted (a temporary larger mixing zone), although the plume would still be expected to rapidly disperse. As per [Section 6.3.12.4](#), it would remain unlikely that exposure to marine fauna would be sufficient to elicit a toxic response. As such no change to the significance of the impact to water quality, plankton communities, marine fauna, KEFs, State marine parks and nature reserves, managed fisheries or other users would be expected. Deepwater benthic habitats may be greater than the negligible impact predicted due to the unexpected interaction within the marine environment of heavy metals or contamination of solids such as precipitated salts. In this case the impact would increase to slight. Refer to Produced Water Toxicity Uncertainty in [Section 6.3.12.2](#) for proposed management of PW discharge toxicity.

In the event that the discharge of PW at levels significantly above the indicative discharge specifications occurs at the Torosa FPSO at a time where the prevailing conditions result in the plume moving towards Scott Reef, there is a risk of resultant impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) including coral and seagrass. This impact would be expected to be slight due to its temporary and localised nature. Given the controls in place and the distance from the Torosa FPSO to Scott Reef, the likelihood of such an event occurring and resulting in adverse effects on Scott Reef shallow water benthic habitat (<75 m bathymetry) is considered remote, with the subsequent risk assessed to be low.

Risk event: Discharge mixing zone significantly greater than modelled

If the dispersal and fate of produced water discharges is greater than expected, there is a risk of impact to Scott Reef benthic communities and habitats. This risk is particularly relevant for cooling water discharges at the Torosa FPSO. To manage this during steady state FPSO operations, produced water mixing zone modelled will be verified infield.

6.3.12.5 Cumulative Impacts

Given the results of the modelling which demonstrate the localised nature of the impacts associated with the PW discharge from the proposed FPSO facilities, no cumulative effects from the separate discharges of PW are expected given the geographic spread

between sources (i.e. FPSO facilities at Torosa, Calliance/Brecknock and MODU during well unloading). Similarly, no regional cumulative impacts are expected when considering oil and gas activities within the broader Browse Basin, (i.e. Shell's Prelude FLNG facility and INPEX's Ichthys LNG Project).

6.3.12.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact and risk assessment for the discharge of PW is provided in [Table 6-101](#) and [Table 6-102](#) respectively. The acceptability assessment is provided in [Table 6-103](#).

Table 6-101 Impact assessment summary and adopted controls – marine discharges: produced water

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Sediment quality (medium value (open waters))	Change in sediment quality	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.	FPSO Operations + Where practicable, design of the proposed Browse to NWS Project infrastructure will take into consideration opportunities to reduce the need for chemical additives (e.g. the use of active heating for hydrate management).	No lasting effect	Negligible (F)
Water quality (medium value (open waters))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	+ Chemicals that may be operationally released or discharged to the marine environment will be subject to Woodside's chemical selection and assessment process and approved prior to use.	Minor	Minor (D)
Plankton (medium value (open water))	Injury or mortality to marine fauna	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	+ FPSO PW will be treated prior to being discharged overboard using a tertiary treatment system, such as a Macro Porous Polymer Extraction (MPPE) system that meets Woodside and accepted industry standards.	Slight	Slight (E)
Deepwater benthic communities and habitats (>75 m depth) – (medium value)	Change in water quality	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.	+ PW discharge from the FPSO facilities will be conducted below the water surface to promote dispersion and mixing.	No lasting effect	Negligible (F)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in water quality	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	+ For the FPSO PW discharge, the defined threshold values (i.e. 99% species protection or no effect concentrations) will be met at the edge of the mixing zone and the State waters	No lasting effect	Slight (E)
Fish (high value species)	Injury or mortality to marine fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.	+ 3 nm boundary, 95% of the time based on dispersion modelling results.	No lasting effect	Slight (E)
Marine turtles (high value species)	Injury or mortality to marine fauna	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.	+ Periodic and 'for cause' toxicity testing and characterisation of the physical and chemical composition of the FPSO PW stream prior to discharge will be undertaken.	No lasting effect	Slight (E)
Marine mammals (high value species)	Injury or mortality to marine fauna	Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.	+ Baseline and periodic water and sediment quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to detect changes as a result of FPSO PW discharge.	No lasting effect	Slight (E)

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
KEFs (medium value)	Change in water quality	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
State marine parks and nature reserves (high value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No impact expected	
Other protected places (high value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No impact expected	
State and Commonwealth managed fisheries (high value marine user)	Changes to the function interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies (high value users)	Changes to the function interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No impact expected	
Aboriginal or indigenous heritage (high value users)	Changes to the function interests or activities of other users	Objective 19: To not have a substantial adverse impact on heritage values. ¹ Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Table 6-102 Risk assessment summary and adopted controls – marine discharges: produced water

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Sediment quality (medium value (open waters))	Discharge of PW at levels significantly above the indicative discharge specifications resulting from human error or equipment failure	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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. Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	<i>FPSO operations</i> + Hydrocarbon content in the FPSO PW discharge will be no greater than an average of 30 mg/L over any period of 24 hours during steady-state operations (excluding start-up, shut-downs etc.) as demonstrated by monitoring. + During steady state FPSO operations, PW modelling and infield verification will be completed to verify the modelling predictions. + In the event the PW discharge does not meet the defined thresholds in the range predicted for any constituent concentrations, an adaptive management strategy will be implemented which will be included during the Environment Plan process.	Slight	Highly unlikely	Low (EI)
Water quality (medium value (open waters))				No increase to significance/consequence		
Plankton (medium value (open water))				No increase to significance/consequence		
Shallow water benthic habitats – (high value habitat)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		Minor	Remote	Low (DO)
Deepwater benthic habitat (epifauna and Infauna) – medium value habitat		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		Slight	Highly unlikely	Low (EI)
Fish (high value species)		Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No increase to significance/consequence		
Marine turtles (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No increase to significance/consequence		
Marine mammals (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.		No increase to significance/consequence		
		Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No increase to significance/consequence		
		Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No increase to significance/consequence		
KEFs (medium value)		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No increase to significance/consequence		
State marine parks and nature reserves (high value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
Other protected places (high value).		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
State and Commonwealth managed fisheries (high value marine user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		
Other users including tourism and recreation and scientific studies (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		
Aboriginal or indigenous heritage (high value users)		Objective 19: To not have a substantial adverse impact on heritage values. ¹ Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		

Table 6-103 Acceptability Assessment – marine discharges: produced water

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts associated with the discharge of produced water as: + PW dispersion modelling has been undertaken with a validate hydrodynamic model (refer to Section 6.3.12.3). Further, during steady state FPSO operations, infield verification using a range of monitoring techniques will be completed to verify the model predictions and confirm that the mixing zone, including at the 3 nm State waters boundary is met. + PW dispersion modelling indicates that the PW plume will disperse to below toxicity threshold concentrations within 1,200 m which is well before the 3 nm State waters boundary at Scott Reef. + The modelling undertaken is conservative in that it assumes that only dilution processes reduce the concentration of various components in PW. Reductions due to weathering processes (e.g. evaporation of volatile compounds) or mixing processes (e.g. wave action in the upper water column) are not taken into account. This results in an overestimation of concentrations in modelling predictions. + Periodic and 'for cause' toxicity testing and characterisation of the physical and chemical composition of the PW stream prior to discharge will be undertaken. This toxicity testing will determine the whole of effluent toxicity used to define the mixing zone, while the chemical characterisation will verify that the discharge limits specified in this draft EIS/ERD are met. + In the event the PW discharge does not meet the defined thresholds in the range predicted for any contaminant concentrations, an adaptive management strategy which will be developed during the Environment Plan process, will be implemented. The available pygmy blue whale and green turtle data, 2002 to 2017, were determined to be adequate for the purposes of impact assessment and management planning purposes based on the lack of significantly altered regional cumulative impacts since collection (Chapter 9), ability to extrapolate population trends using existing literature, and conservative interpretation of available data where applied. The existing data will be updated by targeted monitoring programs to verify impact predictions and inform adaptive management approaches at relevant times throughout the project life cycle.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable

Acceptability Assessment

Significant Impacts as defined by the MNES Significant Impact Guidelines

Listed threatened species and ecological communities / listed migratory species

As described in [Table 6-101](#), no lasting effect is predicted to occur from the discharge of PW to listed threatened and migratory species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

As described in [Table 6-102](#), potential risk events associated with the discharge of PW are not predicted increased the significance/consequence of impacts to listed threatened and migratory species.

Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines ([Table 6-5](#))) are predicted.

Commonwealth Marine Environment

As described in [Table 6-129](#), the potential impact from the discharge of PW to deepwater benthic communities and habitats (>75 m depth) and KEFs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to plankton, fauna and managed fisheries. Minor (D) impacts are predicted to water quality, while no impact is predicted to occur to, shallow water benthic communities and habitats (<75 m depth), other protected places and other marine users.

As described in [Table 6-130](#), potential risk events associated with the discharge of PW present a Low risk to shallow water benthic communities and habitats (<75 m depth) and deepwater benthic habitat (epifauna and Infauna).

Given this, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines ([Table 6-5](#))) are predicted.

Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of PW discharge against the WA EPA Objectives is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)). In summary:

Marine environmental quality

As described in [Table 6-101](#), the potential impact from the discharge of PW to plankton and marine fauna has been as Slight (E). Minor (D) impacts are predicted to water quality, while no impact is predicted to occur to or shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-102](#), potential risk events associated with PW discharge present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective *“to maintain the quality of water, sediment and biota so that environmental values are protected”* will be achieved.

Marine Fauna

As described in [Table 6-101](#), no lasting effect is predicted to occur from PW discharge to marine fauna species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

As described in [Table 6-102](#), potential risk events associated with PW discharge are not predicted increased the significance/consequence of impacts to marine fauna.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective *“To protect marine fauna so that biological diversity and ecological integrity are maintained”* will be achieved.

Benthic communities and habitats

As described in [Table 6-101](#), no impact from PW discharge to deepwater benthic communities and habitats (>75 m depth) is predicted.

As described in [Table 6-102](#), potential risk events associated with PW discharge present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective *“to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained”* will be achieved.

Conclusion: Acceptable

External Context

To date there have been no specific matters raised by stakeholders regarding discharge of PW in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal Context

This impact and risk assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System.

Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside's chemical selection and assessment process and approved prior to use. Woodside will implement its internal requirement that states that chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

Conclusion: Acceptable

Acceptability Assessment

Other Requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-99](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d).

KEFs

As detailed in [Table 6-100](#) proposed PW discharge will not materially increase existing relevant pressures on the conservation values of KEFs.

Other protected places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.13 Marine Discharges: Cooling Water

6.3.13.1 Impact and Risk Overview

[Table 6-90](#) presents an overview of the potential impacts and risks from cooling water discharges associated with the proposed Browse to NWS Project.

Table 6-104 Cooling water impact and risk overview

Aspect	Marine discharges: cooling water
Description	Seawater is used as a cooling media for heat exchangers to remove excess heat from the production processes on the FPSO facilities as well as from machinery systems on: + project vessels + FPSO facilities + MODUs. Seawater cooling systems draw seawater from the ocean which is then pumped through heat exchangers where it absorbs heat. It is then discharged overboard at a higher temperature than source. Cooling water is often treated with additives including scale inhibitors and biocide (such as chlorine) to avoid biofouling of pipework. These chemicals are usually added at low dosages, and are typically consumed in the inhibition process, so there is little or no residual chemical concentration remaining upon discharge.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to cooling water associated with the proposed Browse to NWS Project are Objectives 3, 6, 7, 10, 12, 13, 14, 15, 16, 17, 18, 20 and 21. These objectives are detailed in Table 6-7.

Aspect	Marine discharges: cooling water						
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-106). + Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016d) + WA EPA Technical Guidance – Protecting the Quality of Western Australia’s Marine Environment (EPA, 2016b) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) + North-west Marine Parks Network Management Plan (Director of National Parks, 2018).						
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <u>Physical</u> + water quality (medium value (open waters)) <u>Ecological</u> + plankton (low value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + fish (high value species) + marine reptiles (high value species) + marine mammals (high value species) + KEFs (high value) + AMPs (high value) + State marine parks and nature reserves (high value) + other protected places (high value) <u>Socio-economic</u> + managed fisheries (high value user) + other users + tourism and recreation (high value user) + scientific studies (high value user) + aboriginal or indigenous heritage (high value users)						
Potential impacts	+ change in water quality + injury or mortality to fauna + changes to the functions, interests or activities of other users						
Risk	+ unplanned discharge of cooling water significantly above discharge specifications						
Summary of governing impact evaluation	<table><tr><th>Magnitude</th><th>Impact significance level</th><th>Confidence</th></tr><tr><td>Minor</td><td>Minor (D)</td><td>High</td></tr></table>	Magnitude	Impact significance level	Confidence	Minor	Minor (D)	High
Magnitude	Impact significance level	Confidence					
Minor	Minor (D)	High					

Aspect	Marine discharges: cooling water		
Summary of governing risk evaluation	Consequence Minor	Likelihood Remote	Risk rating Low (D0)

6.3.13.2 Source of Aspect

Seawater is used as a cooling media for heat exchangers to remove excess heat from machinery systems on all vessels including the FPSOs and MODUs, as well as from the production processes on the FPSOs. Seawater cooling systems draw seawater from the ocean which is then pumped through heat exchangers where it absorbs heat. It is then discharged overboard at a higher temperature than source. Cooling water is often treated with additives including scale inhibitors and biocide (such as chlorine) to avoid biofouling of pipework. These chemicals are usually added at low dosages, and are typically consumed in the inhibition process, so there is little or no residual chemical concentration remaining upon discharge.

For the proposed Browse to NWS Project, the primary source of cooling water discharges will occur from the FPSO facilities in Commonwealth waters. The FPSOs are proposed to have a cooling water system where seawater is pumped up to the facility, treated with hypochlorite and passed through heat exchangers prior to discharge overboard.

The cooling water system consists of both a Process Seawater System and an Essential Seawater System. In addition to passing through heat exchangers, the Process Seawater System will also cool the inlet gas stream although will not cool any process streams with liquid hydrocarbons. It is estimated that the Process Seawater System demand will be in the order of 720,000 m³/day per FPSO facility, which will be routinely discharged overboard below the water line, at a design temperature of approximately 50°C. The volumes and discharge criteria of the Process Seawater System is comparable with other offshore facilities within the region. For comparison Shell's Prelude FLNG facility discharges approximately 1,200,000 m³/day at between 39°C and 42°C (Shell, 2009), while ConocoPhillips' Barossa FPSO discharges 360,576 m³/day at 45°C (ConocoPhillips, 2018) and INPEX's Ichthys Development central processing platform was stated to discharge 250,000 m³/day at a maximum temperature of 50°C (INPEX, 2010).

The Essential Seawater System demand is significantly smaller (expected to be <5% of the Process Seawater System). The Process Seawater System and Essential Seawater System are expected to be discharged from different locations on the FPSO hull below the water line.

The hypochlorite system will inject chlorine to protect the seawater cooling system from biofouling. The majority of the chlorine injected into the cooling

water system will react and be neutralised in the system. Residual chlorine will be discharged overboard as part of the cooling water discharge stream in the order of 0.2 to 1.0 ppm. Residual chlorine levels will be monitored, and the system routinely maintained so residual chlorine levels at the point of discharge are such that the defined threshold values are achieved at the Scott Reef State waters 3 nm (nautical mile) boundary (95% of the time based on dispersion modelling results).

Cooling water discharges will also occur from the MODUs and vessels operating in both Commonwealth and State waters. However, the discharge volumes are anticipated to be significantly less than FPSO facilities in the order of approximately 50 m³/day, depending on vessel size. The impacts associated with these cooling water discharges are expected to be limited to temporary changes in water quality downstream of the discharge point. For vessels this discharge will also be transient in nature based on the operating profile of the vessel. Noting the largest vessel is likely to be the pipelay vessel for the installation of the BTL, which will move along the BTL and inter-field spur line route at a rate of up to approximately 5 km/day (depending on the pipelay vessel and operational conditions such as sea state). Further, MODU and vessel related cooling water impacts will be primarily limited to the construction phase of the project, with the exception of operations support vessels and IMR activities.

As such the detailed impact evaluation with modelling has been completed for FPSOs due to the nature, scale and duration of the discharge compared to all other sources. It should be noted that the actual discharge rates, temperatures, concentrations and engineering design discussed in this section may be further refined during detailed engineering, however these values have been conservatively selected for the purpose of modelling to support impact and risk assessment and in the determination of acceptability in the context of the receiving environment and relevant receptors.

6.3.13.3 FPSO Cooling Water Modelling

Modelling of the cooling water discharge from the Torosa FPSO (as the closest significant discharge point to sensitive receptors at Scott Reef) was undertaken to predict the plume size, location, concentrations of residual chlorine, and the distance where the plume temperatures approach ambient conditions (RPS, 2019a); [Chapter 10, Appendix D.4](#)). As cooling water discharge characteristics for the Calliance/Brecknock FPSO are the same as for the Torosa FPSO; and the receiving environment at the FPSO locations are

similar, the modelling undertaken at the Torosa FPSO location has been used as a surrogate for the Calliance/Brecknock FPSO facility.

As cooling water rates for the FPSOs are significantly in excess of the cooling water rates for the vessels and MODUs, the FPSOs cooling water discharge is the governing scenario for determining environmental impacts and risks. As such, no modelling for MODU or vessel cooling water discharge has been conducted.

Modelling scenarios and discharge characteristics

The model inputs are provided in [Table 6-105](#), which are based on the current design specification which have been optimised to facilitate dilution outcomes; however, remain conservative for modelling purposes.

The modelling assumed a maximum discharge rate of 720,000 m³/day as a conservative upper limit. The discharge depth of 12 m below mean sea level was selected, which has been optimised during design to facilitate dispersion. The buoyant nature of the discharge stream means dispersion is increased with depth of discharge due to the mixing action that occurs as it rises through the water column. The flow was assumed to occur through twin horizontal outlets of 0.91 m diameter, with a salinity of 35 parts per thousand (ppt). The design temperature of the cooling water system discharge is 50°C.

Table 6-105 Cooling Water Discharge Characteristics

Parameter	Specifications
Discharge constituents	Treated cooling water
Flow rate (m ³ /d)	720,000
Outlet pipe internal diameter (m)	0.91
Discharge depth below sea surface (m)	12
Salinity (ppt)	35
Temperature (°C)	50

Modelling thresholds

The proposed threshold values for the key constituents of concern are provided below. These thresholds have been derived from ecotoxicological testing and guidelines; and are used as the basis for determining the mixing zone for the FPSO cooling water discharges.

- + acute chlorine threshold for intermittent/shock dosing: 13 ppb (0.013 mg/L) which represents the predicted no effect concentration for acute exposure at the 99% species protection level (Charlton and Stuber 2008)

- + chronic chlorine threshold for continuous discharges: 2 ppb (0.002 mg/L) which represents the predicted no effect concentration for chronic exposure at the 99% species protection level (Charlton and Stuber 2008)
- + temperature threshold: differential of 3°C above ambient was applied to the modelling based on the Environmental, Health and Safety (EHS) Guidelines for Offshore Oil and Gas Development by the International Finance Corporation (IFC) (IFC, 2015).

Modelling studies

To determine the fate, transport and dilution of the cooling water discharge, both near-field and far-field modelling was undertaken as these are used to describe different processes and scales of effect. The same modelling approach has been used for PW discharge, cooling water discharge and hydrotest discharge; and is described in [Section 6.3.12.3](#). The only exception is that the mixing and dispersion of the cooling water discharges was predicted using the three-dimensional discharge and plume behaviour model, CHEMMAP (French-McCay et al., 2006; McCay and Isaji, 2004). A further description of the modelling approach and hydrodynamic model validation is described in [Section 6.3.12.3](#) and RPS, (2019a) ([Chapter 10, Appendix D.4](#)).

It should be noted that the modelling took a conservative approach and assumed that no processes other than dilution would reduce the source concentrations over time. The modelling assumed no natural degradation or decay of the chlorine would occur and further reduce the mixing zone. It also did not take account of all mixing processes due to wave action in the upper water column which will likely serve to increase the magnitude of dilution acting on the cooling water plume. This is likely to result in an underestimation of mixing and dilution and overestimation of cooling water concentrations in modelling predictions.

Near-field modelling results

The results show that due to the momentum of the discharge, a turbulent mixing zone is created in the immediate vicinity of the discharge point, which is 12 m below the water surface. For all combinations of discharge scenario and season, the primary factor influencing dilution of the plume is the strength of the ambient current. Medium and strong currents are shown to increase the extent of the turbulent mixing zone, with increased ambient current strengths increasing the horizontal distance travelled by the plume from the discharge point. Following initial mixing, the positively-buoyant plume is predicted to rise in the water column to the surface. The maximum depth of the plume is predicted to be 16 m below the sea surface for all seasons, with the maximum horizontal distance travelled under annualised current speeds predicted to be 42.4 m. Refer to [Figure 6-31](#) representing the near-field mixing under medium annualised currents.

The results also indicate that the temperature differential between the discharge and the ambient water is predicted to achieve the threshold level (3°C above ambient temperature) within the near-field (maximum

distance of 120 m across all seasons) in all conditions and therefore no far-field results are illustrated or discussed.

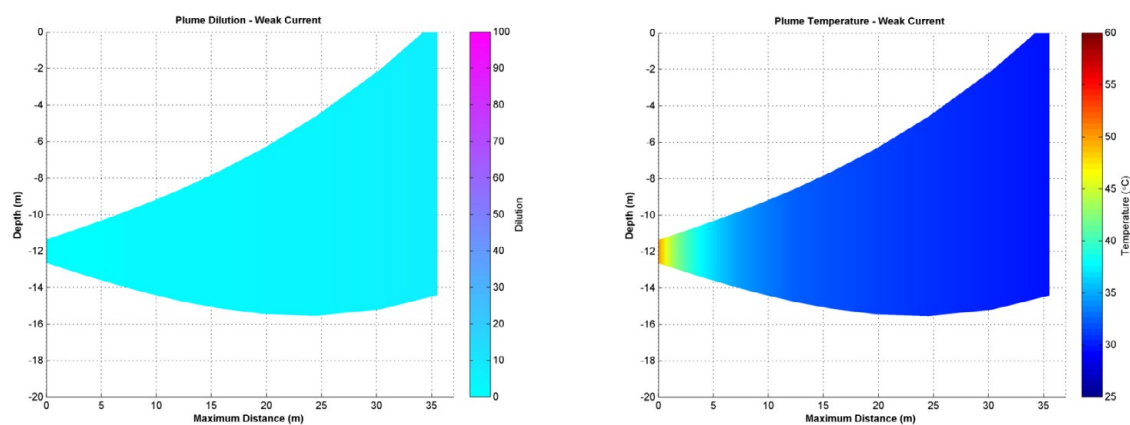


Figure 6-31: Near-field average dilution and temperature results for constant medium annualised currents (12 m depth discharge at 720,000 m³/d flow rate).

Far-field modelling results

Figure 6-32²² illustrates the spatial distribution of the cooling water discharge and the point at which the 99% species protection level is met for continuous discharge, particularly in the context of nearby sensitive receptors within the Browse Development Area (i.e. Scott Reef). It should be noted that while the modelling has not taken the degradation process of the chlorine within the receiving environment into consideration, this natural process will occur due to the inherent reactive nature of the chemical, further reducing the concentration within the dispersed cooling water.

The results demonstrate that the:

- + minimum number of dilutions achieved at 3 nm State waters boundary is 125 dilutions
- + based on the application of the 99% species protection threshold of 0.002 mg/L for chronic exposure this is equivalent to 0.25 mg/L at the discharge point for continuous discharges
- + based on the application of the 99% species protection threshold of 0.013 mg/L for acute exposure this is equivalent to 1.6 mg/L at the discharge point for intermittent discharges
- + maximum horizontal distance till 125 dilutions is achieved is 4.8 km along the prevailing hydrodynamic flow (i.e. NNW – SSE)
- + total area of coverage till 125 dilution is achieved is 5.15 km²

- + maximum depth from discharge is 29 m.

To contextualise the stochastic modelling results, Figure 6-33 shows example time series snapshots of predicted dilutions during a single simulation at 3-hour intervals over a nominated period (from 01:00 to 16:00 on 20th January 2013). These images are representative of typical conditions for the cooling water discharge and demonstrate the spatially-varying orientation of the plume with the currents. The rapidly-varying nature of the concentrations around the source can also be observed. The snapshots show the combined effect of the tide and the drift currents, with a clear tidal oscillation.

Based on the modelling results, 125 dilutions was used to define the full spatial extent of the mixing zone in context of both Scott Reef and the broader open ocean environment. This mixing zone has therefore been applied as the basis of impact evaluation for both the Torosa FPSO and the Brecknock/Calliance FPSO cooling water discharges.

For comparison, the maximum distance required to achieve the acute (0.013 mg/L) and chronic (0.002 mg/L) 99% species protection threshold for chlorine for the ConocoPhillips Barossa Development was 4.6 km and 20.5 km respectively (ConocoPhillips, 2018).

Ongoing development of the FPSO design may impact cooling water discharge parameters, i.e. rate and depth/orientation of discharge, such that the resultant minimum dilutions achieved at the Scott Reef 3 nm State waters boundary will increase (i.e. the mixing

²² Note that the figures do not represent the location of a plume at any point in time; they are a statistical and spatial summary of the percentage of time that dilution values occur across all multiple replicate simulations.

zone size will reduce). The current expected view of minimum dilutions is considered conservative given the predefined assumptions and instantaneous nature of the model (60 time steps), however it is adopted as the result of far-field modelling for the purposes of this impact assessment. Further modelling and the proposed source concentrations will be defined in the secondary approvals process (via relevant Environment Plans).

Model verification

Modelling is a predictive tool and as such has a number of inherent uncertainties which are typically compensated through the application of conservatism. As such during steady state FPSO operations, infield verification using a range of monitoring techniques will be completed to verify the model predictions and confirm that the mixing zone, including at the 3 nm State waters boundary is met. In the event that the mixing zone is larger than anticipated, posing a significant increase in impact than that described in this draft EIS/ERD (below) then corrective actions will be implemented onboard the FPSOs to reduce the impact. Corrective actions include additional engineering to produce a change in discharge characteristics.

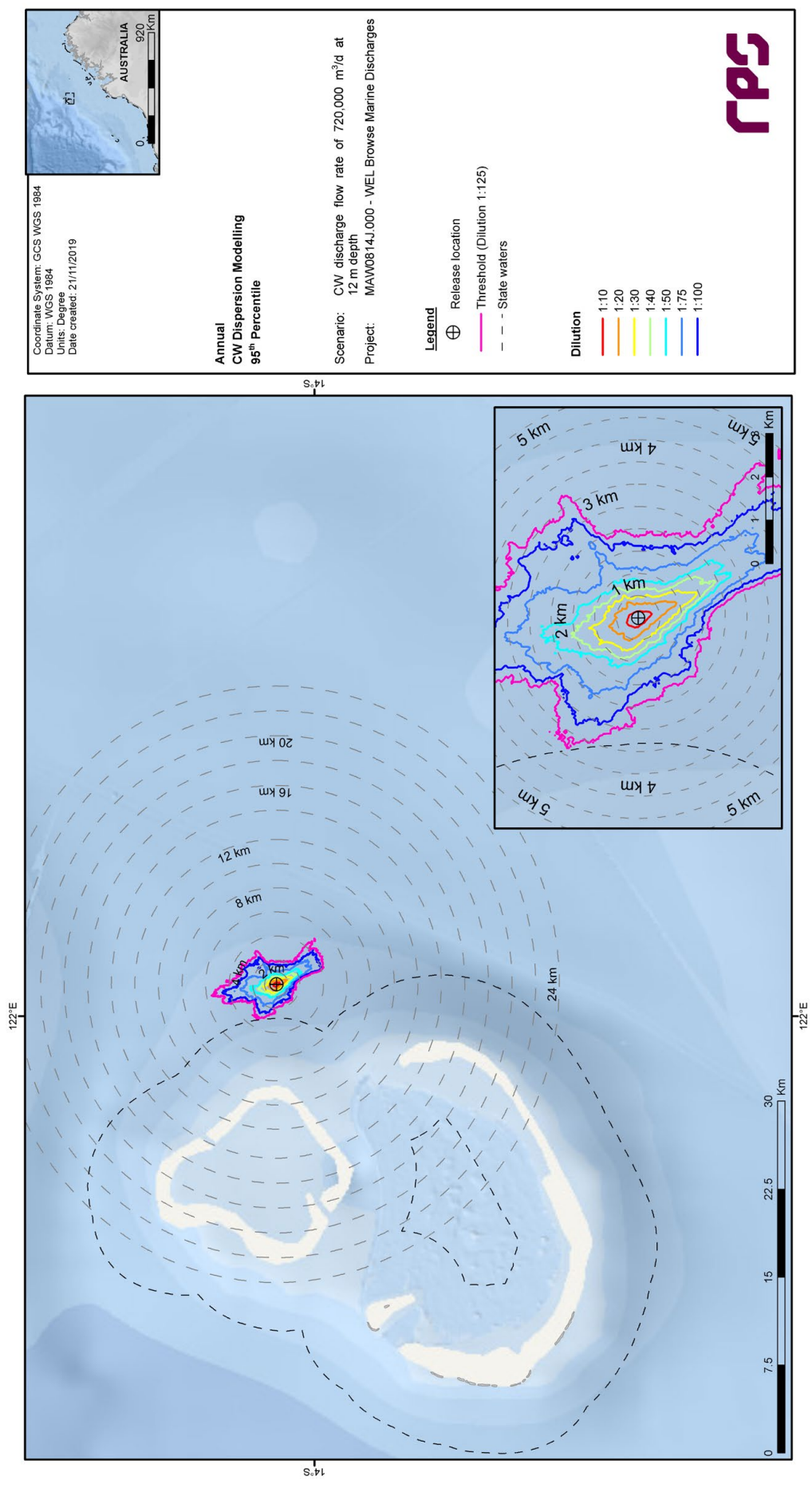


Figure 6-32 Predicted annualised minimum dilutions at the 95th percentile for Scenario 1 (12 m depth discharge at 720,000 m³/d flow rate with no chlorine degradation)

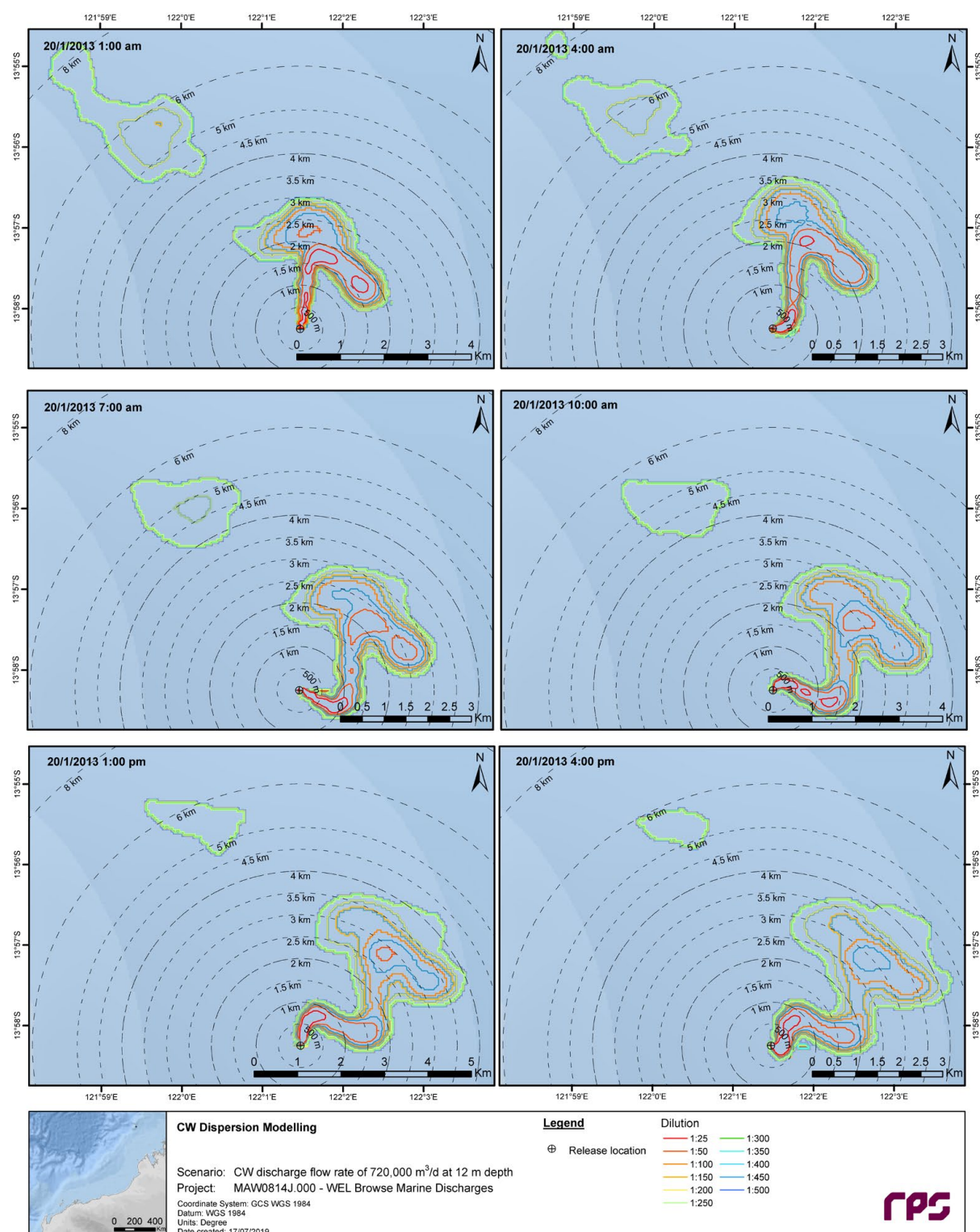


Figure 6-33 Snapshots of predicted dilution levels, at 3-hour intervals from 01:00 to 16:00 on 20th January 2013, for Scenario 1 (Torosa FPSO release location, 12 m depth discharge at 720,000 m³/d flow rate with no chlorine degradation)

6.3.13.4 Environmental Impact

Water quality

Change in water quality

Cooling water discharge may change water quality due to thermal impacts (increased water temperature) and toxicity impacts relating to the residual chlorine concentration within the cooling water discharge.

Within the immediate area of influence of the discharge, water temperatures will be elevated temporarily impacting water quality. However, as outlined within the modelling results, the temperature differential between the discharge and the ambient water is predicted to achieve the threshold level (3°C above ambient temperature) within the near-field (maximum distance of 120 m across all seasons) in all conditions such thermal impacts are not predicted to occur outside of a maximum of 120 m from the discharge location.

A change in water quality due to residual chlorine concentrations within the cooling water will also occur around the cooling water discharge point. The change will be relatively localised (limited to the mixing zone defined by the modelling; [Section 6.3.13](#)). Cooling water discharges from the FPSO will be managed in Commonwealth waters to ensure the required number of dilutions (e.g. 125) to achieve the threshold value at 3 nm State waters boundary (e.g. 99% species protection or no effect concentrations) are met 95% of the time based on dispersion modelling results.

MODU and vessel discharges will be significantly smaller in volume compared to the FPSO discharges. Given this, and the distance from such sources to Scott Reef (under normal operating conditions, drilling and vessel activity within the Browse Development Area will be limited to deep waters away from Scott Reef); no effect on Scott Reef benthic communities and habitats is expected to result from the discharge cooling water. Similarly, vessel discharges during installation and intermittent IMR activities along the BTL will occur well away from any sensitive receptors (the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park (the closest point to the Rowley Shoals)) and are not predicted to impact these receptors.

Plankton communities

Injury or mortality to fauna

There is the potential for plankton present within surface waters to be exposed to residual chlorine above toxicological threshold levels if encountering the cooling water plume as it is transported down-current away from the facilities. Early life stages of fish (embryos, larvae) and other plankton would be the most susceptible organisms to exposure from chlorine in the cooling water discharges, as they have limited mobility and are therefore likely to be exposed to the plume

within the mixing zone. Given the fact that the plume will be mobile due to variable metocean conditions and the weathervaning of the facilities, plankton organisms are expected to have the opportunity to recover following any exposure to the plume, due to their fast population turn-over (ITOPF, 2011). Any potential for acute toxicity impacts to plankton would be expected to be limited to within the modelled mixing zone and confined to a small portion of the water column (i.e. to a maximum of 29 m from the surface). Therefore, it is not expected that there will be any lasting impacts on plankton communities or ecosystem function locally or regionally.

Benthic habitats

Change in water quality (change in water temperature)

Elevated water temperatures have the potential to have a significant impact on benthic habitats, resulting in coral bleaching and mortality of seagrass and macroalgae. Modelling results show that the FPSO cooling water discharge plumes will be within surface layers (max depth of 29 m) and will not interact with the seabed. Therefore, thermal impacts to deepwater benthic communities (> 400 m water depth) are not predicted. No thermal impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) (> 8 km distant from the FPSO facilities) are predicted as modelling indicated a rapid reduction in cooling water temperature from the FPSO discharge point (to within 3°C of ambient within 120 m).

As stated earlier, MODU and vessel discharges will be significantly smaller in volume compared to the FPSOs discharges. Given this, and the distance from such sources to the shallow water benthic habitats of Scott Reef; no effect on Scott Reef benthic communities and habitats is expected to result from the discharge cooling water. Similarly, the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park (the closest point to the Rowley Shoals) and therefore cooling water discharges from the pipelay vessel are not predicted to affect benthic habitats within the Rowley Shoals.

Change in water quality (toxicity impacts)

Chlorine has the potential to significantly impact benthic habitats, resulting in coral bleaching and mortality of seagrass and macroalgae. Modelling results show that the discharge plumes will be within surface layers and will not interact with the seabed. Therefore, toxicity impacts to deepwater benthic communities (> 400 m water depth) are not predicted.

The modelling demonstrates that for 95% of the time, residual chlorine concentrations above threshold levels are not expected to reach the 3 nm State waters boundary around Scott Reef (Figure 6-32), with a minimum dilutions of 125 dilutions achieved at Scott Reef 3 nm State waters boundary. Therefore, no impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) or coral larvae from cooling water discharge are predicted.

Furthermore, studies on the dispersion of coral larvae at Scott Reef (Done et al., 2015; Foster and Gilmour, 2018) we examine distance decay among coral communities in a common habitat on northwestern Australian reefs, seeking to better understand the roles of disturbance and coral life history strategies in the changing reefscape. In established communities in 1997, when coral cover and generic richness were uniformly high, there was high similarity (~81 %) demonstrates that while there is marked movement of larvae within the reef system itself (broadcast spawning corals), there is no evidence to suggest that those coral larvae that initially dispersed off the reef return to Scott Reef to settle. Therefore, the cooling water plume is not likely to impact the recruitment of corals within the Scott Reef system as larvae affected by the cooling water plume would not have been available to resettle on the reef regardless if the impact had occurred or not.

MODU and vessel discharges will be significantly smaller in volume compared to the FPSO discharges. These discharged are expected to dilute to below threshold levels within tens of metres of the discharge point. Given this, and the distance from the discharge to Scott Reef; no effect on Scott Reef benthic communities and habitats is expected to result from the discharge of cooling water from vessels.

Marine fauna

Injury or mortality to fauna (thermal impacts) – fish, marine mammals, marine turtles

Elevated water temperatures have the potential to induce minor physical stress in marine fauna and may result in potential mortality from prolonged exposure.

Elevated seawater temperatures have the potential to alter the physiological processes of exposed biota (Wolanski, 1994). These alterations may cause a variety of effects, ranging from behavioural responses (including attraction and avoidance behaviour), minor stress and potential mortality for prolonged exposure (Walkuska and Wilczek, 2010).

For the proposed Browse to NWS Project, the potential for thermal impacts and associated reduction in oxygen is limited due to the rapid reduction in cooling water temperature in the receiving waters (maximum distance

of 120 m from the discharge point to achieve threshold levels and restricted to surface waters) and subsequent highly localised affected area.

While the proposed facilities are within an area known to host a variety of mobile marine fauna (e.g. cetaceans, fish and marine turtles) individuals are likely to be transient within the discharge area of influence and therefore it is unlikely that such fauna would be sufficiently exposed to elevated seawater temperatures to elicit a significant impact. In addition, as the plume is positively-buoyant, impacts to demersal and pelagic species are unlikely.

Injury or mortality to fauna (toxicity impacts) – fish, marine mammals, marine turtles

The effect of chlorine on marine organisms is well known, given its common use as a biocide. Sublethal effects can include growth reduction in some juvenile life stages, alteration of the permeability of membranes and modification of blood composition (Walkuska and Wilczek, 2010).

The results demonstrate that there is potential for marine organisms present in the surface layer of the sea (above 16 m water depth) to be exposed to residual chlorine levels above threshold levels if the organisms encounter the cooling water plume as it is transported down-current away from the FPSO facility discharge point.

It is important to note however that the direction of the plume emanating away from the discharge point will change depending on the current direction, such that exposure to cooling discharges of specific areas surrounding the FPSO facilities will not be continuous. Furthermore, it should be noted that the threshold concentrations and the subsequent mixing zone have been determined through the application of chronic exposure ecotoxicological tests on marine fauna (over days) and therefore if marine fauna are transient within the receiving environment adjacent to the discharge location, they are unlikely to be exposed to sufficient concentrations or durations of the discharge constituents to elicit a response.

Fish

Pelagic fish are likely to be exposed to the cooling water plume above threshold concentrations (within the mixing zone). Exposure will be minimal however, given the buoyant nature of the plume. Given the above and the high mobility of pelagic fish species, it is not predicted that fish will be exposed to the discharge constituents in sufficient concentrations or durations to elicit a response.

The whale shark is the only threatened fish species that has the potential to be present within the Browse

Development Area. Given the above and the low numbers and infrequent nature of whale shark presence in the Browse Development Area, it is predicted that no lasting effects to fish will occur as a result of cooling water discharge.

Marine turtles

Acute and chronic effects of chemical discharges are highlighted within the Recovery Plan for Marine Turtles in Australia (2017-2027) as a threat to green turtles within the Scott Reef and Browse Island area (Commonwealth of Australia, 2017a). Modelling predicts that the cooling water plume from the FPSO facilities will not reach the area defined as habitat critical to the survival of green turtles in the Recovery Plan for Marine Turtles 2017-2027. However, cooling water discharge from the Torosa FPSO will occur in an area defined as a green turtle interesting BIA. Cooling water discharge from vessels will occur within both the area defined as habitat critical to the survival of green turtles in the Recovery Plan for Marine Turtles 2017-2027 and the green turtle interesting BIA. The Recovery Plan includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a).

It should be noted that studies have shown that while interesting areas ranged up to 14 km out from the Sandy Islet, most stayed within 3 km of the islet (Guinea, 2011). As such, it is not expected that a large number of marine turtles will be exposed to cooling water

discharges from the operating FPSO at Torosa, MODU or project vessels. Furthermore, it is not predicted that any marine turtles within the discharge mixing zone of the facility will be exposed to sufficient concentrations or long enough durations of toxicants to elicit an impact.

Marine mammals

The mixing zone for the Torosa FPSO overlaps a possible foraging area for pygmy blue whales, while the mixing zones for both FPSOs overlaps the migration BIAs for pygmy blue whales. Chronic chemical pollution is identified as a potential risk to pygmy blue whales in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c). Conservation advices for other EPBC listed marine mammals that may occur in the Project area do not identify chemical pollution as a key threat (Table 5-19). Given the low numbers of marine mammals within the Browse Development Area and the relatively small area of the predicted mixing zones for each FPSO facility, it is not predicted that adverse impacts would occur to marine mammals as a result of cooling water discharges from the operating facilities, MODU or project vessels.

Assessment against EPBC Act recovery and conservation plans and advices

Table 6-106 provides an assessment of the discharge of cooling water discharge from the proposed activities in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-106 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – cooling water

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Whale shark (<i>Rhincodon typus</i>)	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The potential impact of cooling water discharges resulting from the proposed Browse to NWS Project have been assessed and mitigation measures proposed. Given the low numbers and infrequent nature of whale shark presence in the Project Area, dynamic nature of the plume, and mobility of the species, there is a high level of confidence that cooling water discharges will not result in adverse impact to whale sharks.

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Green turtle (<i>Chelonia mydas</i>)	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival.	Potential impacts to turtles have been assessed and will be managed in accordance with the Recovery Plan for Marine Turtles in Australia (2017-2027) which includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a). In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival is predicted to be met.
Hawksbill turtle (<i>Eretmochelys imbricata</i>)		+ Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Cooling water discharges from the FPSOs will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection) at the State waters 3 nm boundary are met 95% of the time based on dispersion modelling results. Given this, and evidence that most interesting turtles at Scott Reef stay within 5 km of Sandy Islet, it is not expected that a large number of marine turtles will be exposed to the Torosa FPSO cooling water discharge mixing zone. Further, it is unlikely that any exposure will be of sufficient concentration or duration (given plume dynamics and fauna mobility) to elicit a toxic response. Therefore, there is a high level of confidence that any impacts will not compromise the long-term recovery objectives for marine turtles or result in the displacement of the Scott Reef – Browse Island green turtle genetic stock, from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Discharges in biologically important areas will be managed such that blue whales continues to utilise the area and are not displaced from a foraging area.	Occasional exposure of individuals of these species to the cooling water discharge plume may occur. However, given the highly mobile nature of marine mammals, exposure would be temporary. As such, it is unlikely that any exposure will be of sufficient concentration or duration to elicit a response. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback Whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Marine discharges have not been identified as a direct threat to these whale species; however, habitat degradation	
Sei Whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale	has been identified as a threat and unmanaged discharges may contribute to this threat.	
Fin Whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale	The conservation advice relevant for this threat – identifies modification to the coastal region in areas of importance to listed whales may result in reduced occupancy, compromised reproductive success and even mortality.	

Key Ecological Features

Change in water quality - Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF

Discharge of cooling water from the MODU, project vessels and the Torosa FPSO will occur within the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF. The primary values of this KEF relate to high primary productivity, diverse aggregations of marine life and high species richness of the coral reefs. The relevant pressure related to cooling water discharge (chemical pollution / contaminants) is identified as not being of concern for this KEF within the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

As described above, while a change in water quality is predicted to occur within the modelled mixing zone, subsequent adverse impacts to fauna such as fish, marine mammals and marine turtles are not predicted. Impacts to plankton are predicted to be localised and not expected to have any lasting affect with plankton communities expected to rapidly recover, as they are known to have high levels of natural mortality and a rapid replacement rate (ITOPF, 2011). Modelling

indicated that the cooling water plume will remain in surface waters so is not predicted to impact deepwater benthic habitats. Based on the modelling, the cooling water discharge is not predicted to impact Scott Reef shallow water benthic habitat (<75 m bathymetry). As such adverse impacts to the conservation values of the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF are not predicted.

Change in water quality - Continental slope demersal fish communities KEF

Cooling water discharge will also occur from MODUs, project vessels and the Calliance/Brecknock FPSO into the Continental slope demersal fish communities KEF. This KEF is recognised mainly for its high diversity of demersal fish. As described above, fish are not likely to be exposed to the discharge for enough time to elicit a toxic response and as such adverse impacts to the values of the Continental slope demersal fish communities KEF are not predicted. The relevant pressure related to cooling water discharge (chemical pollution / contaminants) is identified as not being of concern for this KEF within the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Change in water quality - Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF

Depending on the final route of the BTL, determined during detailed engineering, cooling water discharge may occur from project vessels within the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF. This KEF is recognised mainly for its high productivity and aggregations of marine life. Cooling water discharges from vessels within this KEF will be very small compared to the FPSO facilities, transient in nature (as vessels will move along the BTL route rather than remain in one location) and will only occur during installation of the BTL and during intermittent IMR activities. Given this, biota are not likely to be exposed to the discharge for enough time to elicit a toxic response and as such adverse impacts to the values of the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF are not predicted. The relevant pressure related to cooling water discharge (chemical pollution / contaminants) is identified as not being 'data deficient or not assessed' for this KEF within the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Change in water quality - Ancient coastline at 125 m depth contour KEF

Cooling water discharge will also occur from project vessels into the Ancient coastline at 125 m depth contour KEF. This KEF is recognised mainly for its unique seafloor feature with ecological properties of regional significance. Cooling water discharges from vessels within this KEF will be very small compared to the FPSO facilities, transient in nature (as vessels will move along the BTL route rather than remain in one location), restricted to surface waters, and will only occur during installation of the BTL and during intermittent IMR activities. Given the buoyant nature of cooling water discharges, no contact with the seafloor will occur and as such adverse impacts to the values of the Ancient coastline at 125 m depth contour KEF. The relevant pressure related to cooling water discharge (chemical pollution / contaminants) is identified as not being of concern for this KEF within the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Summary

Table 6-107 provides an assessment of the proposed cooling water discharge in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-107 Alignment with protection of conservation values of KEFs – cooling water

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Chemical pollution / contaminants - currently identified as 'not of concern'	Given that only minor localised changes in water temperature are expected and no significant changes to water quality are expected within these KEFs, there is a high level of confidence that changes in water quality will not result in an adverse impact to marine ecosystem function or integrity within the KEFs; or any reduction in to the conservation values of the KEFs will occur.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Ancient coastline at 125 m depth contour			
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals		Chemical pollution / contaminants - currently identified as 'data deficient or not assessed'	

Australian marine parks

Change in water quality

Vessels associated with the installation of the BTL and transiting project vessels will be discharging cooling water within the Multiple Use Zone (VI) of the Argo-Rowley Terrace and Kimberley AMPs (see [Section 5.3.3.2](#) for a description of the values of these AMPs). Cooling water discharges from vessels operating within the AMPs will be temporary and transient in nature (e.g. the slowest moving Project vessel will be the pipelay vessel, which will move at a rate of up to 5 km/day). Cooling water discharges from the operational facilities are not expected within any AMPs due to the distance from the facilities. The Argo-Rowley Terrace and Kimberley AMPs protect values including seabirds, marine turtles, inshore dolphins, humpback whales, pygmy blue whales, dugongs and whale sharks (Director of National Parks, 2018). The introduction of cooling water has the potential impact marine fauna within the AMP through thermal and toxicity effects.

The discharge of cooling water from project vessels within AMPs will be undertaken in accordance with the requirements of the applicable zoning. Cooling

water discharges from vessels within the AMPs will be very small compared to the FPSO facilities, transient in nature (as vessels will move along the BTL route rather than remain in one location) and will only occur during installation of the BTL and during intermittent IMR activities. Any impacts on fauna through thermal or toxicity impacts is unlikely due to the dispersive action on the cooling water discharge and the transient nature of the fauna. It is considered that the identified conservation values of the Argo-Rowley Terrace and Kimberley AMPs will not be detrimentally impacted by cooling water discharges associated with the proposed Browse to NWS Project. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park therefore it is unlikely that the cooling water would reach this AMP from the discharge point.

Summary

[Table 6-108](#) provides an assessment of the proposed discharge of cooling water in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Table 6-108 Alignment with the North-west Marine Parks Network Management Plan – marine discharges: cooling water

Australian Marine Park	Relevant plan(s)	Australian Marine Park objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	Cooling water discharges from vessels operating within these AMPs, will cause temporary change in water quality. However, given the low discharge rate from project vessels and the dynamic nature of the open water marine environment, discharges are expected to dilute to below threshold values within metres to tens of metres of the discharge point.
Kimberley Marine Park Multi Use Zone (VI)			Therefore, there is a high level of confidence that cooling water discharges will not result in any adverse impacts to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, no cooling water discharge will occur in this AMP and no affect to ecosystems, habitats or native species in the AMP will occur. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

State Marine Parks and nature reserves

Change in water quality – Scott Reef nature reserve

Cooling water discharges from the FPSO facilities will be managed in Commonwealth waters to ensure the defined threshold values (i.e. 99% species protection) at the State waters 3 nm boundary are met 95% of the time based on dispersion modelling results. Given this the cooling water plume is not predicted to reach Scott Reef, no impact to the values of the Scott Reef Nature Reserve are predicted.

Other protected places

Change in water quality – Scott Reef and Surrounds Commonwealth Area National Heritage Place

The Scott Reef and Surrounds - Commonwealth Area National Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef. Cooling water discharges from the FPSO will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection) at the State waters 3 nm boundary are met 95% of the time based on dispersion modelling results. As such the cooling water discharge plume is not predicted to reach the Scott Reef and Surrounds - Commonwealth Area National Heritage Place and no impacts to the conservation values of the protected place are predicted.

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no lasting effects to fish from cooling water discharge have been predicted, subsequent impact to fisheries is also not predicted.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

Cooling water discharges from the FPSO will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection) at the State waters 3 nm boundary are met 95% of the time based on dispersion modelling results. Due to a 500 m petroleum safety zone around the FPSO facilities and their remote location, there will be limited use of the marine waters in close proximity by other users and as such there is not expected to be any significant impact to other users. Activities such as scientific studies, tourism and recreation at Scott Reef are unlikely to be impacted because Scott Reef is approximately 8 km away from the Torosa FPSO facility which is well away from the edge of the cooling water discharge mixing zone. MODU and vessel discharges will be significantly smaller in volume compared to the FPSO discharges. Given this, and the distance from such sources to Scott Reef (under normal operating conditions, drilling and vessel activity will be limited to deep waters away from Scott Reef); no effects on users of Scott Reef are expected from cooling water discharge.

Aboriginal or indigenous heritage (high value users)

Changes to the functions, interests or activities of other users

Given that no lasting effect to fish from cooling water discharge have been predicted, subsequent impact to traditional Indonesian fishers is also not predicted.

6.3.13.5 Environmental Risk

Risk Event: Unplanned discharge of cooling water significantly above discharge specifications

Though unlikely, discharges of cooling water at levels significantly above the planned discharge specifications resulting from human error or equipment failure may occur. These risks could potentially result in a larger area being impacted (a temporary larger mixing zone), although the plume would still be expected to rapidly disperse. Furthermore, it would remain unlikely that exposure to marine fauna would be sufficient to elicit a toxic response. As such no change to the significance of the impact to water quality, plankton communities, benthic habitats, marine fauna, KEFs, AMPs, State marine parks and nature reserves, other protected places, managed fisheries or other users would be expected.

In the event that the discharge of cooling water at levels significantly above the indicative discharge specifications occurs at the Torosa FPSO at a time where the prevailing conditions result in the plume moving towards Scott Reef, there is a risk of resultant impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) including coral and seagrass. This impact would be expected to be slight due to its temporary and localised nature. Given the controls in place, conservatism built into the above modelling, and the distance from the Torosa FPSO to Scott Reef, the likelihood of such an event occurring and resulting in adverse effects on Scott Reef shallow water benthic habitat (<75 m bathymetry) is considered remote, with the subsequent risk assessed to be low.

Risk event: Discharge mixing zone significantly greater than modelled

If the dispersal and fate of cooling water discharges is greater than expected, there is a risk of impact to Scott Reef benthic communities and habitats. This risk is particularly relevant for cooling water discharges at the Torosa FPSO. To manage this during steady state FPSO operations, cooling water mixing zone modelled will be verified infield.

6.3.13.6 Cumulative Impacts

Impacts resulting from the cooling water discharge are expected to be localised to each discharge location with no expected cumulative effects from the separate discharges given the geographic spread of the proposed discharge points (i.e. Torosa and Calliance/Brecknock FPSO facilities). Cooling water discharge from project vessels and MODU(s) will be at levels considerably less than the FPSO facilities and are not expected to result in significantly cumulative impacts.

6.3.13.7 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact assessment and risk assessments, and the adopted controls for marine discharges: cooling water is provided in [Table 6-109](#) and [Table 6-110](#). The acceptability assessment is provided in [Table 6-111](#).

Table 6-109 Impact assessment summary and adopted controls – Cooling Water

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Water quality (medium value (open water))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	<i>FPSO operations</i> + Cooling water discharge from the FPSO facilities will be conducted below the water surface to promote dispersion and mixing.	Minor	Minor (D)
Plankton (medium value (open water))	Injury or mortality to marine fauna	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	+ Hypochlorite will be used to control fouling in sea water systems in line with best practice, due to its solubility in water and rapid biodegradability.	Slight	Slight (E)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in water quality	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	+ For FPSO cooling water discharges, the defined threshold value (i.e. 99% species protection; 3°C above ambient) will be met at the edge of the mixing zone and the State waters 3 nm boundary, 95% of the time based on dispersion modelling results.	No impact expected	No impact expected
Deepwater communities and habitats (>75 m depth) (medium value habitat)	Injury or mortality to marine fauna	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No impact expected	No impact expected
Fish (Marine fauna (high value species))	Injury or mortality to marine fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No lasting effect	Slight (E)

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Marine turtles (high value species)	Injury or mortality to marine fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No lasting effect	Slight (E)
Marine mammals (high value species)	Injury or mortality to marine fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No lasting effect	Slight (E)
KEFs (medium value)	Change in water quality	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
AMPs (medium value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Negligible (F)
State marine parks and nature reserves (high value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No impact expected	
Other protected places (high value)	Change in water quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No impact expected	
State and Commonwealth managed fisheries (high value marine users)	Changes to the function interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies (high value users)	Changes to the function interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Aboriginal or indigenous heritage (high value users)	Changes to the function interests or activities of other users	Objective 19: To not have a substantial adverse impact on heritage values.¹ Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Table 6-110 Risk assessment summary and adopted controls – Cooling water

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Water quality (medium value (open waters))	Unplanned release of cooling water at significantly elevated discharge concentrations that would lead to water quality impacts within the State waters 3 nm boundary	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	FPSO operations + The FPSO facilities' cooling water systems have been designed to be segregated from process liquid hydrocarbon streams to prevent potential contamination of the cooling water. + During steady state FPSO operations, cooling water modelling and infield verification will be completed to verify the modelling predictions.	No increase to significance/ consequence		
Plankton (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		No increase to significance/ consequence		
Deepwater benthic communities and habitats (>75 m depth) – (medium value)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No increase to significance/ consequence		
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		Minor	Remote	Low (D0)
Fish (high value species)		Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No increase to significance/ consequence		
Marine turtles (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No increase to significance/ consequence		
Marine mammals (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.		No increase to significance/ consequence		
		Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No increase to significance/ consequence		
		Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No increase to significance/ consequence		
KEFs (medium value)		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No increase to significance/ consequence		
AMPs (medium value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/ consequence		
Managed fisheries (high value users)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/ consequence		
Other protected places (high value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/ consequence		

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
State and Commonwealth managed fisheries (high value marine user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/ consequence		
Other users including tourism and recreation and scientific studies (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/ consequence		
Aboriginal or indigenous heritage (high value users)		Objective 19: To not have a substantial adverse impact on heritage values. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/ consequence		

Table 6-111 Acceptability Assessment – Cooling Water

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of potential impacts and risks associated with cooling water as: + Modelling of the FPSO facilities cooling water discharge demonstrate that for 95% of the time, residual chlorine concentrations above threshold levels are not expected to reach the 3 nm State waters boundary around Scott Reef. + The modelling took a conservative approach and assumed that no processes other than dilution would reduce the source concentrations over time. The modelling assumed no natural degradation or decay of the chlorine would occur and further reduce the mixing zone. It also did not take account of all mixing processes due to wave action in the upper water column which will likely serve to increase the magnitude of dilution acting on the cooling water plume. This is likely to result in an underestimation of mixing and dilution and overestimation of cooling water concentrations in modelling predictions. + Temperature thresholds are expected to be reached within 120 m of the release location. + During steady state FPSO operations, cooling water modelling and infield verification will be completed to verify the mixing zone and demonstrate that the defined threshold are met at the State waters 3 nm boundary. The available pygmy blue whale and green turtle data, 2002 to 2017, were determined to be adequate for the purposes of impact assessment and management planning purposes based on the lack of significantly altered regional cumulative impacts since collection (Chapter 9), ability to extrapolate population trends using existing literature, and conservative interpretation of available data where applied. The existing data will be updated by targeted monitoring programs to verify impact predictions and inform adaptive management approaches at relevant times throughout the project life cycle.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines Listed threatened species and ecological communities / listed migratory species As described in Table 6-109, no lasting effect is predicted to occur from the discharge of cooling water to listed threatened and migratory species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E). As described in Table 6-110, potential risk events associated with the discharge of cooling water are not predicted increased the significance/consequence of impacts to listed threatened and migratory species. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Commonwealth Marine Environment As described in Table 6-109, the potential impact from the discharge of cooling water to KEFs and AMPs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to plankton, fauna and managed fisheries. Minor (D) impacts are predicted to water quality, while no impact is predicted to occur to deepwater benthic communities and habitats (>75 m depth), shallow water benthic communities and habitats (<75 m depth), other protected places and other marine users. As described in Table 6-110, potential risk events associated with the discharge of cooling water present a Low risk to shallow water benthic communities and habitats (<75 m depth). Given this, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environmental (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of cooling water discharge against the WA EPA Objectives is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)). In summary:

Marine environmental quality

As described in [Table 6-109](#), the potential impact from the discharge of cooling water to plankton and marine fauna has been as Slight (E). Minor (D) impacts are predicted to water quality, while no impact is predicted to occur to deepwater benthic communities and habitats (>75 m depth) or shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-110](#), potential risk events associated with cooling water discharge present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to maintain the quality of water, sediment and biota so that environmental values are protected” will be achieved.

Marine Fauna

As described in [Table 6-109](#), no lasting effect is predicted to occur from cooling water discharge to marine fauna species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

As described in [Table 6-110](#), potential risk events associated with cooling water discharge are not predicted increased the significance/consequence of impacts to marine fauna.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “To protect marine fauna so that biological diversity and ecological integrity are maintained” will be achieved.

Benthic communities and habitats

As described in [Table 6-109](#), no impact from cooling water discharge to deepwater benthic communities and habitats (>75 m depth) is predicted.

As described in [Table 6-110](#), potential risk events associated with cooling water discharge present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained” will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders regarding discharge of cooling water in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact and risk assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System.

Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside's chemical selection and assessment process and approved prior to use. Woodside will implement its internal requirement that states that Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-106](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d).

KEFs

As detailed in [Table 6-107](#), proposed cooling water discharge will not materially increase existing relevant pressures on the conservation values of KEFs.

AMPs

As detailed in [Table 6-108](#), the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other protected places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.14 Marine Discharges: Hazardous and Non-Hazardous Inorganic Waste

6.3.14.1 Impact and Risk Overview

Table 6-112 presents an overview of the potential impacts and risks from hazardous and non-hazardous inorganic wastes associated with marine discharges from proposed Browse to NWS Project infrastructure and vessels.

Table 6-112 Hazardous and non-hazardous inorganic waste impact and risk overview

Aspect	Marine discharges: hazardous and non-hazardous inorganic waste
Description	Hazardous and non-hazardous inorganic waste will be generated from three main sources: + project vessels + FPSO facilities + MODUs. Hazardous wastes are defined as an object or substance that displays toxic, explosive, poisonous or flammable characteristics, which can no longer fulfil its intended use and requires disposal. Hazardous waste that may be accidentally lost to the marine environment includes: + batteries, aerosol cans, empty paint cans, printer cartridges, fluorescent tubes + hydrocarbon-contaminated materials (e.g. oily rags, oil filters) + contaminated personal protective equipment + hazardous process waste, including chemicals (i.e. amine and TEG). Non-hazardous wastes are those which are not classified as hazardous (as per the characteristics described above) but which, if released into the marine environment, may pose a threat to receptors through smothering, entanglement or ingestion. Non-hazardous waste includes: + paper and cardboard + wooden pallets + scrap steel, metal, aluminium, cans, etc + glass.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to hazardous and non-hazardous inorganic waste associated with the proposed Browse to NWS Project are Objectives 1, 2, 3, 6, 7, 9, 10, 12, 13, 14, 15, 16, 17, 18, 20 and 21. These objectives are detailed in Table 6-7 .

Aspect	Marine discharges: hazardous and non-hazardous inorganic waste
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-113). + Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983. This is the primary federal legislative instrument for Australia's implementation of the International Convention for the Prevention of Pollution from Ships (MARPOL). + Commonwealth Navigation Act 2012 + Threat abatement plan for the impacts of marine debris on vertebrate marine life (DEWHA, 2009) + Marine Order 93 (Marine pollution prevention—noxious liquid substances) + Marine Order 94 (Marine pollution prevention—packaged harmful substances) + Marine Order 95 (Marine pollution prevention – garbage) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016d) + WA EPA Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016b). + North-west Marine Parks Network Management Plan (Director of National Parks, 2018) + Threat abatement plan for the impacts of marine debris on vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia, 2018) + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012)

Aspect	Marine discharges: hazardous and non-hazardous inorganic waste						
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <i>Physical</i> + sediment quality (low value (open waters)) + water quality (low value (open waters)) <i>Ecological</i> + plankton communities (low value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + seabirds and migratory shorebirds (high value species) + fish (high value species) + marine reptiles (high value species) + marine mammals (high value species) + KEFs (high value) + AMPs (high value) + State marine parks and nature reserves (high value) + other protected places <i>Socio-economic</i> + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value users) + scientific studies (high value users)						
Potential impacts	As there is no planned discharge of hazardous or non-hazardous inorganic waste, there are no environmental impacts expected relating to this aspect.						
Risks	Unplanned discharge of hazardous or non-hazardous inorganic waste leading to: + change in water quality + change in sediment quality + injury or mortality to fauna + changes to the function, interests or actions of other users						
Summary of governing impact evaluation	<table><tr><th>Magnitude</th><th>Impact significance level</th><th>Confidence</th></tr><tr><td>n/a</td><td>n/a</td><td>n/a</td></tr></table>	Magnitude	Impact significance level	Confidence	n/a	n/a	n/a
Magnitude	Impact significance level	Confidence					
n/a	n/a	n/a					
Summary of governing risk evaluation	<table><tr><th>Consequence</th><th>Likelihood</th><th>Risk rating</th></tr><tr><td>Slight</td><td>Unlikely</td><td>Moderate (E2)</td></tr></table>	Consequence	Likelihood	Risk rating	Slight	Unlikely	Moderate (E2)
Consequence	Likelihood	Risk rating					
Slight	Unlikely	Moderate (E2)					

6.3.14.2 Source of Aspect

Hazardous and non-hazardous inorganic waste will be generated from three main sources the project vessels, MODUs and FPSO facilities.

Hazardous wastes are defined as an object or substance that displays toxic, explosive, poisonous or flammable characteristics, which can no longer fulfil its intended use and requires disposal. Hazardous waste that may be accidentally lost to the marine environment includes:

- + batteries, aerosol cans, empty paint cans, printer cartridges, fluorescent tubes
- + hydrocarbon-contaminated materials (e.g. oily rags, oil filters)
- + contaminated personal protective equipment
- + hazardous process waste, including chemicals (i.e. amine and TEG). PW and MEG may also be treated as hazardous waste for disposal onshore if PW discharge specifications cannot be met – please refer [Section 6.3.12](#).

Non-hazardous wastes are those which are not classified as hazardous (as per the characteristics described above) but which, if released into the marine environment, may pose a threat to receptors through smothering, entanglement or ingestion. Non-hazardous waste includes:

- + paper and cardboard
- + wooden pallets
- + scrap steel, metal, aluminium, cans, etc
- + glass.

These wastes are handled and stored onboard and are transported to shore to be disposed of at licensed onshore facilities.

Hazardous and non-hazardous inorganic wastes can further be separated into three general classifications: buoyant materials, non-buoyant materials and liquids. While each type of waste is generally inert, they demonstrate differing impact pathways:

- + Buoyant materials - Buoyant material such as sacks, wooden pallets, plastic containers or packing/shipping materials are generally inert and non-hazardous. Their release has the potential to directly impact marine fauna due to entanglement, ingestion or smothering, particularly for air breathing marine fauna, which spend a significant amount of time at the surface.
- + Solid non-buoyant materials - These materials are likely to be items such as batteries or scrap metal, which if released to the marine environment are likely to sink, physically impacting the seabed and/or benthic habitats.

- + Liquids - Hazardous liquids include chemicals, hydrocarbons (e.g. oils and lubricants) and paints, where the receptor sensitivity is in relation to toxicity impacts and a reduction in water quality if discharged to the receiving environment.

It is likely that larger volumes of wastes will be generated during drilling, installation, commissioning and decommissioning phases, compared to during operations, where smaller quantities will be generated from routine operational activities such as maintenance facilities). Waste material may be lost to the marine environment because of:

- + human error
- + incorrect or inappropriate waste storage
- + mechanical failure or breakdown of equipment used to store wastes
- + inadequate hazardous waste management.

6.3.14.3 Environmental Impact

In accordance with MARPOL 73/78 and Protection of the Sea (*Prevention of Pollution from Ships*) Act 1983, such waste will not be discharged overboard and will be transferred onshore for recycling or disposal at a licenced waste disposal facility. Therefore, no impacts within the marine environment or Project Area are expected from the generation of general hazardous and non-hazardous inorganic waste during all phases of the proposed Browse to NWS Project.

6.3.14.4 Environmental Risk

Risk event: Unplanned release of hazardous or non-hazardous inorganic waste

An unplanned release of hazardous or non-hazardous inorganic waste during transfer, handling and storage may be caused by human error, equipment or poor weather conditions. An accidental discharge or release of hazardous waste to the marine environment in particular may adversely affect water quality and result in toxicity effects to marine flora or fauna, depending on the nature, volume spilled and location (relative to sensitive receptors) of the accidental discharge, as well as its behaviour in the marine environment (e.g. settlement to seabed, rapid dispersion).

Accidentally released waste has the potential to impact the marine environment in a number of ways depending on the nature of the waste. For non-buoyant waste, the materials would be expected to sink to the seabed, resulting in direct localised impacts to benthic habitats and epibenthic fauna or localised physical impacts on the seabed. The discharge of buoyant materials has the potential to impact marine fauna due to ingestion or smothering, particularly for air breathing marine fauna, which need to come to the sea surface to breathe.

Marine Sediments

Change in sediment quality

The accidental discharge of hazardous waste (in liquid or sludge form) to the marine environment, may potentially result in a localised change in sediment quality. However, even in the unlikely event of such a discharge, it would likely be dispersed and diluted by prevailing currents in the open oceanic waters in the Project Area. Given the location of the activities (minimum depth approximately 125 m near the NRC tie-in point) and the expected rapid dispersion of the discharged waste, the likelihood of a change in sediment quality occurring is considered remote with the subsequent risk assessed to be low.

Water quality

Change in water quality

The accidental discharge of waste (in liquid or sludge form) to the marine environment may potentially result in a localised change in water quality. However, even in the unlikely event of such a discharge it would be subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the Project Area. Given the typical small volumes and temporary duration of accidental discharge events, these would result in a temporary and highly localised change in water quality. The likelihood of an accidental discharge of waste occurring and resulting in change in water quality is considered unlikely with the subsequent risk assessed to be moderate.

Plankton

Injury or mortality to fauna

Plankton populations may be affected by the accidental release of hazardous waste (in liquid or sludge form). Given the localised nature of any changes to water quality, impacts to plankton would be highly localised (limited the immediate area of the release). Given the fast population turnover of open water plankton populations (ITOPF, 2011), the potential impacts are expected to be localised and temporary. The likelihood of an accidental discharge of waste resulting in impacts to plankton is considered unlikely with the subsequent risk assessed to be low.

Benthic habitats

Injury or mortality to fauna – epifauna and infauna

Accidentally discharged non-buoyant waste has the potential to sink to the seabed and impact epifauna. Given the minimum water depth at potential discharge locations (i.e. 125 m at the NRC tie-in), impacts would be limited to the deepwater habitats of the Project Area. Given the likely small size of any accidentally discharged waste, the subsequent impact to these deepwater habitats is expected to be negligible. The likelihood of an accidental discharge of waste resulting in impacts to deepwater habitats is considered highly unlikely, with the subsequent risk assessed to be low.

Change in water quality – shallow water benthic habitats

Accidentally discharged waste can behave in a number of ways depending on the types of waste e.g. buoyant waste would float and eventually degrade (e.g. cardboard) or persist (e.g. plastic), or liquid waste would dissolve and disperse in the water leading to localised and temporary decline in water quality. It should be noted that under normal operating conditions, drilling and vessel activity will be limited to the deep waters in proximity to the location of the proposed development wells and subsea infrastructure or the BTL (> 2 km from Rowley Shoals).

Further, given the small volume of waste that could be accidentally released, it is not considered that even if the accidentally discharged waste reached these sensitive receptors that this would result in lasting impacts to these receptors. The likelihood of an accidental discharge of waste resulting in impacts to shallow water habitats associated with Scott Reef or Rowley Shoals, is considered highly unlikely with the subsequent risk assessed to be low.

Marine fauna

Injury or mortality to fauna

Seabirds

Sandy Islet is used for roosting by seabirds and supports minor seabird breeding colonies including for the little tern. Scott Reef is recognised as a resting BIA for the little tern. The islands of the Rowley Shoals are known to support a wide range of seabird species, including WA's second largest breeding colony of red-tailed tropicbird. The Rowley Shoals have also been identified as BIAs for white-tailed tropicbirds and little terns.

Seabirds and migratory shorebirds have the potential to be impacted by hazardous and non-hazardous inorganic waste associated with the proposed Browse to NWS Project. Anthropogenic disturbance is identified in the Wildlife Conservation Plan for Migratory Shorebirds as a moderate threat to the conservation of migratory shorebirds (Commonwealth of Australia, 2015a). The threat abatement plan for the impacts of marine debris on vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia, 2018) identifies birds as being adversely impacted by marine debris.

Entanglement of seabirds and shorebirds in marine debris can lead to restricted mobility, drowning, starvation and smothering. Ingestion of debris can occur with seabirds and shorebirds confuse the debris with prey species and some species can feed non-selectively and may consume marine debris, particularly ones accumulated in the vicinity of food items leading to physical blockage of the digestive system, leading to internal injuries and pain.

Accidentally discharged buoyant waste has the potential to be carried by currents and reach Scott Reef where seabirds and migratory shorebirds may be present.

Given the controls in place and the distance of the proposed activities from the main aggregation areas, it is considered highly unlikely that an unplanned discharge leading to impacts on seabirds and migratory shorebirds would occur. In the event, this did occur, impacts would be limited to injury or mortality to a small number of individuals. As such this risk has been assessed to be low.

Fish

Injury or mortality to pelagic fish may result from the unplanned discharge of waste, either via toxicity effects or through entanglement with debris. As detailed above, any change in water quality will be highly localised and subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the Project Area. As such, it is not predicted that fish would be exposed to discharge at concentration or durations enough to elicit a toxic response. The entanglement of fish could potentially occur in the event certain solids wastes (such as nets) were accidentally discharged. Given the controls in place and the types of material used on the vessels, MODU and the FPSO facilities, it is considered highly unlikely that injury or mortality to fish will occur as a result of the unplanned discharge of waste. In the event that it did occur, impacts would be limited to a small number of individuals.

Marine mammals

There are BIAs for migration and breeding and calving for the humpback whale along the WA coast and within the NWMR, but there are no known BIAs within the Project Area. A migratory BIA exists for the pygmy blue whale which extends for most of the length of the NWMR within offshore waters and encompasses Scott Reef. It also documents a possible foraging area at Scott Reef which encompasses the majority of Scott Reef. The threat abatement plan for the impacts of marine debris on vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia, 2018) identifies whales as being adversely impacted by marine debris.

Entanglement in marine debris has been identified as a threat for the recovery of the Humpback whale in the Conservation advice for this species (Threatened Species Scientific Committee, 2015e), in addition, marine debris is listed as presenting a possible threat with minor consequences to pygmy blue whales in the conservation management plan for the Blue whale (Commonwealth of Australia, 2015c). Humpback whales and pygmy blue whales could potentially become entangled in marine debris causing restricted mobility and starvation. Given the controls in place, the types of material used on the vessels and the FPSO facilities, and the low numbers of whales likely to occur in proximity to the proposed activities, it is considered the likelihood that injury or mortality to whales occurring as a result of the unplanned discharge of waste is remote.

Marine turtles

Sandy Islet and the surrounding waters have been identified as habitat critical to the survival of green turtles in the DoEE's Recovery Plan for Marine Turtles 2017-2027 (Commonwealth of Australia, 2017a) ([Figure 5-27](#)). In addition, a BIA exists for interbreeding green and hawksbill turtles around Sandy Islet with interbreeding occurring just offshore in waters 4-15 m deep (Commonwealth of Australia, 2017a). Marine debris (entanglement and/or ingestion) is highlighted within the Recovery Plan for Marine Turtles in Australia as a moderate threat to green turtles within the Scott Reef and Browse Island area (Commonwealth of Australia, 2017a). The Threat Abatement Plan for the impacts of marine debris on vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia, 2018) identifies marine turtles as being adversely impacted by marine debris.

Marine turtles frequently ingest plastic bags, confusing them with jelly fish which is common prey for all turtles. Their flippers can also become entangled in waste which may lead to restricted mobility, drowning and amputation of limbs.

Given the controls in place and the distance of the proposed activities from Sandy Islet (where marine turtles nest), it is considered highly unlikely that an unplanned discharge leading to impacts on marine turtles would occur. In the event, this did occur, impacts would be limited to injury or mortality to a small number of individuals. As such this risk has been assessed to be low.

Assessment against EPBC conservation plans and advices

[Table 6-113](#) provides an assessment of the risk related to hazardous and non-hazardous inorganic waste in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-113 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – hazardous and non-hazardous inorganic waste

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Vertebrate wildlife	The threat abatement plan for the impacts of marine debris on vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia, 2018)	Contribute to long-term prevention of the incidence of marine debris. No explicit management actions for non-related industries.	Controls will be in place to prevent the discharge of solid waste and resultant marine debris. Therefore, it is considered that the proposed activities are not inconsistent with the Threat Abatement Plan.
Migratory shorebirds	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)	Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated.	It is considered the risk of impacts to migratory shorebirds as a result of unplanned discharge of hazardous and non-hazardous inorganic waste is low. Therefore, it is considered that the proposed activities are not inconsistent with the Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a) .
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	Given the low number and infrequent nature of whale shark presence in the Project Area, it is considered the risk of impacts to whale sharks as a result of unplanned discharge of hazardous and non-hazardous inorganic waste is low. Therefore, it is considered that the activities are not inconsistent with the conservation advice.
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Support the implementation of the EPBC Act Threat Abatement Plan for the impacts of marine debris on vertebrate marine life. In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival is predicted to be met	Controls will be in place to prevent the discharge of solid waste and resultant marine debris. Therefore, it is considered that the proposed activities are not inconsistent with threat abatement plan. In relation to the Scott Reef – Browse Island green turtle genetic stock, as the risk posed to marine turtles from the unplanned discharge of hazardous and non-hazardous inorganic waste has been assess as low, the priority action to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival is predicted to be met. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Marine debris is identified as a potential threat with minor consequences in the plan, however no specific management actions identified.	Controls will be in place to prevent the discharge of solid waste and resultant marine debris. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback whale	Conservation Advice for <i>Megaptera novaeangliae</i> (humpback whale) (Threatened Species Scientific Committee, 2015e)	Entanglement in marine debris is identified as a threat to humpback whale in the advice, however no specific management actions identified.	

Key Ecological Features

The Continental slope demersal fish communities KEF and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs overlap with the Browse Development Area. The BTL traverses the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF (depending on the final BTL route) and the Ancient coastline at 125 m depth contour KEF. The conservation values of these KEFs are described in [Section 5.3.3.1](#). Unplanned discharge of hazardous and non-hazardous inorganic waste could potentially occur from project vessels, MODU or FPSO facilities within these KEFs. The relevant pressure related to hazardous and non-hazardous inorganic waste discharge is not identified as a concern for this KEF within the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Change in sediment quality

As discussed above, the risk presented by the unplanned discharge of hazardous or non-hazardous inorganic wastes to sediment quality in the deep waters of the Project Area has been assessed as low. As such no impacts to the conservation values of these KEFs is predicted.

Change in water quality

As discussed above, the risk presented by the unplanned discharge of hazardous or non-hazardous inorganic wastes to water quality has been assessed as low. As such no impacts to the conservation values of these KEFs is predicted.

Injury or mortality to fauna

As discussed above, the risk presented by the unplanned discharge of hazardous or non-hazardous inorganic wastes to plankton and other marine fauna such as seabirds and migratory shorebirds, fish, marine mammals and marine reptiles has been assessed as low. As such no impacts to the conservation values of these KEFs is predicted.

Summary

[Table 6-114](#) provides an assessment of the risk associated with unplanned hazardous and non-hazardous waste discharge in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-114 Alignment with protection of conservation values of KEFs – hazardous and non-hazardous inorganic waste

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Chemical pollution/contaminants	It is considered the risk of adverse impacts to water quality and marine fauna as a result of unplanned discharge of hazardous and non-hazardous inorganic waste is low.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex		Marine debris	
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals		Oil pollution	Therefore, there is a high level of confidence that there will not be an adverse impact to marine ecosystem function or integrity within the KEFs; or any reduction to the conservation values of the KEFs will occur.
Ancient coastline at 125 m depth contour			

Australian marine parks

Vessels associated with the installation of the BTL and transiting project vessels will discharge sewage and sillage within the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley AMPs. Unplanned discharge of hazardous and non-hazardous inorganic waste could potentially occur from project vessels facilities within these AMPs during installation of the BTL and intermittent IMR activities. It should be noted that the risk of accidental discharge of hazard and non-hazardous inorganic waste in the AMPs is low given proposed activities within the AMPs will only occur for a short duration of time.

Change in sediment quality

As discussed above, the risk presented by the unplanned discharge of hazardous or non-hazardous inorganic wastes to sediment quality in the deep waters of the Project Area has been assessed as low. As such no impacts to the conservation values of these AMPs is predicted.

Change in water quality

As discussed above, the risk presented by the unplanned discharge of hazardous or non-hazardous inorganic wastes to water quality has been assessed as low. As such no impacts to the conservation values of these AMPs is predicted.

Injury or mortality to fauna

As discussed above, the risk presented by the unplanned discharge of hazardous or non-hazardous inorganic wastes to plankton and other marine fauna such as seabirds and migratory shorebirds, fish, marine mammals and marine reptiles has been assessed as low. As such no impacts to the conservation values of these AMPs is predicted.

Summary

Table 6-115 provides an assessment of the risk associated with hazardous and non-hazardous inorganic waste in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Table 6-115 Alignment with the North-west Marine Parks Network Management Plan – hazardous and non-hazardous inorganic waste

Australian Marine Park	Relevant plan(s)	AMP Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	It is considered the risk of adverse impacts to water quality and marine fauna as a result of unplanned discharge of hazardous and non-hazardous waste inorganic is low.
Kimberley Marine Park Multi Use Zone (VI)			Therefore, there is a high level of confidence that unplanned discharge of hazardous and non-hazardous inorganic wastes will not result in an adverse impact to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced.
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

State marine parks and nature reserves

Injury or mortality to fauna

Accidentally discharged buoyant waste has the potential to be carried by currents and reach State marine parks and nature reserves such as the Rowley Shoals Marine Park and the Scott Reef Nature Reserve. There is potential that the fauna species utilising these areas are impacted by debris reaching the area. As discussed above, the risk presented by the unplanned discharge of hazardous or non-hazardous inorganic wastes to marine fauna such as seabirds and migratory shorebirds, fish, marine mammals and marine reptiles has been assessed as low. As such no impacts to the conservation values of these State marine parks and nature reserves are predicted.

Other protected places

Change in water quality

The Scott Reef and Surrounds - Commonwealth Area Commonwealth Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef. The Commonwealth Heritage Place is utilised by seabirds, marine mammals and marine turtles; and supports diverse fish and coral communities. Project vessels will not operate within this area under normal operations. Given the above assessment of potential changes to sediment quality and water quality; and the potential impacts to marine fauna, the risk posed by the accidental discharge of hazardous or non-hazardous inorganic waste to the conservation values of the Scott Reef and Surrounds, Commonwealth Area and Mermaid Reef, Rowley Shoals Commonwealth Heritage Places is considered low.

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that the risk to marine fauna including fish has been assessed as low no subsequent impact to fisheries is expected.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

As described above, the risk posed by unplanned discharge of hazardous and non-hazardous organic waste on water quality, Scott Reef shallow water benthic habitat (<75 m bathymetry) and marine fauna has been assessed as low. As such activities such as tourism and recreation and scientific studies at Scott Reef are highly unlikely to be impacted.

6.3.14.5 Cumulative Impacts

No hazardous or non-hazardous inorganic waste discharge to the environment is proposed during any phase of the proposed Browse to NWS Project and as such no cumulative impacts are predicted.

6.3.14.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the risk assessments, and the adopted controls for marine discharges: hazardous and non-hazardous inorganic waste is provided in [Table 6-116](#). The acceptability assessment is provided in [Table 6-117](#).

Table 6-116 Risk assessment summary and adopted controls – marine discharges: hazardous and non-hazardous inorganic waste

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Sediment quality (medium value (open waters))	Unplanned discharge of hazardous and non-hazardous organic waste	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.	<i>MODU and project vessel operations</i> + Waste storage areas will allow segregation into recyclable and non-recyclable wastes. + Segregated waste will be securely stored through the provision of appropriate waste receptacles and suitable containment measures such as lids and netting to prevent any loss of wastes to the marine environment.	Negligible	Remote	Low (F1)
Water quality (medium value (open waters))		Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	+ Non-hazardous solid waste will not be discharged into the marine environment and will be transported onshore to a recycling contractor or appropriate waste disposal site in accordance with MARPOL 73/78 Annex V: Garbage (as implemented in Commonwealth waters by the Protection of the Sea (Prevention of Pollution from Ships) Act 1983) and Marine Order 95 (Marine Pollution Prevention – Garbage).	Slight	Unlikely	Moderate (E2)
Plankton (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	+ Hazardous waste will not be discharged to the marine environment and will be transported to shore for disposal in accordance with MARPOL 73/78 Annex III: Packaged Harmful Substances (as implemented in Commonwealth waters by the Protection of the Sea (Prevention of Pollution from Ships) Act 1983) and Marine Orders 93 (Marine Pollution Prevention – noxious liquids), 94 (Marine Pollution Prevention – packaged harmful substances) and 95 (Marine Pollution Prevention – Garbage).	Negligible	Unlikely	Low (F2)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)		Objective 9: To avoid direct (i.e. physical footprint) disturbance to Scott Reef shallow water benthic habitat (<75 m bathymetry). Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	+ In the event that hazardous or non-hazardous inorganic waste is released to the marine environment, any surface residue will be recovered where safe to do so.	Slight	Highly unlikely	Low (E1)
Deepwater benthic communities and habitats (>75 m depth) – (medium value)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.	+ Hazardous waste will be handled and stored in accordance with the relevant SDS and tracked from source to its final destination, where applicable. + Waste management measures will be included in the relevant Environment Plans and will specify the appropriate disposal method for hazardous waste, including NORM and mercury-contaminated solids (if encountered).	Slight	Highly unlikely	Low (E1)

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Seabirds and migratory shorebirds (high value species)		Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population. Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		Slight	Highly unlikely	Low (E1)
Fish (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		Slight	Highly unlikely	Low (E1)
Marine turtles (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.		Slight	Highly unlikely	Low (E1)
Marine mammals (high value species)		Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		Slight	Highly unlikely	Low (E1)
KEFs (medium value)		Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population. Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		Slight	Highly unlikely	Low (E1)
AMPs (medium value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		Slight	Highly unlikely	Low (E1)
State marine parks and nature reserves (high value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		Slight	Highly unlikely	Low (E1)
Other protected places (high value)		Objective 18: Two not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		Slight	Highly unlikely	Low (E1)
Managed fisheries (high value user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Slight	Highly unlikely	Low (E1)
Other users (scientific studies, tourism and recreation) (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Slight	Highly unlikely	Low (E1)

Table 6-117 Acceptability assessment – hazardous and non-hazardous inorganic waste

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts and risks associated with hazardous and non-hazardous inorganic waste as: + Controls, including the implementation of Navigation Act 2012, MARPOL and the various Marine Orders (as appropriate to vessel class) will be implemented to mitigate potential impacts. + There is a good understanding of the hydrodynamic regime in the Project Area and it is expected that if there was an accidental discharge of liquid waste there would be rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the Project Area so that any changes in water quality would be temporary and localised.
Principles of ESD There are no planned discharges of hazardous or non-hazardous inorganic waste. With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> There are no planned discharges of hazardous or non-hazardous inorganic waste. As such, no impact to listed threatened species or migratory species is predicted to occur. As described in Table 6-116, potential risk events associated with the unplanned discharge of hazardous and non-hazardous waste are predicted to present a Low risk to marine fauna species such as seabirds and migratory shorebirds, fish, marine mammals and marine turtles. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted <u>Commonwealth Marine Environment</u> There are no planned discharges of hazardous or non-hazardous inorganic waste. As such, no impact to the Commonwealth marine environment is predicted to occur. As described in Table 6-116, potential risk events associated with the unplanned discharge of hazardous and non-hazardous waste are predicted to present a Low risk to sediment quality, water quality, plankton, deepwater benthic communities and habitats (>75 m depth), shallow water benthic communities and habitats (<75 m depth), marine fauna, KEFs, AMPs and other protected places. As such, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the risks associated with unplanned hazardous and non-hazardous inorganic waste discharge against the WA EPA Objective is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Marine environmental quality

There are no planned discharges of hazardous or non-hazardous inorganic waste. As such, no impact to marine environmental quality within the State Proposal Area is predicted to occur.

As described in [Table 6-116](#), potential risk events associated with the unplanned discharge of hazardous and non-hazardous waste are predicted to present a moderate risk to water quality and a low risk to sediment quality and plankton, deepwater benthic communities and habitats (>75 m depth), shallow water benthic communities and habitats (<75 m depth) and marine fauna.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*to maintain the quality of water, sediment and biota so that environmental values are protected*” will be achieved.

Marine Fauna

There are no planned discharges of hazardous or non-hazardous inorganic waste. As such, no impact to marine fauna within the State Proposal Area is predicted to occur.

As described in [Table 6-116](#), potential risk events associated with the unplanned discharge of hazardous and non-hazardous waste are predicted to present a Low risk to marine fauna species such as seabirds and migratory shorebirds, fish, marine mammals and marine turtles.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*To protect marine fauna so that biological diversity and ecological integrity are maintained.*” will be achieved.

Benthic communities and habitats

There are no planned discharges of hazardous or non-hazardous inorganic waste. As such, no impact to benthic habitats and communities within the State Proposal Area is predicted to occur.

As described in [Table 6-116](#), potential risk events associated with the unplanned discharge of hazardous and non-hazardous waste are predicted to present a Low risk to deepwater benthic communities and habitats (>75 m depth) and shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*” will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders regarding general waste in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact and risk assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)) The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-113](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + The threat abatement plan for the impacts of marine debris on vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia, 2018)
- + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)
- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b).

Key Ecological Features

As detailed in [Table 6-114](#), unplanned discharge of hazardous and non-hazardous inorganic waste will not materially increase existing relevant pressures on the conservation values of the KEFs.

AMPs

As detailed in [Table 6-115](#), the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other Protected Places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.15 Marine Discharges: Drilling or Completions Discharges

6.3.15.1 Impact and Risk Overview

[Table 6-118](#) presents an overview of the potential impacts and risks from the discharge of drilling or completions discharges associated with drilling activities for proposed Browse to NWS Project.

Table 6-118 Marine discharges: drilling or completions discharges impact and risk overview

Aspect	Marine discharges: drilling or completions discharges
Description	During development drilling for the proposed Browse to NWS Project, up to 54 production wells will be drilled and completed, 24 of which will be in the State Proposal Area, with the remaining 30 located Commonwealth waters. Drilling of production wells will generate drill cuttings, require cementing of the casing, and require the use of a range of fluids, that may be discharged to the marine environment, typically at the seabed and at or near the sea surface depending on the hole section.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	Drilling and Completions
Environmental objectives	The environmental objectives in relation to drilling or completions discharges (drill cuttings and drilling or completion fluids) associated with the proposed Browse to NWS Project are: Objectives 1, 2, 3, 6, 7, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21. These objectives are detailed in Table 6-7 .

Aspect	Marine discharges: drilling or completions discharges
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-120). + Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) + WA EPA Environmental Factor Guideline - Benthic Communities and Habitats (EPA, 2016c) + WA EPA Technical Guidance - Protection of Benthic Communities and Habitats (EPA, 2016d) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. Physical + sediment quality (low value (open waters)) + water quality (low value (open waters)) Ecological + plankton (low value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + fish (high value species) + marine reptiles (high value species) + marine mammals (high value species) + KEFs (high value) + Other protected places (high value) Socio-economic + State and Commonwealth managed fisheries (high value marine users) + other users + tourism and recreation (high value user) + scientific studies (high value user) + aboriginal or indigenous heritage (high value users)
Potential impacts	+ change in water quality + change in sediment quality + injury or mortality to fauna + change in habitat + changes to the functions, interests or activities of other users

Aspect	Marine discharges: drilling or completions discharges		
Risk	Distribution of drilling or completions discharges significantly greater than expected leading to increased spatial extent of: + change in water quality + change in sediment quality + injury or mortality to fauna + change in habitat		
Summary of governing impact evaluation	Magnitude	Impact significance level	Confidence
	Minor	Minor (D)	High
Summary of governing risk evaluation	Consequence	Likelihood	Risk rating
	Moderate	Remote	Low (D0)

6.3.15.2 Source of Aspect

Development well construction activities associated with the proposed Browse to NWS Project involve the drilling and completion of up to 54 production wells, with 24 wells in the State Proposal Area and the remaining 30 in Commonwealth waters. Drilling and completion of production wells will generate drill cuttings, require cementing of the casing, and require the use of a range of fluids, that may be discharged to the marine environment, typically at the seabed and at or near the sea surface depending on the hole section.

During the life of the proposed Browse to NWS Project, well components will require maintenance, repair or replacement. This will require well intervention and/or well workovers. Relevant discharge types generated from these activities may include subsea control fluid (control of subsea tree) (refer to [Section 6.3.16](#) and completions fluids).

In addition, well abandonment activities can result in discharges to the marine environment including but not limited to installation and pressure testing of the blow out preventer (BOP), cutting/perforation of casing or production tubing; and installation of permanent reservoir and surface barrier (cementing). Relevant discharge types generated from these activities may include subsea control fluids (refer to [Section 6.3.16](#)), well completion fluids and cement.

Drilling and completion activities required for the proposed Browse to NWS Project are expected to be broadly similar to that of the previous development concepts ([Section 2.7.1](#)).

Drill cuttings

Drilling generates drill cuttings due to the breakup of solid material from within the borehole. The resultant drill cuttings are basically rock particles of various shapes, with sizes typically ranging from very fine to very coarse. Cuttings generated during drilling of the top-hole sections are typically discharged to the seabed at the well site.

Once the top-hole sections are complete, installation of the riser and BOP provides a conduit back to the MODU, forming a closed circulating system. The bottom hole sections will be drilled with a marine riser in place that enables cuttings and drilling fluids to be circulated back to the MODU, where the cuttings are separated from the drilling fluids by the solids control equipment (SCE). The SCE comprises equipment such as shale shakers, cuttings dryer(s) and centrifuges. The SCE uses shale shakers to remove coarse cuttings from the drilling fluid. The recovered fluids from the cuttings may then be directed to centrifuges, which are used to remove fine solids (4.5 to 6 µm). The cuttings are usually discharged below the water line and the fluid is recirculated into the fluid system.

The drilling fluid retained on cuttings is determined by the SCE and typically, treated water based fluid (WBF) cuttings may retain 5 to 25% of the drilling fluid after passage through SCE (Neff, 2005) and treated cuttings when drilling with non water based fluid (NWBF) may retain 5 to 15% of the drilling fluid (Neff et al., 2000). The cuttings with retained NWBF also pass through a cutting's dryer and associated SCE, to reduce the average oil on cuttings to 6.9% wt/wt or less on wet cuttings, prior to discharge.

The fate and dispersion of the cuttings once discharged into the marine environment is determined by particle size and the density of the unrecoverable fluids. The larger cuttings particles will drop out of suspension and deposit in close proximity to the well site (tens of metres) with potential for localised spreading downstream. In contrast, the finer particles will remain in suspension and be transported away from the well site, rapidly diluting and eventually depositing over a widespread area (hundreds of metres) downstream of the well site.

Drill cuttings and unrecoverable fluids are discharged at the seabed at each well site for the top-hole sections drilled riser-less (no closed loop with the MODU). This results in a localised area of sediment deposition (known

as a cuttings pile) in close proximity to the well site. The spread of cuttings and associated water based fluids is expected to be up to 50-200 m downstream from the discharge location based on a review of seven studies summarised by International Association of Oil and Gas Producers (IOGP, 2016). Drill cuttings and retained NWBF (<6.9% OOC) released at or below the surface after treatment on the MODU for the bottom-hole well sections are generally dispersed and settle within a seabed area confined to a maximum of 500 m distance of the discharge point (IOGP, 2016).

Drilling fluids

Drilling fluids (also termed drilling muds) serve many purposes including maintaining borehole stability and hydrostatic pressure, reducing friction and cleaning/cooling of the drill bit, in addition to acting as a medium to carry cuttings from the well bore and return them to the surface at seabed or on the MODU. Drilling fluids are either mixed on the MODU or received pre-mixed, then stored and maintained in a series of mud pits aboard the MODU or a suitable vessel. There are two main types of drilling fluids, including water based fluids (WBF) and non-water based fluids (NWBF).

Water based drilling fluids

The proposed Browse to NWS Project will use WBF as the preferred option. WBF consists mainly of seawater with the addition of chemical and mineral additives to aid in its function. Drilling additives typically used may include chlorides (e.g. sodium, potassium), bentonite (clay), cellulose polymers, guar gum, barite or calcium carbonate. These additives are either completely inert in the marine environment, naturally occurring benign materials, or readily biodegradable organic polymers with a very fast rate of biodegradation in the marine environment.

WBF will be discharged to the marine environment at the location of the well being drilled under the following scenarios:

- + at the seabed when drilling the top-hole (riser less) sections
- + below sea surface as fluid remaining on drill cuttings, after passing through SCE (bottom-hole sections, drilled with riser in place)
- + from the mud pits via a discharge pipe below the sea surface. If WBF cannot be re-used due to bacterial deterioration or does not meet required drilling fluid properties, it may be discharged to the marine environment using seawater flushing. WBF may not be able to be reused between drilling sections due to the drilling sequence, technical requirements of the fluid (i.e. no tolerance for deterioration of fluid during storage) and maintenance of productivity/injectivity. Unused or spent WBFs may be disposed from the MODU as a bulk discharge (defined as a

discrete discharge of large quantities) at the end of each well section.

Additional products such as barite and bentonite may be discharged in bulk/single discharge at the end of the activity if they cannot be reused or taken back to shore. Use and discharge of all chemicals will be performed in line with Woodside's chemical selection and assessment process and approved prior to use. Discharge may be in the form of dry bulk or as a slurry; however, discharges will not be contaminated with hydrocarbons. Planned bulk discharges at wells within the State Proposal Area will be managed in accordance with the **Management Approach for Torosa wells in State Proposal Area** (refer to later sub-section).

Non water based drilling fluids

Non-water-based fluids (NWBF) refers to drill fluids that are hydrocarbon rather than water based fluid. NWBF may be used to manage well stability to safe levels based on the offset history, geohazards assessment and borehole stability studies. Like a WBF system, a range of standard solid and liquid additives may be added to alter specific fluid properties for each section of the well, dependent on the conditions encountered while drilling. NWBFs will be selected in accordance with Woodside's chemical selection and assessment process on the basis of lowest health, safety and environmental risks while meeting operational requirements.

During drilling operations, the NWBF (like WBF) are pumped by high pressure pumps down the drill string and out through the drill bit, returning via the annulus between the drill string and the casing of the well bore, and back to the MODU via the riser. Discharge scenarios are much the same as that described for WBF, however NWBF will not be used for top-hole section drilling (riserless); therefore, no direct seabed discharge of NWBF will occur.

The NWBF that cannot be re-used (i.e. do not meet required drilling fluid properties or are mixed in excess of required volumes) are recovered from the mud pits and returned to the shore base for onshore processing for recycling and/or disposal. The mud pits and associated equipment/ infrastructure are cleaned when NWBF is no longer required, with wash water discharged with mud pit washings, or returned to shore for disposal if discharge criteria cannot be achieved.

There are typically a number of mud pits (tanks) on the MODU that provide a capacity to mix, maintain and store fluids required for drilling activities. The mud pits form part of the drilling fluid circulating system. The mud pits, any supply vessel storage tanks carrying WBF or NWBF, and associated equipment/infrastructure are cleaned out during and at the end of drilling and completions operations. Mud pit wash residue is operationally discharged from the MODU with less than 1% oil contamination by volume. Where the mud pit residue

exceeds 1% by volume, the residue will be retained and disposed onshore.

Drilling fluids toxicity

Components of the WBF system have a low toxicity. Bentonite and guar gum are listed as 'E' category fluids under the OCNS and is included on the Oslo Paris (OSPAR) Commission PLONOR (chemicals that 'pose little or no risk to the environment') list (OSPAR, 2019). They may, however, cause physical damage to benthic organisms by abrasion or clogging, or through changes in sediment texture that can inhibit the settlement of planktonic larvae, such as polychaete and mollusc early life stages (Swan et al., 1994). However, these impacts are not expected to be significant due to the rapid biodegradation and dispersion of WBFs (Terrens et al., 1998).

NWBF may contain a range of synthetic hydrocarbons, such as paraffins and olefins; however, such additives are designed to be low in toxicity and biodegradable, as well as not being readily bioavailable or likely to bioaccumulate amongst the deepwater benthic biota that live within the seabed (infauna) or on the seabed (epifauna). However, it is noted that microbial biodegradation can result in oxygen reduction within sediments. Nedwed et al. (2004), however, found that depth is an important factor for residual concentrations of NWBF once they reach the seabed, suggesting that loss of base fluid during settling acted to significantly reduce chemical effects from discharges. It is also noted that NWBF cuttings tend to clump and settle to the seabed rapidly adding to the cuttings pile in proximity to the well site. The Nedwed et al. (2004) study concluded that NWBF discharged in deep water caused very limited environmental impacts (from analysis of differences in benthic fauna between pre- and post-drilling samples).

Cement

Once each of the top-hole sections are drilled, casing is installed in the wellbore and secured in place by pumping cement into the annular space and may involve a discharge of excess cement at the seabed (~80 m³/well). Wherever possible, the cement line flush volumes are included in the planned cement jobs. When a job is completed, the cement unit is cleaned, and the residual cement discharged overboard. The discharge volumes of residual cement products are approximately 1 m³.

At the commencement of the drilling campaign there may be a requirement to run a cement unit test to test the functionality of the cement unit and the cement bulk delivery system prior to performing an actual cement job. This test would result in a small volume of approximately 10 m³ of cement slurry being discharged at surface to sea. The slurry is usually a mix of cement and water however may sometimes contain stabilisers or chemical additives. Excess cement (dry bulk) after well operations are completed, will be held onboard

and used for subsequent wells, provided to the next operator at the end of the program, or discharged to the marine environment. Planned bulk discharges at wells within the State Proposal Area will be managed under the **Management Approach for Torosa wells in State Proposal Area** (refer to later sub-section).

Completion fluids

Completion fluids are usually brines (i.e. a mixture of seawater or formation water) with additives that can include chlorides (often sodium, potassium or calcium), bromides, hydrate inhibitor (MEG), biocide and/or oxygen scavenger. They are designed to have the proper density and flow characteristics to be compatible with the reservoir formation. Completion fluids may also include solids-free fluid, gravel pack carrier fluid and loss circulation material. Completion fluids are used during wellbore clean-up, while running completions, and may be returned to surface during well unload activities. Most of the gravel pack carrier fluid is bulk discharged.

Wellbore and casing clean-up are required at various stages of the operations to ensure the contents of the well are free of contaminants before the next stage of well construction. A chemical wellbore cleanout fluid train may be used to remove residual fluids (including NWBF, if used) from the wellbore. The wellbore cleanout fluid is usually brine (similar to completion fluid) that can include several chemicals, such as biocide and surfactant. During the wellbore clean-out process, fluids are circulated back to the MODU, and, if required, analysed before they are discharged overboard. Discharge volume would be ~400 m³ (based on the designs of the proposed production wells).

A brine of adequate density to control formation pressure may also be used during well suspension or well abandonment.

Well unload

During well unloading activities, all completion and reservoir fluids will be flared or discharged to the environment. The base oil column, completion fluid, some drilling fluid remnants, hydrocarbons and produced/condensed water will be measured, handled, separated, treated for overboard discharge (non-hydrocarbon) and flared/burned (hydrocarbon) through the temporary production system on the MODU.

The well test water treatment package will be used to treat produced/reservoir water before discharge. Prior to discharging, the fluids are cycled through an oilbond filtration system and gauge tank. Water filtration is standard practice for well unloading operations.

Discharges will occur during well unloading to a MODU or suitable vessel. These discharges will constitute leftover drilling fluids, completion fluids and small amounts of produced water (PW; refer to [Section 6.3.12](#)). Well unloading is anticipated to take 1-2 days per well, and discharge of fluids during this time has been indicatively estimated at approximately 100 m³ to 130 m³ per well.

Well annular fluids

Annular fluids fall within the category of completion fluids and refer to the fluids that remain in the annular spaces between the casing and previous casing strings or formation. It may consist of weighted drilling fluid and cement-contaminated mud, seawater, barite, cement, polymer, and may include small amounts of hydrocarbon. For the proposed Browse to NWS Project, the reference case annular fluid is base oil with no additives apart from a demulsifier.

If a well is underperforming, or surveillance indicates debris is contained within the well, the contents of the wellbore may be flowed to a MODU. This displaces the well fluids (i.e. suspension/completion fluids). These are discharged overboard, as potential gas content makes it too dangerous for personnel to filter or treat them.

WBF used during riserless drilling will be released to the marine environment when the well head is removed during abandonment. Upon wellhead removal, small volumes (~ 1 m³) of fluid exchange between the annular spaces and the ocean may occur. The exchange will not

be instantaneous as the annular spaces are small and the fluids are typically heavier than seawater, however, as the fluids are released it is expected that they will be rapidly diluted within metres of the release location.

Overview of drill cuttings and drilling fluids

An indicative well profile is shown in [Table 6-119](#). During drilling of the top-hole well sections drill cuttings (~ 625 m³) and drilling fluids (~ 1,095 m³) based on a typical well profile are generated and will be released from the well directly onto the seabed. During drilling of the bottom-hole well sections, drill cuttings (~ 225 m³) and drilling fluids (~ 1,020 m³) based on a typical well profile are generated and may be discharged at or below the sea surface.

Contingent drilling activities include well side-track and well resud. If either of these activities are required, they will result in additional volumes of drilling discharges equal to the re-drilled sections of the well. The impacts of these unlikely scenarios are broadly covered by the base case impact assessment considerations.

It should be noted that the detailed impact evaluation with modelling is based on the primary drilling discharges (cuttings and residual fluids) due to the nature, scale and duration of the discharge compared to other sources (e.g. completion fluids). These results have been used to support impact and risk assessment and in the determination of acceptability in the context of the receiving environment and relevant receptors.

Table 6-119 Indicative cuttings volumes and fluid type for a typical Browse well

Indicative well section diameter	Indicative Drill Length (m)	Indicative Cuttings Volume (m ³)	Indicative Fluids Volume (m ³)	Indicative Fluid Type
42"	100	89 m ³	427	Seawater with bentonite sweeps
26"	440	151 m ³	1327	Seawater with bentonite sweeps
16"	2970	385 m ³	965	Weighted Gel (Bentonite) WBF
12 ¼"	2799	213 m ³	925	WBF or NWBF
9 7/8"	243	12 m ³	790	WBF or NWBF
Total per well	6,552 m	850 m³	4,435 m³	

6.3.15.3 Modelling

Modelling was undertaken by DHI (DHI Water & Environment Pty Ltd (DHI), 2011, 2010)²³ to assess the dispersion of and sedimentation by drill cuttings (and residual fluids) from the drilling of wells proposed within the Torosa reservoir, as part of the previous JPP development concept for the Browse resource. The modelling was subsequently used for the previous FLNG development concept, given that the change in development concept does not alter well installation methodology.

Torosa was selected for modelling given its proximity to Scott Reef and, hence, elevated potential for impacts to high value shallow water benthic habitats (i.e. worst-case scenario). The assessment focused on identifying sedimentation impacts to coral habitats at Scott Reef to inform the management approach (and associated effectiveness of controls) that may be adopted for the drilling campaign. Furthermore, the modelling provided an indication of dispersion for all other wells associated with the proposed Browse to NWS Project.

It is considered that this modelling remains representative for the proposed Browse to NWS project due to the governing hydrodynamics, similar input data and commitment with regard to undertaking the activity in such a manner that it results in no impacts to the Scott Reef shallow water benthic communities and habitats (<75 m water depth). Additional modelling will be completed to support Environment Plans under Petroleum legislation, following further detailed design.

Modelling scenarios and discharge volume

For the previous development concept, production wells within the Torosa reservoir were proposed within three main locations, namely the TRE drill centre (approximately 2 km from South Scott Reef), the TRD drill centre (approximately 3 km from North Scott Reef) and the previous TRA/TRB drill centre (approximately 8 km from North Scott Reef) (DHI, 2011) ([Figure 6-34](#) to [Figure 6-36](#)).

To appropriately assess the potential for impacts to Scott Reef (including potential cumulative impacts), the model simulated drilling 25 wells at the three locations (6 at the TRE drill centre, 7 at the TRD drill centre and 12 at the TRA/TRB drill centre) over an 18-month period. This provides a comparative approach for the assessment of the proposed Browse to NWS Project given 24 wells are proposed within the State Proposal Area.

At each of the three previously proposed drilling locations, modelling parameters for each well included:

- + Seabed discharge from top-hole sections of each well equivalent to a cuttings volume of 584 m³, which is comparable to the current well design volume of ~625 m³.

- + Sea surface discharge from bottom-hole sections of each well equivalent to a cuttings volume of 181 m³, which is comparable to the current well design volume of ~225 m³.

Modelling studies

Modelling was undertaken using the calibrated and validated 3D hydrodynamic model (MIKE 3 Classic) for Scott Reef and surrounds to run the Lagrangian-based particle module for simulating sediment dispersion, sedimentation and resuspension of the drill cuttings releases.

Although actual volumes, discharge rates and scheduling of drilling activities are yet to be confirmed, modelling assumptions provided for a conservative assessment of potential impacts from drill cuttings disposal. This is based on the assumption of no intervals between the drilling of different well sections, and the highest number of wells that could be constructed in a year at a location, both of which resulted in higher intensity of cuttings discharge than is likely to occur under actual conditions. Further, the Particle Size Distribution (PSD) of the cuttings adopted in the modelling was based on cuttings PSD measured from the Torosa-5 exploration well, which was expected to provide a good proxy of the sediment particle size for cuttings expected from the proposed drilling locations.

Modelling results

The thresholds for ecological impact to Scott Reef habitats are defined as <10 mg/L for Total Suspended Solids (TSS) concentrations (based on Nelson et al. (2016) and 20 g/m² as a daily net sedimentation rate (based on a low level impact to corals (Negri et al., 2008))

The modelling undertaken in support of the previously approved development concept indicated that, at all three drill centre locations, the sea surface discharge of drill cuttings from well bottom-hole sections resulted in incursions of sediment plumes and associated increased deposition at some parts of North and South Scott Reef including within the lagoons. As a result, Woodside has committed to manage drilling discharges (in particular bottom-hole well section discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD, TRE and TRF) in such a manner to avoid potential impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth) will occur. This management approach is further described in the following section.

In contrast, the seabed discharge of drill cuttings from top-hole well sections may result in sediment plumes and associated deposition of sediment to the surrounding seabed and was confined to the deeper layers of the water column with no contact with deeper water or shallow water coral habitats at Scott Reef. As outlined in [Section 5.2.5.7](#), while there is some evidence of localised

²³ DHI (2011) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides, there is no evidence of persistent upwelling or downwelling currents around Scott Reef (Green et al., 2019) and therefore, no transport mechanisms to mobilise drill cuttings from deep waters to the shallower waters of the reef system. As such, given the location of the drill centres in deep water, which experience strong surface and subsurface currents, drill cuttings and fluid discharge disposal at seabed would be expected to settle rapidly. Therefore, any reduction in water quality such as elevated TSS is expected to occur in a localised area around the drill centre and will be temporary in nature.

To further inform the impact assessment, for the seabed discharge of drill cuttings generated from the top-hole sections of the wells, the modelling results indicated that at the:

- + previously proposed TRE drill centre location (water depths of 360 m):
 - + Sediment plume predominantly extended westward, driven by the stronger ebb tide, with some eastward extension during the flood tide ([Figure 6-34](#)).
 - + Cuttings sedimentation would be limited to the deep seabed and water layers of the channel, with no sedimentation on Scott Reef shallow water benthic communities and habitats (<75 m water depth) including in the lagoons of North and deeper water coral habitat of South Scott Reef.
 - + Maximum net sediment deposition at seabed over the duration of the 12-month drilling program is estimated at approximately 46 cm at the previously proposed TRE drill centre location ([Figure 6-34](#)).

- + previously proposed TRD drill centre location (water depths of 400 m):
 - + Sediment plume confined to the deep-water layers of the water column ([Figure 6-35](#)).
 - + Modelling did not predict elevated suspended sediment concentrations or net sedimentation at Scott Reef shallow water benthic communities and habitats (<75 m water depth) including in the lagoons of North and deeper water coral habitat of South Scott Reef.
 - + Net sediment deposition at seabed over the duration of the drilling program is approximately 35 cm at the previously proposed TRD drill centre location ([Figure 6-35](#)).
- + previously proposed TRA/TRB drill centre location (water depths of 460 m):
 - + Sediment plume confined to the deep-water layers and was not expected to reach Scott Reef shallow water benthic communities and habitats (<75 m water depth) including in the lagoons of North and deeper water coral habitat of South Scott Reef ([Figure 6-36](#)).
 - + Sedimentation was predicted to extend eastwards of Scott Reef, influenced by the north-west south-east tidally-induced currents.
 - + Net sediment deposition at seabed over the duration of the drilling program is approximately 21 cm at the previously proposed TRA/TRB drill centre location ([Figure 6-36](#)).

Maximum suspended sediment concentrations in the water column in the vicinity of the release points (near the seabed) was predicted to reach 1250 mg/L at TRE, 1530 mg/L at TRD and 2500 mg/L at the previously proposed TRA/TRB drill centre location.

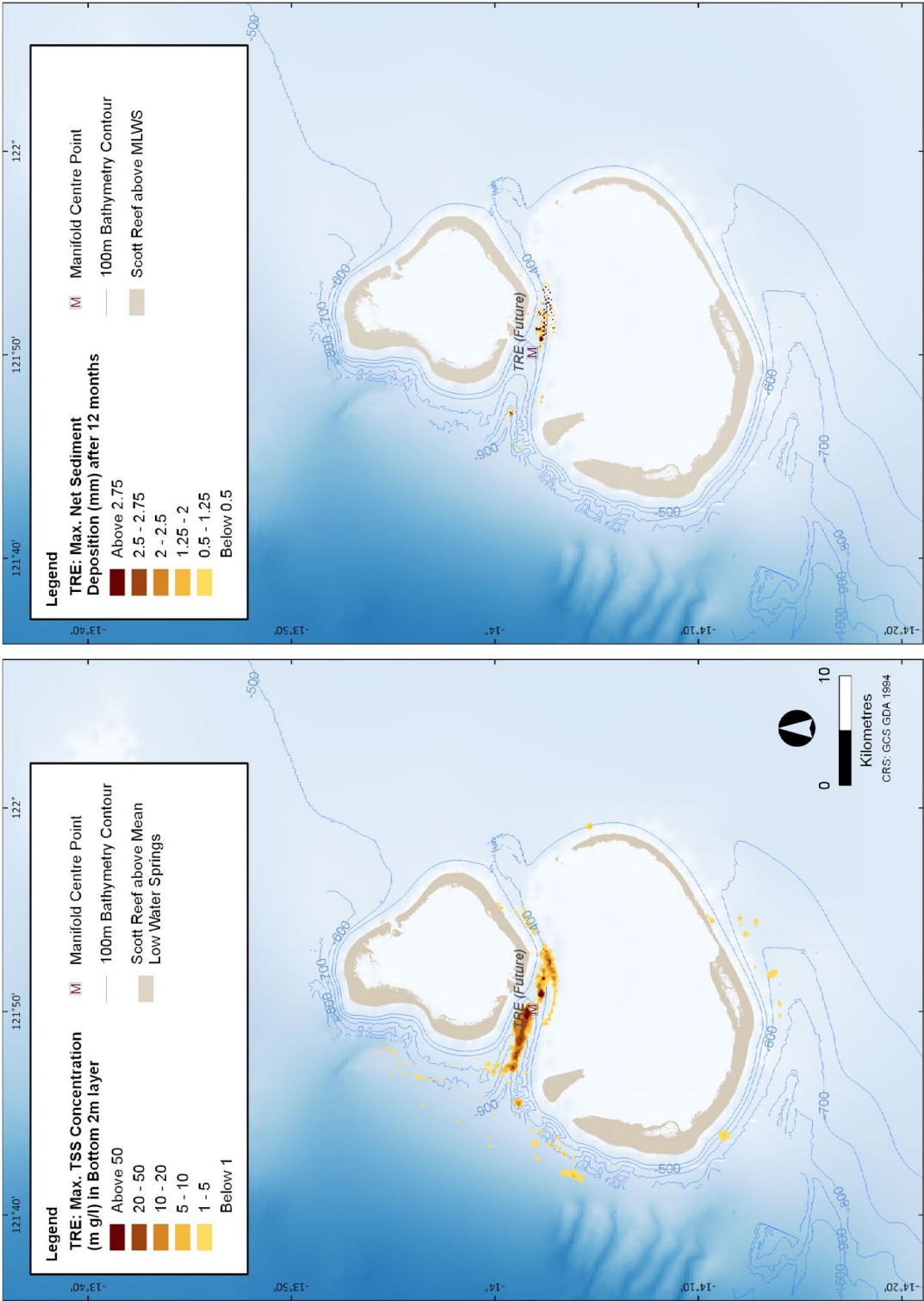


Figure 6-34: Drill Cuttings Discharge at the Seabed at TRE Drill Centre Showing: Maximum TSS Concentration (mg/L) in the Bottom 2 m (left) and Maximum Net Sedimentation (mm) (right) (DHI 2011b)

Note: The contour plots illustrate the overall footprint of elevated suspended solid concentrations and sedimentation over the entire course of the drilling program (12 months) at TRE. It is important to note the occurrence of elevated TSS concentrations and sedimentation shown in the contour plots are cumulative and represent the maximum concentrations for the whole modelled drilling program. This approach allows for the prediction of any areas at Scott Reef where elevated turbidity or sedimentation may occur over the modelled drilling period.

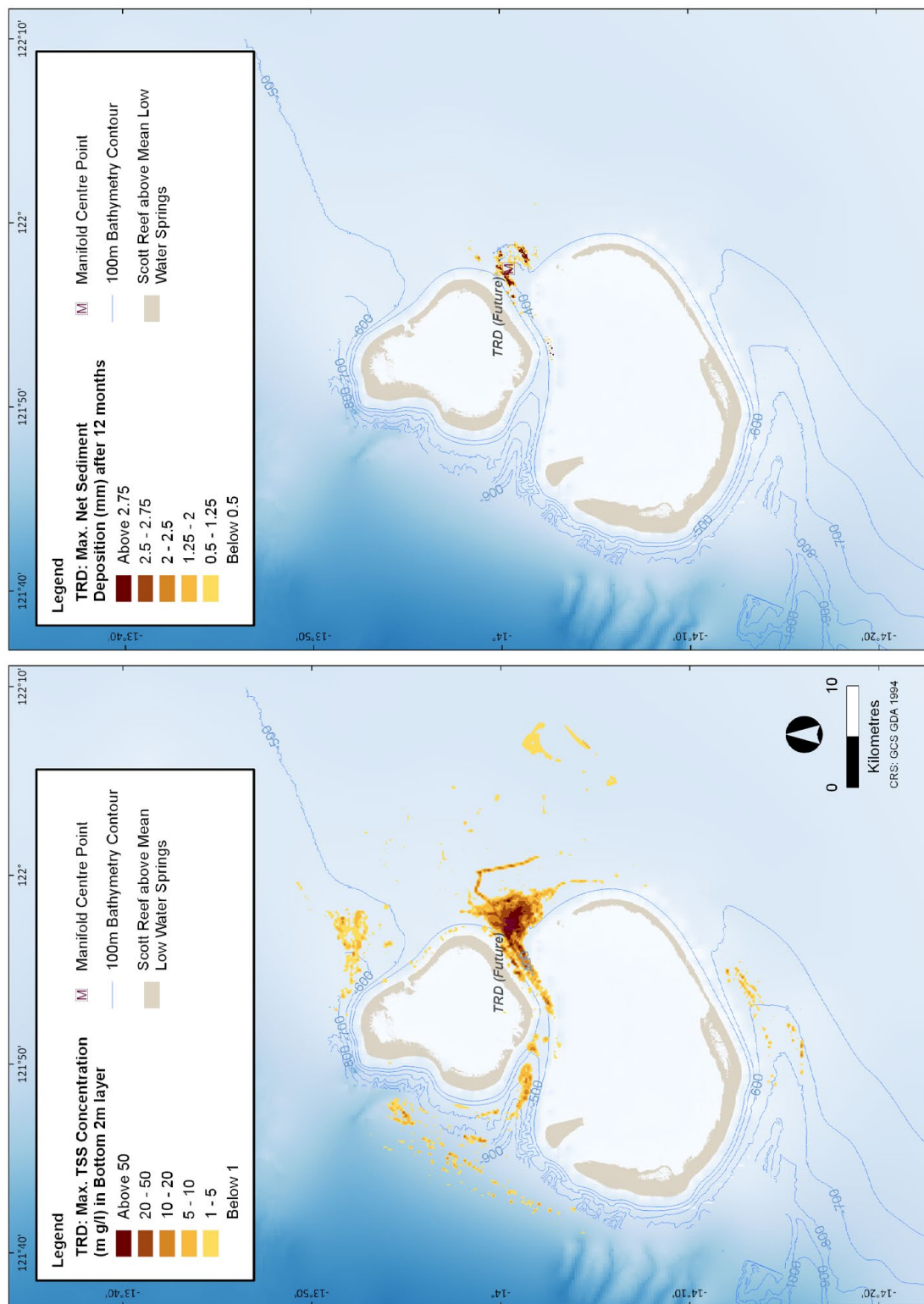


Figure 6-35: Drill Cuttings Discharge at the Seabed at the previously proposed TRD Drill Centre Showing: Maximum TSS Concentration (mg/L) in the Bottom 2 m (left) and Maximum Net Sedimentation (mm) (right) (DHI 2011b)

Note: The contour plots illustrate the overall footprint of elevated suspended solid concentrations and sedimentation over the entire course of the drilling program (12 months) at the previously proposed TRD drill centre location. It is important to note the occurrence of elevated TSS concentrations and sedimentation shown in the contour plots are cumulative and represent the maximum concentrations for the whole modelled drilling program. This approach allows for the prediction of any areas at Scott Reef where elevated turbidity or sedimentation may occur over the modelled drilling period.

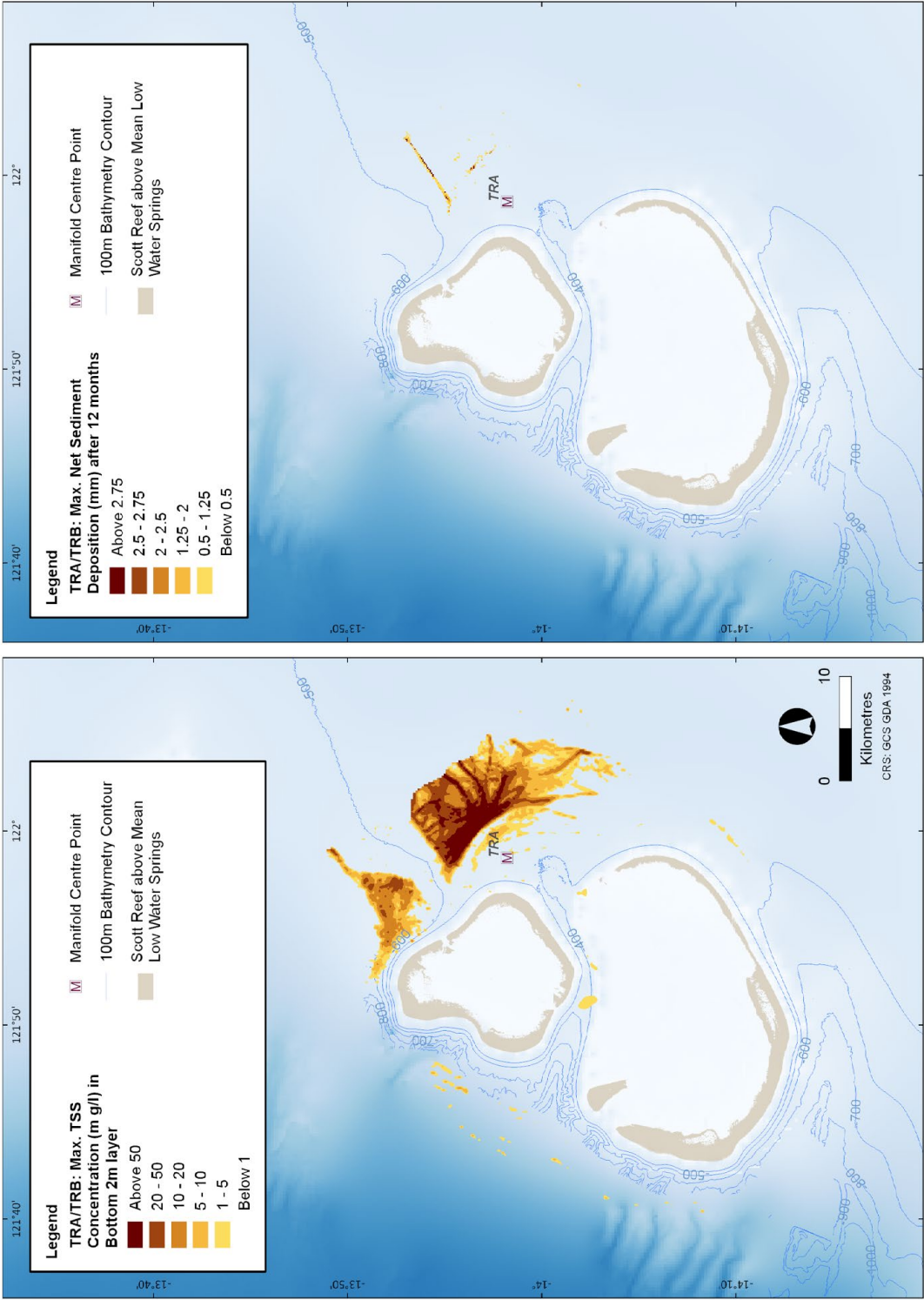


Figure 6-36: Drill Cuttings Discharge at the Seabed at the previously proposed TRA/TRB Drill Centre Location Showing: A. Maximum TSS Concentration (mg/L) in the Bottom 2 m (left) and Maximum Net Sedimentation (mm) (right) (DHI 2011b)

Note: The contour plots illustrate the overall footprint of elevated suspended solid concentrations and sedimentation over the entire course of the drilling program (18 months) at TRA/TRB. It is important to note the occurrence of elevated TSS concentrations and sedimentation shown in the contour plots are cumulative and represent the maximum concentrations for the whole modelled drilling period. This approach allows for the prediction of any areas at Scott Reef where elevated turbidity or sedimentation may occur over the modelled drilling period.

Management approach - Torosa wells in the State Proposal Area

Modelling indicated that the sea surface discharge of drill cuttings from the bottom-hole sections generated at the previously proposed TRE and TRD drill centre locations would potentially result in incursions of sediment plumes and associated increased sedimentation to portions of North and South Scott Reef including within the lagoons.

Given the potential sensitivities of Scott Reef shallow water benthic habitat (<75 m bathymetry) to sedimentation from drilling discharges, Woodside has committed to managing the drilling discharges (in particular, bottom-hole section discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD, TRE and TRF) in such a manner to avoid potential impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth). This approach is as follows:

1. For each identified drill centre, drilling discharge modelling will be completed using final design data to assess the dispersion and fate of drill cuttings, residual drilling fluids on cuttings, as well as bulk discharge (collectively referred to as drilling or completions discharges). This information will be provided in the relevant Environment Plan.
 - a. Where modelling can demonstrate that the discharge techniques and operational parameters (e.g. depth, rate and duration) are such that no impact to Scott Reef shallow water benthic communities and habitats (<75 m water depth) are predicted, drilling will be undertaken accordingly.
 - b. For those scenarios where modelling suggests impact to Scott Reef shallow water benthic communities and habitats (<75 m water depth) may occur, alternative drilling discharge techniques and operational parameters (e.g. depth, rate and duration) will be assessed and selected to avoid potential impacts.
2. Where bottom-hole section drilling discharges are planned to be undertaken at the specified drill centre locations based on outcomes from the drilling discharge modelling, monitoring at discharge source will be undertaken to verify the model predictions and ensure they are appropriately conservative.
3. For those scenarios where modelling predicts impact to Scott Reef shallow water benthic communities and habitats (<75 m water depth), and no alternative discharge techniques and operational parameters are available, then the relevant drilling or completions discharges predicted to cause the impact will be transported to a suitable location (e.g. at a sufficient distance from the reef or onshore) for disposal.

4. For those scenarios where verification monitoring at the discharge point indicates a potential impact to Scott Reef shallow water benthic communities and habitats (<75 m water depth), then the management of drilling or completions discharges (as predicted to cause the impact) will be addressed by transportation to a suitable location (e.g. at a sufficient distance from Scott Reef or onshore) for disposal.

These management objectives are supported by a range of both feasible and industry proven management measures.

6.3.15.4 Environmental Impact

Background

The impacts of drilling or completions discharges on water and sediment properties, and benthic communities are well documented. The United Kingdom Offshore Operators Association (UKOOA) sponsored an extensive initiative to assess the issue of cuttings piles in the North Sea from operations between 1970 and 2000 (Danielsson et al., 2005). More recently, the International Association of Oil and Gas Producers (IOGP) published a report which reviews scientific literature on the fate and effects of ocean discharge of drill cuttings and associated drilling fluids from offshore oil and gas operations (IOGP, 2016). Drill cuttings have been studied specifically on the NWS of Australia (Oliver and Fisher, 1999; SKM, 2007). The effects of turbidity and sediment deposition on sensitive ecological receptors such as corals have also been the subject of many peer-reviewed studies (e.g. Fabricius, 2005).

Drilling or completions discharges have the potential to impact the marine environment through:

- + temporary increase in TSS in the water column
- + attenuation of light penetration as an indirect consequence of the elevation of TSS and the rate of sedimentation
- + sediment deposition to the seabed leading to the alteration of the physio-chemical composition of sediments, and burial and potential smothering effects to sessile benthic biota
- + potential contamination and toxicity effects to benthic and in-water biota from drilling fluids.

It should be noted that the following assessment is restricted to potential impacts to open ocean receiving environment of the Brecknock and Calliance drill centres, and deepwater habitats around Scott Reef, given Woodside's commitment (see **Management approach - Torosa wells in the State Proposal Area**) to not undertake sea surface discharge from the bottom-hole sections that could potentially affect Scott Reef habitats.

Sediment quality

Change in sediment quality

Seabed sediment characteristics of the Brecknock, Calliance and Torosa reservoirs within the Browse Development Area, were generally soft silt and clay including the seabed areas surrounding Scott Reef, and the channel separating North and South Scott Reefs comprised well-rounded cobble/rubble and very coarse shell fragments. Seabed sediments sampled as part of previous studies (see [Section 5.2.10](#)) have demonstrated nutrient levels do not exceed background concentrations, variable metal concentrations and no detectable hydrocarbon contamination.

Cuttings discharged at the seabed will result in localised cuttings piles on the seabed surrounding the wellhead, with a greater spread of cuttings expected to occur down current from the well site. Sediment quality can be impacted by drilling or completions discharges as the drill cuttings alter the particle size distribution and physico-chemical composition of sediments and from the introduction of contaminants (e.g. hydrocarbons and metals) from drilling fluids. This in turn can have an impact on benthic communities through sediment deposition causing burial and smothering, or toxicity effects from drilling fluids.

The modelling indicates that sediment deposition would potentially occur to a distance in the order of a couple of hundred metres from each well location (in the direction of the prevailing current). This assessment aligns with several studies which indicate that the spread of cuttings can be expected to be up to about 150 m from the discharge location (IOGP, 2016).

Given the localised nature of potential changes to sediment quality, the deepwater biota and widespread, representative deepwater habitat where drilling or completions discharges will be disposed at the seabed and the low toxicity of the drilling or completions discharges (refer to [Section 6.3.15.2](#)), changes to sediment quality are not expected to be significant.

Water quality

Change in water quality

The discharge of drill cuttings and unrecoverable fluids is expected to increase turbidity and TSS levels in the water column. Drilling or completions discharges are generally intermittent and of relatively short duration for each production well drilling activity. Nelson et al. (2016) identified <10 mg/L as no effect or sub lethal minimal effect concentration, with Boesch and Rabalais (1987) demonstrating that surface discharges are likely to affect water quality and be confined to within 350 m - 1,500 m downstream from the discharge location.

The modelling ([Section 6.3.15.2](#)) indicates that both seabed and surface drilling or completions discharges would result in impacts to water quality as a result of elevations in TSS and the introduction of low toxicity contaminants. This reduction in water quality will be temporary (i.e. limited to the duration of the activity) and subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the Browse Development Area. Increased turbidity due to surface discharges at the Brecknock and Calliance drill centres, may have indirect impacts on plankton (discussed further below). Note, the implementation of the proposed management approach for the proposed Torosa drill centres mitigates the potential for impacts to Scott Reef water quality values.

Overall, given the predicted rapid dispersion of suspended sediments within the open ocean environment of the Browse Development Area, the short period of intermittent discharge and the generally low concentration of TSS within the plume tens of metres from the release location, any change in water quality associated with drilling or completions discharges are expected to be temporary with a slight effect and with no long-term reduction in the environmental values of the Browse Development Area.

Plankton communities

Injury or mortality to fauna

Surface discharges may potentially impact photosynthetic processes of phytoplankton due to increased turbidity. However, any impacts on plankton are predicted to be temporary and not expected to have any lasting effect on plankton communities, as they are known to have high levels of natural mortality and a rapid turnover rate (ITOPF, 2011). Therefore, discharge of drill cuttings is not expected to measurably impact local productivity within the water column at the Brecknock, Calliance, or Torosa reservoirs.

Benthic habitats

Change in habitat, injury or mortality to fauna

Following the discharge of drill cuttings and fluids, the coarser fractions (sand and gravel-sized particles), will rapidly settle to the seabed. Where cuttings are discharged to the seabed, a cuttings pile will develop immediately around the well site. The nature and size of the pile will depend on a number of factors including particle size of the cuttings, tidal and current forces and water depth. Discharge of cuttings at the surface will result in a sediment plume with the dispersion and settlement of cuttings dependent on the particle sizes of cuttings, water depth, as well as the prevailing wind, tidal influence and current directions. In addition, the overspill of cement associated with the cementing of the well casing will result in an irreversible loss of an area (0.008 km²) of the seabed immediately adjacent to the well (within a <50 m radius).

Potential impacts resulting from deposition of discharges are expected to be confined to sessile biota such as sediment burrowing infauna and epifauna (where present) in or on the seabed in the immediate proximity to the well location. Ecological impacts to such biota are predicted when sediment deposition is equal to or greater than 6.5 mm (in thickness) (IOGP, 2016). Modelling ([Section 6.3.15.2](#)) indicated that such deposition would potentially occur out from the well location to approximately 200 m (following the direction of the prevailing current). This aligns with IOGP, (2016) review of seven studies, which indicated that the spread of drill cuttings and WBFs is expected to be up to about 150 m from the discharge location. It should also be noted that sedimentation was modelled concurrently for multiple wells at the drill centres, resulting in a likely overestimation of net sedimentation given that in reality wells will be drilled sequentially and therefore further dispersion of deposited sediments will occur in between individual well drilling activities.

This deposition may result in the reversible loss in the order of 0.13 km² of deepwater benthic habitat per well based on an assumption of an expected spread radius of 150 m from each well (in addition to the irreversible loss of 50 m). Balcom et al., (2012) concluded that impacts associated with the discharge of cuttings and NWBFs are minimal, with impacts highly localised to the area of the discharge. Changes to benthic communities are normally not severe. Organic enrichment can occur leading to anoxic conditions in the surface sediments and a loss of infauna species that have a low tolerance to low oxygen concentrations, and to a lesser extent chemical toxicity near the well location. These impacts are highly localised with short-term recovery that may include changes in community composition with the replacement of infauna species that are hypoxia-tolerant (IOGP et al., 2016).

Recovery of affected benthic infauna, epifauna and demersal communities is expected to occur. Jones et al., (2012) compared pre- and post-drilling ROV surveys and documented physical smothering effects from WBF cuttings within 100 m of a well. Outside the area of smothering, fine sediment was visible on the seafloor up to at least 250 m from the well. After three years, there was significant removal of cuttings particularly in the areas with relatively low initial deposition (Jones et al., 2012). The area impacted by complete cuttings cover had reduced from 90 m to 40 m from the drilling location, and faunal density within 100 m of the well had increased considerably and was no longer significantly different from conditions further away. As such, the impacts to the deepwater benthic habitats are considered reversible with benthic biota expected to recolonise the area on completion of the drill cuttings discharge at each well.

Based on the modelling ([Section 6.3.15.2](#)), the sedimentation footprint associated with discharge of drilling or completions discharges at the seabed, indicates that away from the immediate area around the well (i.e. 50 m radius associated with the permanent impact from well casing cement overspill), sedimentation over the course of the drilling program would be low, equating to a thin veneer of settled drilling discharges away from the immediate deposition area around the well (in the order of 200 m from the well) which will likely be naturally reworked into surficial sediment through processes including bioturbation (US EPA, 2002). Ecological impacts in these areas are not expected for mobile benthic fauna such as crabs and shrimps or pelagic and demersal fish, given their mobility (IOGP, 2016).

Summary

In summary, likely impacts to benthic communities and habitats from seabed drilling discharges (i.e. drill cuttings and drilling fluids) and cement will be restricted to the burial of deepwater benthic biota and likely changes to sediment quality within the vicinity each well (in the order of several hundreds of metres). However, outside of approximately 200 m from each well, little to no impact to the deepwater benthic communities and habitats is expected.

Impacts associated with the surface discharge of drill cuttings at Torosa outside the State Proposal Area and at Brecknock and Calliance will be dependent on the rate of sedimentation determined by the fate and dispersion of the drill cuttings and retained drilling fluids based on particle size. Given water depths at the subsea well centres at these reservoirs (Brecknock: approximately 530 to 590 m; Calliance: approximately 410 to 590 m), surface cuttings discharges are likely to sink rapidly and deposit on the seabed in proximity to the drill centre and the fines associated with the drilling fluids are likely to disperse over a wider area (downstream of the drill centre), resulting in extremely low sedimentation levels and little to no impacts on the deepwater biota associated with the widespread sediment habitat. MODUs at Brecknock and Calliance drill centres may discharge from near the sea surface, as well as MODUs at Torosa outside the State Proposal Area where it can be demonstrated that there is no potential for impact to Scott Reef shallow water benthic communities and habitats from the discharges.

Overall, the loss (both reversible and irreversible) of benthic biota associated with the deep-water sediment habitat that are well represented both in the Browse Development Area and regionally, is not expected to reduce biological diversity and ecological integrity in the region.

Marine fauna

Injury or mortality to fauna – fish, marine reptiles, marine mammals

Marine fauna such as fish, marine turtles and marine mammals may be exposed to drill cuttings and fluid discharge if present in the immediate vicinity of the discharge.

As discussed in [Section 5.3.2](#), fish assemblage species richness and habitat complexity have been shown to decrease with increasing depth in the NWMR (Last et al., 2005). Due to the predominantly featureless, sediment habitat of the Browse Development Area and depth, the demersal fish presence will be low and representative of a deepwater area. Impacts to fish habitat will occur on a local scale (hundreds of metres) and the area outside the immediate 50 m radius of the well locations will return to previous condition. Adult fish are likely to move away and avoid elevated TSS associated with sedimentation and this will be limited in extent on spatial and temporal scales. Air breathing fauna, marine turtles and marine mammals are not expected to be adversely impacted by any encounters with elevated TSS. The green turtle breeding population has been shown to inhabit the shallow waters surrounding Sandy Islet and will not be exposed to drilling discharges disposed at the seabed (top-hole well sections) at deepwater drill centre locations. In addition, most visual orientated fish/ fauna species would likely relocate to an unaffected area to avoid the plume or simply pass unaffected through turbid waters.

Acute and chronic effects of chemical discharges are highlighted within the Recovery Plan for Marine Turtles in Australia (2017-2027) as a threat to green turtles of the Scott Reef-Browse Island genetic stock (Commonwealth of Australia, 2017a). Chronic chemical pollution is identified as a potential risk to pygmy blue whales in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c). Conservation advices for other EPBC listed marine mammals that may occur in the Project area do not identify chemical pollution as a key threat ([Table 5-19](#)).

There is a large body of knowledge indicating a discharge of cuttings with adhered fluids dilutes rapidly. These studies have found that that within 100 m of the discharge point, a drilling cuttings and fluid plume released at the surface will have diluted by a factor of at least 10,000, while Neff (2005) states that in well-mixed oceans waters (as is likely to be the case within the proposed drilling area), drilling fluid is diluted by more than 100-fold within 10 m of the discharge. While marine fauna such as fish, marine mammals and marine turtles may come into contact with these discharges, given that the discharges will disperse rapidly close to the discharge point and that any contact with the discharge will be of extremely short duration, it is not considered credible that toxic affects to marine fauna will occur as a result of the discharge of drill cuttings and fluids within the Browse Development Area.

Assessment against EPBC Act recovery and conservation plans and advices

[Table 6-120](#) summarises how the proposed drilling or completion discharges align with the objectives/actions of the relevant EPBC Act recovery and conservation management and recovery plans and advices.

Table 6-120 Alignment with protection of fauna conservation values – drilling or completion discharges

Fauna	Relevant plan(s)/ Conservation Advice	Plan/advice objectives and actions	Assessment
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	The impact of drilling or completions discharges resulting from the proposed Browse to NWS Project have been assessed and mitigation measures proposed. Given the low numbers and infrequent nature of whale shark presence in the Project Area, and mobility of the species, there is a high level of confidence that drilling or completions discharges will not result in adverse impact to whale sharks.
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Given the commitment to implement a management approach for the proposed Torosa drill centres adjacent to Scott Reef (including habitat critical for green turtles), as well as the inherent low toxicity and temporary nature of the drill cuttings discharges, impacts to turtles will be managed in accordance with the Recovery Plan for Marine Turtles in Australia (2017-2027) which includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a). There is a high level of confidence that any impacts will not compromise the long-term recovery objectives for marine turtles or result in the displacement of the Scott Reef – Browse Island green turtle genetic stock, from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the defined BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Chronic chemical pollution is identified as a potential risk to pygmy blue whales, however there are no specific actions identified.	Given the predicted temporary change in water quality and lack of significant impacts on plankton communities, the discharge of drilling or completions discharges is not expected to have any lasting effect on threatened whale species, particularly the possible foraging area for pygmy blue whales. As such, no adverse impacts are predicted to occur. It is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed for other migratory whale species
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Marine discharges have not been identified as a direct threat to these whale species; however, habitat degradation has been identified as a threat and unmanaged discharges may contribute to this threat. The conservation advice relevant for this threat – identifies modification to the coastal region in areas of importance to listed whales may result in reduced occupancy, compromised reproductive success and even mortality.	
Sei whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale		
Fin whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale		

Key Ecological Features

The discharge of drill cuttings and fluid will occur in:

- + the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF, which is recognised for high primary productivity, diverse aggregations of marine life and high species richness.
- + the Continental slope demersal fish communities KEF, which is recognised for its high diversity of demersal fish.

Change in sediment quality

As discussed above, changes to sediment quality as a result of drilling or completions discharges will be localised to an area (approximately 12 ha) adjacent to each well location. As such no lasting change to sediment quality within the KEFs is expected, with no subsequent adverse effect on the conservation values of KEFs predicted.

Change in water quality

As described above, any change in water quality as a result of drilling discharge is expected to be temporary and highly localised. Woodside has committed to, and demonstrated that feasible management measures exist to ensure drilling or completions discharges at TRA, TRD, TRE and TRF drill centre locations occur in such a manner that no impacts are predicted to Scott Reef shallow water benthic communities and habitats (<75 m water depth) associated with the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF. As such no impacts to the conservation values of these KEFs is predicted.

Injury or mortality to fauna

As discussed above, no lasting impacts to fish, marine mammals or marine reptiles are predicted to occur as a result of the drilling or completions discharges. As such no impacts to the conservation values of these KEFs is predicted.

Summary

Table 6-121 summarises how the drilling or completion discharges will not materially increase existing relevant pressures on the conservation values of KEFs.

Table 6-121 Alignment with protection of conservation values of KEFs – drilling or completions discharges

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Physical habitat modification	Given that drilling or completion discharges leading to physical modification of benthic communities and habitats will occur to a very small portion (0.01% for Continental slope demersal fish communities and 0.16% for Seringapatam Reef and Commonwealth waters in the Scott Reef Complex) of deepwater benthic habitats that are well represented both within each of the KEFs in the Browse Development Area, and regionally, there is a high level of confidence that such disturbance will not result in an adverse impact to marine ecosystem function or integrity within the KEFs; or any reduction in conservation values of the KEFs will occur.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex		Chemical pollution/contaminants	

Other protected places

Change in water quality, change in sediment quality

The Scott Reef and Surrounds - Commonwealth Area Commonwealth Heritage Place comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef.

As described above, Woodside has committed to managing drilling or completions discharges at TRA, TRD, TRE and TRF drill centre locations in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth) will occur. As such no impacts to the conservation values of the Scott Reef and Surrounds - Commonwealth Area Commonwealth Heritage Place is predicted.

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no adverse impacts to fish from drilling or completions discharges have been predicted, subsequent impact to fisheries is also not predicted.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

As described above, Woodside has committed to a management approach, implementing feasible mitigation measures, to manage the drilling or completions discharges at TRA, TRD, TRE and TRF drill centre locations in such a manner that no impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth) will occur. Given the

tourism, recreation and scientific studies values of the area relate primarily to Scott Reef, no impacts to these other users is predicted.

Aboriginal or indigenous heritage (high value users)

Changes to the functions, interests or activities of other users

Given that no lasting effect to fish from hydrotest fluid discharge have been predicted, subsequent impact to traditional Indonesian fishers is also not predicted.

6.3.15.5 Environmental Risk

Risk event: Distribution of drilling or completion discharges significantly greater than expected leading to impacts for Scott Reef shallow water benthic habitat (<75 m bathymetry)

If the dispersal and fate of drilling or completion discharges is greater than expected, there is a risk of impact to Scott Reef benthic communities and habitats, including high sensitivity and light-dependent photosynthetic communities. This risk would be particularly relevant for any surface drilling discharges at the TRA, TRD, TRE and TRF drill centre locations, which has led Woodside to implement the proposed management strategy (including monitoring) to manage drilling or completions discharges at these locations ([Section 6.3.15.2](#))

Scott Reef is renowned for its high-water clarity, with these conditions being essential to the health and survival of its coral assemblages, particularly in deep lagoonal waters of South Reef. TSS concentrations in the central lagoon are reported to be persistently low (<1 mg/L) and sediment deposition rates are low (<0.8 mg/cm²/day) (Brinkman et al., 2010). These

conditions allow reef development at deep depths (>30 m) with corals deeper than 50 m likely to be occurring at the lower limits of their light regime tolerance (Cooper et al., 2010; Falkowski et al., 1990; Titlyanov et al., 2001; Titlyanov et al., 2001). Corals that inhabit low turbidity offshore reefs have long been recognised as among the most sensitive to elevated sedimentation compared to corals that inhabit coastal environments where larger fluctuations in sedimentation conditions occur (Anthony, 1999; Fabricius, 2005; Gilmour et al., 2006; Rogers, 1990). As such, impacts to these communities in the event that drilling or completions discharges reach a broader spatial area than predicted could potentially lead to moderate impacts to Scott Reef.

Although modelling indicated that the sediment plume and associated deposition of sediment from drilling or completions discharges released at the seabed is expected to be confined to the seabed ([Section 6.3.15.3](#)), there are inherent uncertainties associated with modelling results and assumptions that these results are based on (e.g. oceanographic conditions). Despite this, modelling outputs are supported by research findings at Scott Reef which show that there is no evidence of persistent upwelling or downwelling currents around Scott Reef (Green et al., 2019), with a year-round strong stratification in the water column. Therefore cold denser water masses deeper than 200 m are unlikely to be upwelled and reach Scott Reef (Brinkman et al., 2009). Given this and considering the water depths and locations of the proposed wells, it is considered highly unlikely that impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) will occur.

6.3.15.6 Cumulative Impacts

As discussed in the preceding sections, cumulative impacts associated with the discharge of drill cuttings are predicted to deep-water benthic habitats. Such impacts will range from short-term reductions in water quality to potentially permanent impacts to the seabed surrounding the drill centres, resulting in the loss of deep-water biota. Up to 54 wells will be drilled, with up to 24 wells occurring in State waters within the Torosa reservoir (see [Section 6.3.15.2](#)). The proposed Browse to NWS Project will result in an approximately cumulative volume of 45,900 m³ of drill cuttings discharged to the seabed, resulting in an irreversible loss of 0.42 km² and a reversible loss of 6.79 km² within the Browse Development Area. The wells are expected to be located in proximity to each drill centre and therefore these estimates are considered to be conservative as the impacted areas will likely overlap.

6.3.15.7 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact and risk assessments for drilling or completions discharges is provided in [Table 6-122](#) and [Table 6-123](#). The acceptability assessment is provided in [Table 6-124](#).

Table 6-122 Impact assessment summary and adopted controls – drilling or completions discharges

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Sediment quality (medium value (open waters))	Change in sediment quality	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.	<i>Development drilling operations</i> + The number of wells will be optimised to meet hydrocarbon recovery objectives and operational requirements and thereby reduce unnecessary use of drilling fluids and generation of drill cuttings. + For technical, operational and environmental reasons NWBFs will be selected in accordance with Woodside's chemical selection and assessment processes.	Minor	Minor (D)
Water quality (medium value (open waters))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	+ Risers will be used to ensure that NWBF and associated cuttings are recirculated to the MODU, where cuttings will be treated prior to discharge.	Slight	Slight (E)
Plankton (low value (open water))	Injury or mortality to fauna	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	+ There will be no discharge of unused NWBF at sea during drilling and completion operations.	No lasting effect	Negligible (F)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in habitat and injury or mortality to fauna	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	+ Drill cuttings will be tested to confirm that the average oil on cuttings for the entire well (sections using NWBF) will not exceed 6.9% by wet weight.	No impact expected	
Deepwater benthic communities and habitats (>75 m depth) – (medium value)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		Slight	Slight (E)
Fish (high value species)	Injury or mortality to fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.		No lasting effect	Slight (E)
Marine turtles (high value species)	Injury or mortality to fauna	Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.		No lasting effect	Slight (E)
Marine mammals (high value species)	Injury or mortality to fauna	Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No lasting effect	Slight (E)

Receptor (sensitivity)	Potential Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
KEFs (medium value)	Change in water quality, Change in sediment quality and Injury or mortality to fauna	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
Other protected places (high value)	Change in water quality and change in sediment quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No impact expected	
Managed fisheries (high value user)	Changes to the functions, interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation and scientific studies (high value users)	Changes to the functions, interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Aboriginal or indigenous heritage (high value users)	Changes to the function interests or activities of other users	Objective 19: To not have a substantial adverse impact on heritage values. ¹ Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Table 6-123 Risk assessment summary and adopted controls – drilling or completions discharges

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Sediment quality (low value (open waters))	Dispersal of drilling discharges greater than predicted resulting in impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry).	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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. Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution. Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population. Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry). Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature. Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place. Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.	Drilling or completions discharges (in particular, bottom hole discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD, TRE and TRF) will be managed in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth) (see Management approach - Torosa wells in the State Proposal Area).	No increase to significance/consequence		No increase to significance/consequence
Water quality (low value (open waters)).				No increase to significance/consequence		No increase to significance/consequence
Plankton (low value (open water))				No increase to significance/consequence		No increase to significance/consequence
Fish (high value species)				No increase to significance/consequence		No increase to significance/consequence
Marine turtles (high value species)				No increase to significance/consequence		No increase to significance/consequence
Marine mammals (high value species)				No increase to significance/consequence		No increase to significance/consequence
Benthic habitat (Scott Reef) – (high value habitat)				Minor	Highly unlikely	Moderate (D1)
Benthic habitat (epifauna and infauna) (low value habitat)				No increase to significance/consequence		No increase to significance/consequence
KEFs - high value				No increase to significance/consequence		No increase to significance/consequence
Other protected places - high value				No increase to significance/consequence		No increase to significance/consequence
State and Commonwealth managed fisheries (high value marine user)				No increase to significance/consequence		No increase to significance/consequence

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Other users (scientific studies, tourism and recreation) - High value users		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		
Aboriginal or indigenous heritage (high value users)		Objective 19: To not have a substantial adverse impact on heritage values. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		

Table 6-124 Acceptability assessment – drilling or completions discharges

Acceptability Assessment
Confidence in assessment Woodside has a high level of certainty with respect to the assessment of the potential impacts and risks associated with drilling or completions discharges as: + Surveys have characterised the deepwater benthic communities and habitats that may potentially be impacted by the drilling or completions discharges as sparse and well represented both in the Project Area and regionally. + The proposed controls are standard controls widely employed in industry and proven to mitigate the potential impacts and risks effectively. + Woodside has committed to manage drilling or completions discharges (in particular bottom-hole section discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD, TRE and TRF) in such a manner that no impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth) will occur. This management approach is further described Section 6.3.15.2.
Principals of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-122, no lasting effect is predicted to occur from the drilling or completions discharges to listed threatened and migratory species such as fish, marine turtles and marine mammals, with the impact significance level determined to be Slight (E). As described in Table 6-123, potential risk events associated with drilling or completions discharges are not predicted to increase the significance/consequence of impacts to listed threatened and migratory species. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>Commonwealth Marine Environment</u> As described in Table 6-122, no lasting effect is predicted to occur from the drilling or completions discharges to plankton, and KEFs with the impact assessed as Negligible (F). Slight (E) impacts may potentially occur to water quality, deepwater benthic communities and habitats (>75 m depth), marine fauna, managed fisheries and other users. The planned management approach aims to avoid impacts to shallow water benthic communities and habitats (<75 m depth) and other protected places. As described in Table 6-123, potential risk events associated with drilling or completions discharges present a Moderate risk to shallow water benthic communities and habitats (<75 m depth). As such, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

Marine environmental quality

As described in [Table 6-122](#), the potential impact from drilling or completions discharges to plankton has been assessed as Negligible (F). Slight (E) impacts may potentially occur to water quality, while Minor (D) impacts may occur to sediment quality.

As described in [Table 6-123](#), potential risk events associated with drilling or completions discharges is not predicted increased the significance/consequence of impacts to plankton, sediment quality or water quality.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*to maintain the quality of water, sediment and biota so that environmental values are protected*” will be achieved.

Marine Fauna

As described in [Table 6-122](#), no lasting effect is predicted to occur as a result of drilling or completions drilling discharges to marine fauna such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

As described in [Table 6-123](#), potential risk events associated with the drilling or completions discharges are not predicted increased the significance/consequence of impacts to marine fauna species.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*To protect marine fauna so that biological diversity and ecological integrity are maintained*” will be achieved.

Benthic communities and habitats

As described in [Table 6-122](#), a Slight (E) impact is predicted to occur as a result of drilling or completions discharges to deepwater benthic communities and habitats (>75 m depth). The planned management approach will ensure that no impacts will occur to shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-123](#), potential risk events associated drilling or completions discharges present a Moderate risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*” will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders regarding drilling or completions discharges in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact and risk assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)) The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside’s chemical selection and assessment process and approved prior to use. Woodside will implement its internal requirement that states that Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-120](#), the proposed activities are considered to be not inconsistent with the objectives and actions of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d).

KEFs

As detailed in [Table 6-121](#) proposed drill cuttings and fluid discharge will not materially increase existing relevant pressures on the conservation values of KEFs.

Other protected places

No impacts are expected to occur to the values of the Scott Reef and Surrounds Commonwealth Heritage Place.

Conclusion: Acceptable

6.3.16 Marine Discharges: Subsea Control Fluid

6.3.16.1 Impact and Risk Overview

[Table 6-125](#) presents an overview of the potential impacts and risks from subsea control fluid discharges associated with the proposed Browse to NWS Project.

Table 6-125 Marine discharges: subsea control fluid impact and risk overview

Aspect	Marine discharges: subsea control fluid
Description	Subsea control fluids are used on control systems of: + valves on the subsea manifolds + valves on the Christmas tree at the wellheads + valves on the BOP during drilling + valves on ROVs during construction and maintenance activities. Control systems that are under consideration include open (industry standard) and a hybrid system that will be configured such that it can operate in closed loop mode when the spare injection line is not required.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to subsea control fluid associated with the proposed Browse to NWS Project are Objectives 1, 2, 3, 6, 7, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19 and 20. These objectives are detailed in Table 6-7.

Aspect	Marine discharges: subsea control fluid						
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-126). + Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016e). + WA EPA Technical Guidance – Protecting the Quality of Western Australia’s Marine Environment (EPA, 2016b) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).						
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <u>Physical</u> + sediment quality (medium value (open waters)) + water quality (medium value (open waters)) <u>Ecological</u> + plankton (low value (open water)) + benthic habitats: + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + marine fauna + fish (high value species) + marine mammals (high value species) + marine reptiles (high value species) + KEFs (medium value) + AMPs (medium value) <u>Socio-economic</u> + Commonwealth and state managed fisheries (high value user)						
Potential impacts	+ change in water quality + change in sediment quality + injury or mortality to marine fauna + changes to the function interests or activities of others						
Risk	+ Unplanned discharge at a volume significantly greater than predicted						
Summary of governing impact evaluation	<table><tr><th>Magnitude</th><th>Impact significance level</th><th>Confidence</th></tr><tr><td>Slight</td><td>Slight (E)</td><td>High</td></tr></table>	Magnitude	Impact significance level	Confidence	Slight	Slight (E)	High
Magnitude	Impact significance level	Confidence					
Slight	Slight (E)	High					
Summary of governing risk evaluation	<table><tr><th>Consequence</th><th>Likelihood</th><th>Risk rating</th></tr><tr><td>Slight</td><td>Remote</td><td>Low (E0)</td></tr></table>	Consequence	Likelihood	Risk rating	Slight	Remote	Low (E0)
Consequence	Likelihood	Risk rating					
Slight	Remote	Low (E0)					

6.3.16.2 Source of Aspect

Potential impacts associated with the discharge of subsea control fluid will be generated from the following subsea sources:

- + valves on the subsea manifolds
- + valves on the christmas tree at the wellheads
- + valves on the BOP during drilling
- + valves on ROVs during construction and maintenance activities.

The subsea hydraulic control system has high pressure (HP) and low pressure (LP) circuits. The HP system operates the downhole safety valve and the LP system operates all other subsea valves. An open loop subsea control system will be adopted for the HP control systems, whereby the control fluid is pressurised on the FPSO facilities by the hydraulic accumulators and delivered to subsea valves via umbilicals. For the LP control system, a hybrid solution will be used.

Control fluids are sourced from proprietary suppliers and are composed of low toxicity water-based fluids. The specific control fluid has not yet been selected; however, such fluids are typically water based with additives such as MEG (usually about 40% of the total volume), lubricants, corrosion inhibitors, biocides and surfactants.

The open loop HP hydraulic system will discharge a small amount (0.1 L) when testing or operating the downhole safety valve. The release will be at the wellhead subsea control module, typically at 350 m water depth or greater. The hybrid LP hydraulic system utilizes a contingency injection line in the umbilical in order to achieve a closed loop configuration. This hybrid system has no planned discharges and will only release hydraulic fluid if the system leaks or the contingency injection line is required due to failure of the primary. Drill centres will be placed in deep water, away from Scott Reef shallow water benthic habitat (<75 m bathymetry) (wells are laterally deviated to reach reservoir targets under Scott Reef) which will inherently reduce the risk of impacts occurring to the Scott Reef system.

During drilling activities, control fluids will be discharged during function and pressure testing of the BOP control system. The maximum volume of control fluid that will be released to the marine environment per manifold is 1,900 l per year of water-based fluid containing about ~3% active ingredient (i.e. 40–68 L of control fluid additive).

6.3.16.3 Environmental Impact

Water quality

Change in water quality

Given the small volumes and solubility of the proposed water-based discharges, it is anticipated the fluids would be rapidly diluted (within tens of metres) in the prevailing currents adjacent to the discharge location on the seabed. The intermittent discharge of small volumes of subsea control fluid may result in a reduction in water quality that will be temporary (limited to the duration of the activity), restricted to deep water and subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters. Given this and the sparse nature of the deepwater benthic habitats within the Project Area, no impacts to biota are predicted. Further, given the distance from the subsea infrastructure to Scott Reef and the depth of the discharge, this reduction in water quality is not expected to result in any lasting impacts to the environmental values within the including the Scott Reef system.

Sediment quality

Change in sediment quality

Given the expected rapid dispersion and dilution by prevailing currents, discharged subsea fluid is not predicted to accumulate in sediments and as such no lasting change to sediment quality is predicted.

Plankton

Injury or mortality to fauna

Given the minimum water depth at potential discharge locations (i.e. 125 m at the NRC tie-in and greater than 350 m in the Browse Development Area), and the expected rapid dispersion and dilution by prevailing currents, exposure of plankton to the discharge is predicted to be negligible. In addition, the wide spread nature and rapid turn-over of plankton populations leading to relatively quick recovery times, ensures that any impact on local communities would be expected to recover relatively quickly (within weeks or months) (ITOPF, 2011).

Benthic habitats

Change in water quality

As described above, the intermittent discharge of small volumes of subsea control fluid may result in a change in water quality that will be temporary (limited to the duration of the activity), restricted to deepwater (i.e. not affecting Scott Reef benthic communities or habitats) and subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the Project Area including the State Proposal Area. While benthic biota associated with the deep-water habitats of the Project Area may come into contact with these discharges, given that the discharges will disperse rapidly close to the discharge point and that any contact with the discharge with benthic biota will be of extremely short duration, it is not considered credible that toxic affects to benthic biota will occur as a result of the discharge of subsea fluids. It should be noted that at the depths where the subsea control fluid discharges will occur, benthic fauna has been demonstrated (See [Section 5.3](#)) to be sparse with no sensitive communities recorded.

Given the highly localised nature of the reduction in

water quality, and the depth at which the discharges of subsea control fluids would occur, no impact to Scott Reef shallow water benthic habitat (<75 m bathymetry) are predicted.

Marine fauna

Injury or mortality to fauna – fish, marine turtles, marine mammals

Given the low toxicity, the volume and the location of the discharges (at the seabed in water depths exceeding 125 m at the NRC tie in point and 350 m in the Browse Development Area), it is not considered credible that impacts to marine fauna such as fish, marine turtles or marine mammals will occur as a result of the discharge of subsea control fluids within the Project Area.

Assessment against EPBC Act recovery and conservation plans and advices

[Table 6-126](#) provides an assessment of the discharge of subsea control fluids from the proposed activities in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices

Table 6-126 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – subsea control fluid discharge

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	Given the depth of the proposed discharges and the expected rapid dispersion of the subsea fluid, (and the low numbers and infrequent nature of whale shark presence in the Project Area), there is a high level of confidence that subsea control fluid discharges will not result in adverse impact to whale sharks.
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Impacts to turtles have been assessed and will be managed in accordance with the Recovery Plan for Marine Turtles in Australia (2017-2027) which includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a). Given the depth of the proposed discharges and that the change in water quality will be highly localised and temporary, the discharge of subsea control fluid is not expected to have significant impacts on marine turtles. Therefore, there is a high level of confidence that any impacts will not compromise the long-term recovery objectives for marine turtles or result in the displacement of the Scott Reef – Browse Island green turtle genetic stock, from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Acute chemical discharge (oil or condensate spill) pollution is identified as a potential risk to pygmy blue whales, however there are no specific actions identified.	Given the depth of the discharges and that change in water quality will be highly localised and temporary, subsea control fluid discharges are not expected to have any lasting impacts on the listed whale species. It is therefore considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Marine discharges have not been identified as a direct threat to these whale species; however, habitat degradation has been identified as a threat and unmanaged discharges may contribute to this threat.	
Sei whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale	The conservation advice relevant for this threat – identifies modification to the coastal region in areas of importance to listed whales may result in reduced occupancy, compromised reproductive success and even mortality.	
Fin whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale		

Key Ecological Features

Injury or mortality to fauna, change in sediment quality and change in water quality

The Continental slope demersal fish communities KEF and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs overlap with the Browse Development Area. Subsea fluid discharges will occur within these KEFs from the subsea infrastructure and ROVs during construction and IMR activities. The BTL traverses the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF (depending on the final BTL route) and the Ancient coastline at 125 m depth contour KEF. Subsea fluid discharges will occur within these KEFs from ROVs during construction and IMR activities. The conservation values of these KEFs are described in [Section 5.3.3.1](#).

As described above, changes to sediment quality and water quality as a result of subsea fluid discharges are predicted to be temporary and highly localised. Likewise, no lasting impacts to marine fauna are predicted. As such no lasting impacts to the conservation values of these KEFs is predicted. No impact is predicted to the reefs associated with the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF.

[Table 6-127](#) provides an assessment of the proposed discharge of subsea control fluids in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-127 Alignment with protection of conservation values of KEFs – subsea control fluids

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Chemical pollution / contaminants - currently identified as 'not of concern'	Given the depth of the discharges and that change in water quality will be highly localised and temporary, subsea control fluid discharges are not expected to have any significant impacts on the conservation values of these KEFs.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Ancient coastline at 125 m depth contour			
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals		Chemical pollution / contaminants - currently identified as 'data deficient or not assessed'	

Australian Marine Parks

Change in sediment quality, change in water quality

ROV operations associated with the installation of the BTL and IMR activities will discharge subsea control fluids within the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley AMPs. The Marine Bioregional Plan for the North West Marine Region recognises that fauna and ecosystems may be vulnerable to marine discharges that include chemicals and toxins (Director of National Parks, 2018).

As described above, it is expected that discharges will disperse in very close proximity to the discharge point. Given this, it is considered that the identified conservation values of these AMPs will not be adversely impacted by subsea fluid discharges.

Table 6-128 provides an assessment of the proposed discharge of subsea control fluids in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no adverse impacts to fish from subsea control fluid discharge have been predicted, subsequent impact to fisheries is also not predicted.

6.3.16.4 Environmental Risk

Risk Event: Unplanned discharge at a volume significantly greater than predicted

Though unlikely, discharges of subsea control fluid at volumes significantly larger than expected resulting from human error or equipment failure may occur. This would potentially result in a larger area being impacted. As per **Section 6.3.16.3** it would remain unlikely that exposure to marine fauna would be sufficient to elicit a toxic response. As such no change to the significance of the impact to water quality, sediment quality, marine fauna, KEFs or managed fisheries would be expected.

If the discharge of subsea control fluid at volumes significantly greater than expected occurs at well locations near Scott Reef at a time where the prevailing conditions result in the discharge moving towards Scott Reef, there is a risk of resultant impacts to the benthic habitats of Scott Reef. This impact would not be expected to be significant due to its temporary and localised nature.

6.3.16.5 Cumulative Impacts

Cumulative impacts associated with the discharge of subsea control fluid from the proposed Browse to NWS Project, and other projects within the broader Browse Basin (i.e. Prelude and Ichthys) are not expected, given the geographic spread of the facilities and highly localised area where the intermittent reduction in water quality will occur.

Table 6-128 Alignment with the North-west Marine Parks Network Management Plan – subsea control fluid discharge

Australia Marine Park	Relevant plan(s)	Australian Marine Park Objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	Subsea fluid discharges from ROVs operating within these AMPs will be of a small volume, temporary and transient in nature and therefore unlikely to impact marine fauna or benthic habitats in these AMPs. Therefore, there is a high level of confidence that such discharges will not result in any adverse impacts to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
Kimberley Marine Park Multi Use Zone (VI)			
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park. As such, discharges associated with the installation of the BTL and occasional IMR activities are not considered a credible source of impact and no effect on ecosystems, habitats or native species in the AMP is predicted. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

6.3.16.6 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact and risk assessment for the discharge of subsea control fluids is provided in [Table 6-129](#) and [Table 6-130](#). The acceptability assessment is provided in [Table 6-131](#).

Table 6-129 Impact assessment summary and adopted controls – subsea control fluids

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Water quality (medium value (open water))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	<i>Subsea control fluid discharges</i>	Slight	Slight (E)
Sediment quality (medium value (open water))	Change in sediment quality	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.	+ No infrastructure will be placed on Scott Reef shallow water benthic communities and habitat (<75 m bathymetry).	Slight	Slight (E)
Plankton (medium value (open water))	Injury or mortality to marine fauna	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution	+ Chemicals that may be operationally released or discharged to the marine environment will be subject to Woodside's chemical selection and assessment process and approved prior to use.	No lasting effect	Negligible (F)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in water quality	Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	For the subsea LP control system, a hybrid solution in closed loop configuration will be used which returns fluids to the FPSOs and minimises discharges. The system will revert to an open loop system if the return lines to the FPSOs are no longer available to support the LP hydraulic system.	No impact expected	
Deepwater benthic communities and habitats (>75 m depth) – (medium value)	Change in water quality	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No lasting effect	Negligible (F)

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Fish (high value species)	Injury or mortality to marine fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No lasting effect	Slight (E)
Marine turtles (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No lasting effect	Slight (E)
Marine mammals (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.		No lasting effect	Slight (E)
		Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.			
		Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.			
KEFs (medium value)	Change in water quality Change in sediment quality Injury or mortality to fauna	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
AMPS (medium value)	Change in water quality Change in sediment quality	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No lasting effect	Negligible (F)
State and Commonwealth managed fisheries (high value marine user)	Changes to the function interests or activities of others	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Table 6-130 Risk assessment summary and adopted controls – Subsea Control Fluids

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Water quality (medium value (open water))	Unplanned discharge at a volume significantly greater than predicted	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. For chronic discharges 99% species protection levels (or equivalent) will be met by the edge of the modelled mixing zone.	No further controls (in addition to those described in Table 6-129 adopted.)	No increase to significance/consequence		
Sediment quality (medium value (open water))		Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.				
Plankton (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution				

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).		Slight	Remote	Low (EO)
Deepwater benthic communities and habitats (>75 m depth) – (medium value)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		No increase to significance/consequence		
Fish (high value species)		Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No increase to significance/consequence		
Marine turtles (high value species)		Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No increase to significance/consequence		
Marine mammals (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No increase to significance/consequence		
KEFs (medium value)		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No increase to significance/consequence		
AMPs (medium value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No increase to significance/consequence		
State and Commonwealth managed fisheries (high value marine user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No increase to significance/consequence		

Table 6-131 Acceptability assessment – subsea control fluids

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts and risks associated with the discharge of subsea control fluids as: + Given the small volumes and solubility of the proposed water-based discharges, it is anticipated that the fluids would be rapidly diluted in the prevailing currents. + The proposed controls are standard controls widely employed in industry and proven to mitigate the potential impacts and risks effectively.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-129, no lasting effect is predicted to occur from the discharge of subsea control fluids to listed threatened and migratory species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E). As described in Table 6-130, potential risk events associated with the discharge of subsea control fluids are not predicted increased the significance/consequence of impacts to listed threatened and migratory species. Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>Commonwealth Marine Environment</u> As described in Table 6-129, the potential impact from the discharge of subsea control fluids to plankton, deepwater benthic communities and habitats (>75 m depth), KEFs and AMPs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to sediment quality, water quality, marine fauna and managed fisheries, while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth). As described in Table 6-130, potential risk events associated with the discharge of subsea control fluids present a Low risk to shallow water benthic communities and habitats (<75 m depth). Given this, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of subsea control fluid against the WA EPA Objective is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Marine environmental quality

As described in [Table 6-129](#), the potential impact from the discharge of subsea control fluids to plankton and deepwater benthic communities and habitats (>75 m depth) has been assessed as Negligible (F). Slight (E) impacts may potentially occur to sediment quality, water quality and marine fauna, while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-130](#), potential risk events associated with the discharge of subsea control fluids present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to maintain the quality of water, sediment and biota so that environmental values are protected” will be achieved.

Marine Fauna

As described in [Table 6-129](#), no lasting effect is predicted to occur from the discharge of subsea control fluids to marine fauna species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

As described in [Table 6-130](#), potential risk events associated with the discharge of subsea control fluids are not predicted increased the significance/consequence of impacts to marine fauna.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “To protect marine fauna so that biological diversity and ecological integrity are maintained.” will be achieved.

Benthic communities and habitats

Commonwealth Marine Environment

As described in [Table 6-129](#), the potential impact from the discharge of subsea control fluids to deepwater benthic communities and habitats (>75 m depth) has been assessed as Negligible (F), while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth).

As described in [Table 6-130](#), potential risk events associated with the discharge of subsea control fluids present a Low risk to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained” will be achieved.

Conclusion: Acceptable

External Context

To date there have been no specific matters raised by stakeholders regarding discharge of subsea control fluids in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal Context

This impact and risk assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)) The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside’s chemical selection and assessment process, and approved prior to use. Woodside will implement its internal requirement that states that Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

Conclusion: Acceptable

Acceptability Assessment

Other Requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-126](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d).

KEFs

- + As detailed in [Table 6-127](#) proposed subsea fluid discharge will not materially increase existing relevant pressures on the conservation values of KEFs.

AMP

- + As detailed in [Table 6-128](#), the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Conclusion: Acceptable

6.3.17 Marine Discharges: Hydrotest Fluid

6.3.17.1 Impact and Risk Overview

[Table 6-132](#) presents an overview of the potential impacts and risks from hydrotest fluid discharge associated with the physical presence of proposed Browse to NWS Project.

Table 6-132 Marine discharges: hydrotest fluid impact and risk overview

Aspect	Marine discharges: hydrotest fluid
Description	In-situ hydrostatic pressure testing which will be performed following installation of all flowlines, subsea infrastructure and unless dry-commissioning is deemed feasible; the BTL (including existing NWS Project infrastructure (2TL)) and inter-field spur line. This would occur during pre-commissioning, commissioning and during operations as flowlines are installed to accommodate field layout change or repair. Hydrotesting may also be undertaken on the temporary production system on the MODU for the well unloading activities.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	Pre-commissioning, commissioning and operations
Environmental objectives	The environmental objectives in relation to hydrotest water associated with the proposed Browse to NWS Project are Objectives 1, 2, 3, 6, 7, 9, 10, 12, 13, 14, 15, 16, 17, 18, 20 and 21. These objectives are detailed in Table 6-7 .

Aspect	Marine discharges: hydrotest fluid
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered. + Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) + WA EPA Environmental Factor Guideline - Marine Environmental Quality (EPA, 2016e) + WA EPA Technical Guidance – Protecting the Quality of Western Australia’s Marine Environment (EPA, 2016b). + DNV-GL Recommended Practice (DNVGL-RP-F115) – Pre-commissioning of submarine pipelines (DNV 2016) + DNV ST F101 Submarine Pipeline Systems + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012)
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <u>Physical</u> + water quality (medium value (open waters)) + sediment quality (medium value (open waters)). <u>Ecological</u> + plankton (medium value (open water)) + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + Marine fauna + fish (high value species) + marine mammals (high value species) + marine reptiles (high value species) + KEFs (medium value) + other protected places (high value). <u>Socio-economic</u> + State and Commonwealth managed fisheries (high value user) + other users + tourism and recreation (high value user) + scientific studies (high value user).
Potential impacts	+ change in water quality + change in sediment quality + injury or mortality to fauna + changes to the functions, interests or activities of other users
Risk	+ There are no anticipated environmental risks in relation to this aspect associated with unplanned incidents or events.

Aspect	Marine discharges: hydrotest fluid		
Summary of governing impact evaluation	Magnitude	Impact significance level	Confidence
	No lasting effect	Slight (E)	High
Summary of governing risk evaluation	Consequence	Likelihood	Risk rating
	n/a	n/a	n/a

6.3.17.2 Source of aspect

Hydrotest fluids are used for two distinct purposes; testing of the integrity of the pipeline and flowlines and for preservation of the pipelines and flowlines prior to the introduction of reservoir fluids. Hydrotest fluids may consist of a combination of seawater, biocides, corrosion inhibitors, oxygen scavenger, MEG and fluorescent dye. The period of time the hydrotest fluid is left within the infrastructure as a preservation fluid will depend on the type of fluid selected and the Project schedule for construction and installation activities. If treated water is selected as the hydrotest fluid, it may only be suitable to be left in-situ for a period of approximately 12 to 24 months, after which it is typically discharged at sea and the flowline refilled, if required. If MEG is selected, it is likely that it could be left in-situ for longer, therefore reducing the frequency of discharge to sea.

BTL

Once installation and hook up of the subsea infrastructure and the BTL and inter-field spur line is complete, pre-commissioning (leak testing) to test the integrity of the subsea infrastructure, BTL and the inter-field spur line will occur. Three options for the discharge of hydrotest fluid from the BTL, inter-field spur line and 2TL are being considered as described [Table 6-133](#). Note that under the base case scenario, the discharge of the BTL will subsequently be followed by the discharge of 2TL, which has an inventory of 110,000 m³. It is currently planned for these discharges to occur at least six months apart, and therefore have not been modelled as a single scenario. These include:

- + Base case - scenario 1 (NRC PLET): 736,000 m³ hydrotest fluid (BTL and inter-field spur line) is discharged at the NRC PLET location, followed by 110,000 m³ hydrotest fluid (2TL) at least 6 months later.
- + Alternative scenario 2 (Torosa PLET): 846,000 m³ hydrotest fluid (BTL, inter-field spur line and NWS Project's 2TL) is discharged at the Torosa PLET.
- + Alternative scenario 3a / 3b (Brecknock/ Calliance PLET and Torosa PLET): BTL and NWS Project's 2TL hydrotest fluid (790,000 m³) is discharged at the Calliance/ Brecknock PLET, while the hydrotest fluid from the inter-field spur line (56,000 m³) is discharged at the Torosa PLET.

Dry pre-commissioning of BTL eliminates the introduction and subsequent discharge of hydrotest water from BTL and inter-field spur line. If dry-commissioning of the BTL and inter-field spur line is deemed feasible, hydrotesting of this infrastructure would not be required.

For the BTL and inter-field spur line, the hydrotest fluids are likely to consist primarily of seawater which is chemically treated at an appropriate concentration (e.g. 600 ppm or similar) with chemicals such as biocides, corrosion inhibitors and oxygen scavenger to prevent corrosion from oxidation and microbial action for the required preservation period and maintain trunkline integrity. In addition, a fluorescein dye will be added to the hydrotest fluid to visually identify leaks during hydrotesting. The combination of hydrotest fluid constituents for the BTL depends on the trunkline material type and the required preservation period.

For comparison, INPEX's Ichthys Development required a total of approximately 1,000,000 m³ of treated seawater for the hydrotesting and preservation of the 890 km gas export pipeline (INPEX 2010).

SURF infrastructure

For the SURF infrastructure, the flowline and riser hydrotest fluid will most likely be returned to the FPSO facility and then discharged to sea in Commonwealth waters. However, discharge may occur in deep water at the manifolds or riser base FLETS for rigid flowlines.

For flowlines where the manifold is in the State Proposal Area, discharge will occur at the FPSO location (either from the FPSO or from the riser base FLETS) in order to maximise distance of the discharge from Scott Reef. However, for flowlines which are terminated at both ends within the State Proposal Area (specifically for TRE and TRF manifolds only), discharge of flowline hydrotest fluid in the State Proposal Area may be unavoidable. Given that the TRE and TRF manifolds are daisy-chain connected to other manifolds in the State Proposal Area and are not part of Torosa Phase 1 RFSU equipment, future engineering will consider the viability of alternatives to flowline hydrotest fluid discharge in the State Proposal Area, which will be described in a future Environment Plans. Minor hydrotest discharges associated with smaller pieces of subsea equipment may also occur in situ.

For the SURF flowlines (including those in the State Proposal Area), hydrotest fluids may consist of chemically treated seawater (as described above for the BTL) or a MEG/water mixture. The combination of constituents for the SURF flowlines are dependent on the flowline material type and on the period of preservation required.²⁴

Hydrotest fluid volumes being discharged to the marine environment will vary depending on the flowline section to be tested. Volumes are estimated to be up to approximately 950 m³ of hydrotest fluid for the TRE flowline and up to approximately 250 m³ for TRF flowline. A subsea flowline hydrotest discharge is likely to take less than a day to complete. These discharges will occur for each piece of infrastructure during pre-commissioning.

Previous modelling of SURF infrastructure

The size of the mixing zone associated with a hydrotest discharge from flowlines is dependent on the discharge characteristics (e.g. rate, volume, density etc.) and prevailing hydrodynamics. Woodside has previously performed hydrotest modelling for a range of discharge rates (4.8 m³/min, 3.7 m³/min, 1.85 m³/min and 1.5 m³/min), in water depths ranging from 130 m to 830 m on the North West Shelf, which is considered appropriate to support the impact assessment, in recognition that further hydrotest modelling will be completed to support the relevant Environment Plan.

The nearfield dispersion modelling indicated that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge points. Following this initial mixing, the negatively-buoyant plumes are predicted to travel laterally in the water column and remain close to the seabed.

The far-field dispersion modelling indicated that based on an in-pipe chemical concentration of 600 ppm, the plume would achieve 600 dilutions to dilute to below 1 ppm (based on LC50 over 96 hours) in proximity to the discharge location, ranging at a distance from 50 m (130 m water depth; 1.5 m³/min; summer; 95th percentile) to 300 m (844 m water depth; 4.8 m³/min; summer; 95th percentile) downstream of the discharge point. Given the negative buoyancy of the plume, bathymetry of the location (steep reef slopes surrounding the discharge location), and lack of upwelling processes from the depth of discharge, regardless of the size of the mixing zone the zone of influence will remain restricted to depth and avoid Scott Reef shallow water benthic habitat (<75 m bathymetry).

While the modelling for the planned dewatering discharges are not directly comparable with regards to depth of discharge, the typical density and nearfield mixing profile near the seabed provides a good indication that potential impacts to benthic communities, fish or pelagic invertebrates would be limited and restricted to the deepwater location where the SURF infrastructure is located. Noting the results presented are also conservative as they assume that no processes other than dilution would reduce the source concentrations over time, and therefore can be considered as conservative outcomes.

MODU

The temporary production system on the MODU will be hydrotested for well unloading activities. This will be conducted using hydrotest fluids, whereby the temporary production system on the MODU flowlines will be pressurised with fluids and the pressure will be monitored to detect leaks, prior to discharge of the hydrotest fluids.

Contingency discharge

Contingency discharge of hydrotest fluids during construction (e.g. buckling and leaking of the pipeline during installation) are possible but are a contingent planned activity to be undertaken due to an unplanned event. The requirement for contingency discharge is determined by the technical design specifications and performance criteria of the subsea infrastructure. Should these be compromised (i.e. failed welding joint) various repair strategies will be assessed and a decision made should the contingency be required. The volume of hydrotest fluid that would be discharged in the event of a wet buckle depends on the location, extent and repair method. The worst case scenario would be complete dewatering of the BTL. The planned hydrotest discharge would not occur at the same time as contingency discharge. As such, it is considered that the impacts relating to this contingency activity (as a worst case) are consistent with the below assessment and no cumulative impacts would occur.

Hydrotest fluid toxicity

Due to the proposed chemical additives with the hydrotest fluid (i.e. biocides, corrosion inhibitors, oxygen scavenger, fluorescent dyes and MEG), the discharges have the potential to impact sensitive receptors within the discharge area of influence, primarily through toxicological effects ranging from the inhibition of key biological processes (e.g. reproduction) to mortality. In considering the potential impacts to receptors it should be noted that the activity is planned during commissioning, with no ongoing discharge of hydrotest fluids during the normal operations.

²⁴ While the majority of subsea infrastructure will be flooded with hydrotest fluid post installation, some components will be pre-flooded with hydrotest fluid prior to installation.

For the purpose of the impact assessment, the hydrotest chemical treatment is assumed to be Hydrosure 0-3670R as a conservative analogue for other chemical treatments. Hydrosure 0-3670R is a proprietary chemical mixture designed for the treatment of water (neutralising bacteria and dissolved oxygen). The chemical contains 10-30% quaternary ammonium chloride as a biocide, along with an oxygen scavenger and corrosion inhibitor. To identify the potential toxicity of the hydrotest fluids following discharge to the marine environment, Chevron Australia Pty Ltd (2015) conducted whole effluent toxicity (WET) testing on Hydrosure 0-3670R (Champion Chemicals Pty Ltd), diluted in seawater. WET testing was undertaken on five locally relevant species from four different taxonomic groups based on ANZECC & ARMCANZ (2000). Since Hydrosure 0-3670R is a mixture containing both the biocide and oxygen scavenger for chemical treatment, only one assay in each test species was necessary to evaluate the toxicity of the product. The results from study established a 99% species protection value of 0.06 mg/L, which was applied in the modelling over a 48-hr rolling median (Chevron Australia Pty Ltd, 2015).

MEG, which may be used in the SURF flowlines, is commonly used as a hydrate inhibitor within oil and gas developments. The chemical itself is clear and colourless, with a low volatility and miscible with water; however, no hydrolysis of the compound is expected in surface waters (WHO, 2000). MEG is listed as 'E' category fluids under the Offshore Chemical Notification Scheme (OCNS) and are listed on the Oslo Paris Commission (OSPAR) PLONOR ('pose little or no risk to the environment') list. In addition, the compound has little or no capacity to bind to particulates and will be mobile in soil (WHO, 2000). Rapid degradation has been reported in surface waters, with a generally low toxicity to aquatic organisms. Direct toxicity testing of neat MEG, on eight, mainly tropical species, representing seven taxonomic groups, established the lowest no observable effect concentration (NOEC) for sea urchin fertilisation of 130 mg/L (Jacobs, 2019). While MEG may result in highly localised, temporary and minor change in water quality in the immediate vicinity of the discharge point, it will dilute rapidly below levels that could cause impacts to marine biota.

Fluorescein dye is typically selected for use as a leak detection dye due to its low toxicity, availability, low cost, water solubility and stability, and ease of detection. In addition, rapid breakdown of fluorescein dye following exposure to sunlight suggests that concentrations likely to be encountered by organisms in the receiving environment would be low (Walthall and Stark, 1999). During discharge the dye may result in a temporary localised discoloration in the immediate vicinity of

the discharge point on the seabed; however, as the dye is water soluble, it will rapidly dilute in the marine environment with no anticipated toxicity effects on marine organisms.

Due to the addition of oxygen scavengers within the hydrotest fluid, the discharge will have a lower dissolved oxygen level than the surrounding seawater. However, oxygen levels are anticipated to rapidly achieve background levels soon after discharge with any impacts on the surrounding waters expected to be temporary and highly localised. In addition, as the hydrotest fluid is planned to remain inside the pipelines and infrastructure for several months, the toxicity of residual chemicals will be markedly reduced over time, through natural decay and degradation, further reducing the potential impacts associated with the discharge.

6.3.17.3 BTL and Interfiled Spur Line Hydrotest Modelling

In order to further understand the potential impacts and risks associated with the discharge of hydrotest fluid under the worst case scenario (i.e. dewatering of BTL and inter-field spur line), Woodside commissioned RPS to model the fate and transport of the discharge at various considered locations (RPS, 2019a);

[Chapter 10, Appendix D.4](#)). Note, discharge of hydrotest fluid from the subsea flowlines will be significantly less volume when compared to the BTL discharge. As such, it is considered that the impact assessment for these discharges are adequately represented by the BTL hydrotest discharge dispersion modelling.

It should be noted that the modelling undertaken to support the assessment of the hydrotest fluid discharges represents the current understanding of the discharge characteristics and is appropriate for the purposes of this risk assessment, in determining acceptability in the context of the receiving environment and relevant receptors. However, as detailed engineering is undertaken through FEED, hydrotest discharge characteristics and engineering design may change, with renewed modelling undertaken, if required, as part of the Environment Plan assessment process.

Modelling scenarios and discharge characteristics

Three discharge options are being assessed for the dewatering of the BTL and inter-field spur line. For the alternative scenarios, hydrotest fluid required within the existing 2TL as part of the change of use of the pipeline would be discharged with the BTL and inter-field spur line fluid and has been taken into account in the modelling and in the assessment, as detailed in [Table 6-133](#).

Table 6-133 Hydrotest fluid discharge characteristics

Scenario	Details	Modelling inputs
Base case - scenario 1 (NRC PLET)	All hydrotest fluid (BTL and inter-field spur line) is discharged at the NRC PLET location.	736,000 m ³ at 117 m water depth over 490 hours. Note this does not include 110,000m ³ from the 2TL, which is discharged at least 6 months later.
Alternative scenario 2 (Torosa PLET)	All hydrotest fluid (BTL, inter-field spur line and NWS Project's 2TL) is discharged at the Torosa PLET.	846,000 m ³ at 461 m over 564 hours.
Alternative scenario 3a / 3b (Brecknock/ Calliance PLET and Torosa PLET)	BTL and NWS Project's 2TL hydrotest fluid is discharged at the Calliance/ Brecknock PLET, while the hydrotest fluid from the inter-field spur line is discharged at the Torosa PLET.	790,000 m ³ at 539 m over 527 hours at Calliance/Brecknock PLET combined with 56,000 m ³ at 461 m over 37 hours at Torosa PLET.
All scenarios	N/A	For all scenarios a continuous discharge flow was assumed to occur through a single outlet at the seabed of 0.2 m diameter at a maximum rate of 25 m ³ /min with temperature and salinity equivalent to ambient conditions at the seabed.

Modelling threshold

The source concentration of the proposed chemical treatment was based on Hydrosure 0-3670R as discussed earlier. The results from study established a 99% species protection value of 0.06 mg/L, which was applied in the modelling over a 48-hr rolling median (Chevron Australia Pty Ltd, 2015).

The 99% species protection level concentration is suggested by the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) for the development of environmental criteria for high conservation ecosystems or chemicals that have a tendency to bioaccumulate. It was assumed that the residual discharge concentration of the chemicals within the fluid is the same as the initial dosing concentration with no degradation or decay during residence within the pipeline. This represents a conservative approach as it likely over represents the residual toxicity of the fluid following discharge.

Modelling studies

To determine the fate, transport and dilution of the hydrotest discharge, both near-field and far-field modelling was undertaken as these are used to describe different processes and scales of effect. The same modelling approach has been used for PW discharge, cooling water discharge and hydrotest discharge; and is described in [Section 6.3.12.3](#).

A three-dimensional, spatially-varying current data set surrounding the NRC, Torosa and Calliance/Brecknock PLET locations for a ten-year (2006-2015) hindcast period were used, with summer, winter and transitional seasons modelled. The data set included the combined influence of drift and tidal currents and was suitably long as to be indicative of interannual variability in ocean currents. The current data set was validated against metocean data collected in the Browse Development Area.

A further description of the modelling approach and hydrodynamic model validation is described in [Section 6.3.12.3](#) and RPS, (2019a) ([Chapter 10, Appendix D.4](#)).

Near-field modelling results

The results show that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge point for each scenario. Following this initial mixing, the near neutrally-buoyant plume is predicted to travel laterally in the water column ([Figure 6-37](#) to [Figure 6-40](#)). Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point. For all combinations of discharge scenario and season, the primary factor influencing dilution of the plume is the strength of the ambient current.

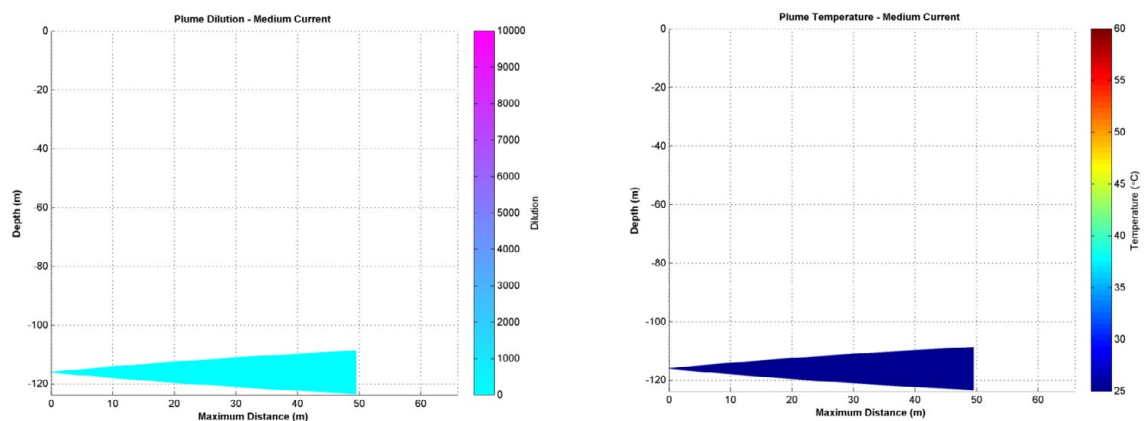


Figure 6-37: Near-field average dilution and temperature results for constant medium annualised currents for Scenario 1 (NRC tie-in 736,000 m³ hydrotest discharge).

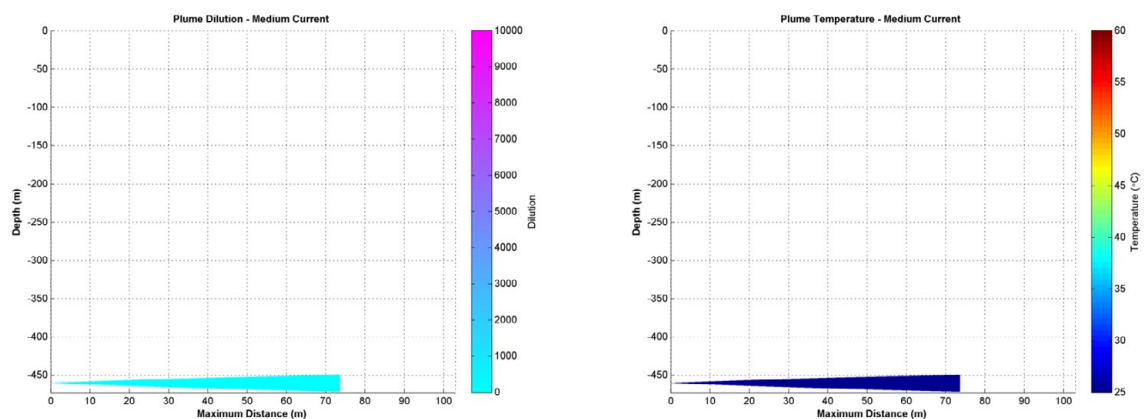


Figure 6-38: Near-field average dilution and temperature results for constant medium annualised currents for Scenario 2 (Torosa 846,000 m³ hydrotest discharge).

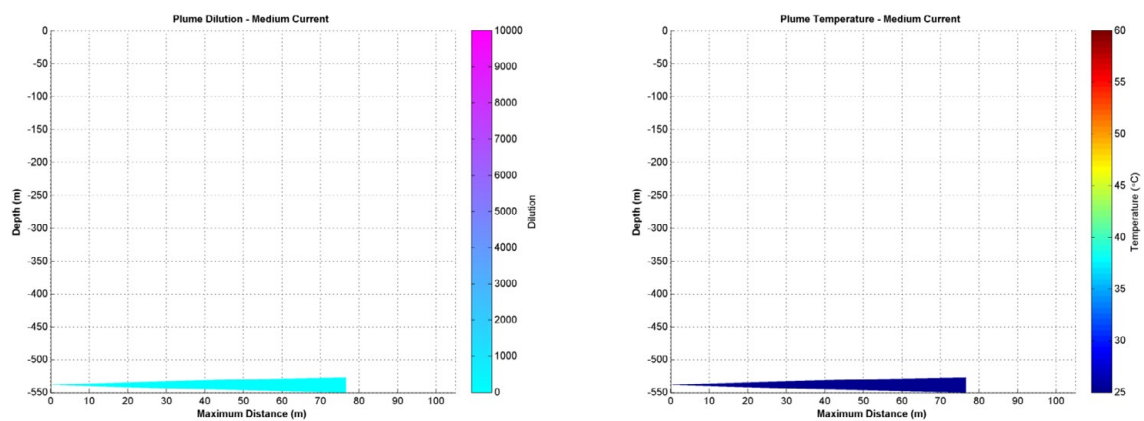


Figure 6-39: Near-field average dilution and temperature results for constant medium annualised currents for Scenario 3a (Brecknock/Calliance 790,000 m³ hydrotest discharge).

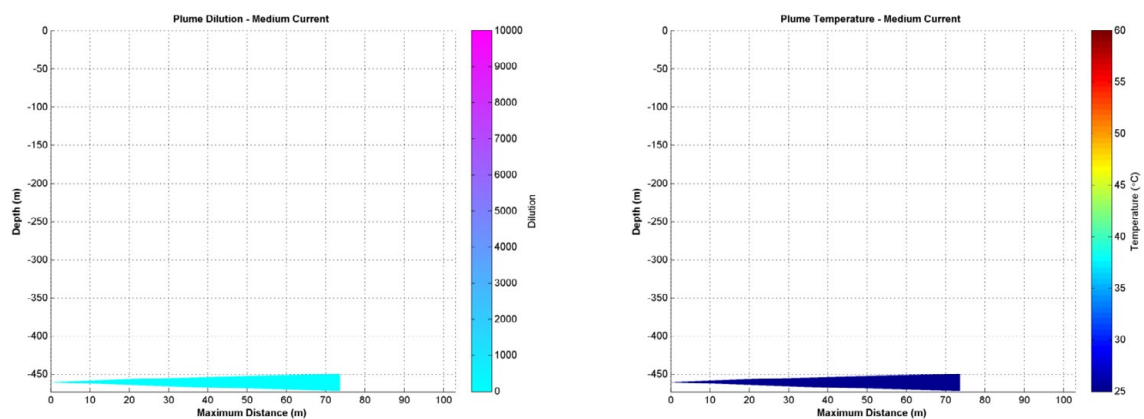


Figure 6-40: Near-field average dilution and temperature results for constant medium annualised currents for Scenario 3b (Torosa 56,000 m³ hydrotest discharge).

Far-field modelling results

The results indicate that dilutions required to reach the threshold concentration (0.6 ppm) at the 95th percentile (48-hour median) is achieved within a maximum distance (based on minimum dilutions) of 16.1 km (Scenario 1); 12.5 km (Scenario 2), 23.4 km (Scenario 3a) and 8.23 km (Scenario 3b) from the discharge point.

Figure 6-41 to **Figure 6-44** portray the spatial distribution of these discharges, particularly in the context of nearby sensitive receptors (e.g. Scott Reef). It should be noted that the figures do not represent the location of a plume at any point in time; they are a statistical and spatial summary of the percentage of time that dilution values occur across all multiple replicate simulations (i.e. stochastic representation).

The results demonstrate that the distribution and extent of the discharges are largely a function of the

predominant drift current trajectories at each location, as well as the bathymetry. Hence, despite the extent of the discharges at the Torosa location, no contact with Scott Reef habitats is predicted due to the depth of the discharge (461 m), with the plume staying in deep water, following the contours at the base of the reef and the prevailing bed currents.

To contextualise the stochastic modelling results, **Figure 6-45** shows example time series snapshots of predicted dilutions during a single simulation at 4-hour intervals on the 12th January 2010. These images are representative of typical conditions for the Scenario 1 discharge and demonstrate the spatially-varying orientation of the plume with the currents. The images also show the combined effect of the tide and the drift currents, with a clear tidal oscillation evident.

Table 6-134 BTL Hydrotest Far Field Modelling Results Summary

Parameter	Scenario 1	Scenario 2	Scenario 3a	Scenario 3b
Description	Base case - (NRC PLET)	Alternative scenario - (Torosa PLET)	Brecknock/ Calliance PLET	Torosa PLET
Indicative discharge specification	600 ppm	600 ppm	600 ppm	600 ppm
Threshold	0.06 mg/L	0.06 mg/L	0.06 mg/L	0.06 mg/L
Minimum dilutions required to achieve threshold	10,000	10,000	10,000	10,000
Maximum horizontal distance required to achieve threshold	16.1 km	12.5 km	23.4 km	8.2 km
Prevailing direction of mixing zone	SW	NNW - SSE	NE (transitional); SW (winter); NE-SW (summer)	NNW - SSE
Total area of coverage to achieve threshold	79.4 km ²	87.1 km ²	89.4 km ²	40.6 km ²
Maximum depth from sea surface	117	461	539	539
Minimum dilutions at 3 nm State Waters boundary	N/A	4,431	>20,000	2,711

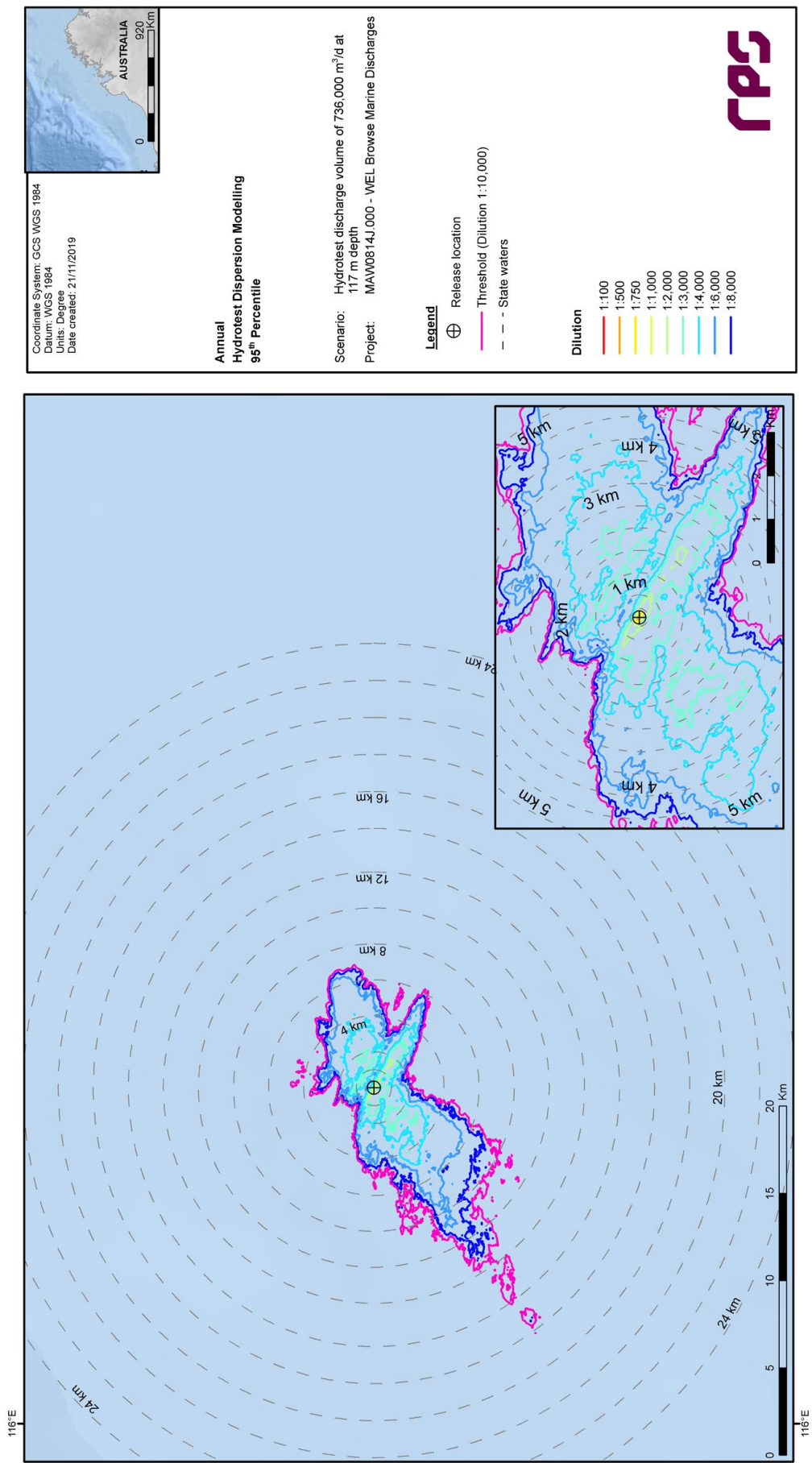
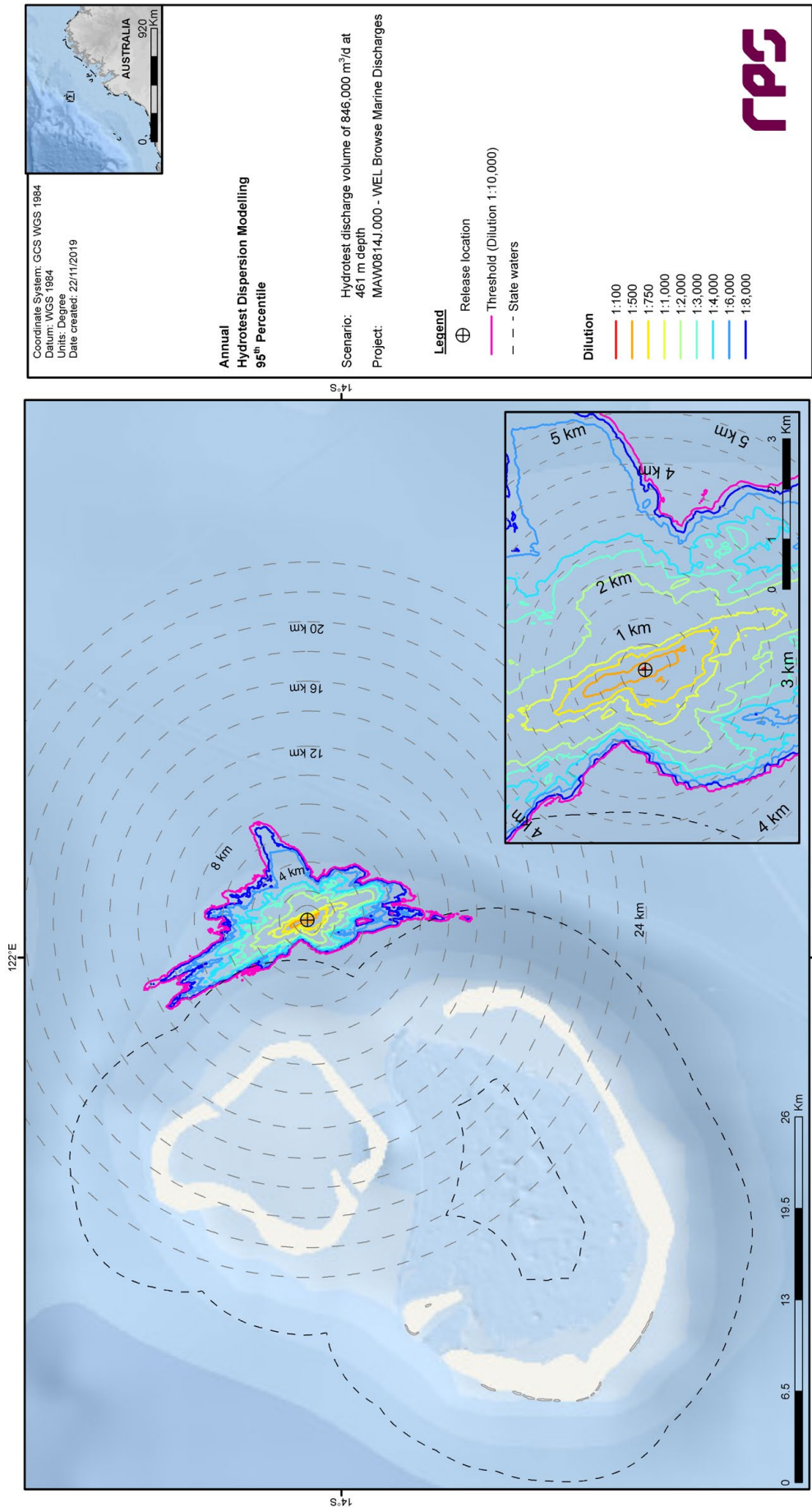
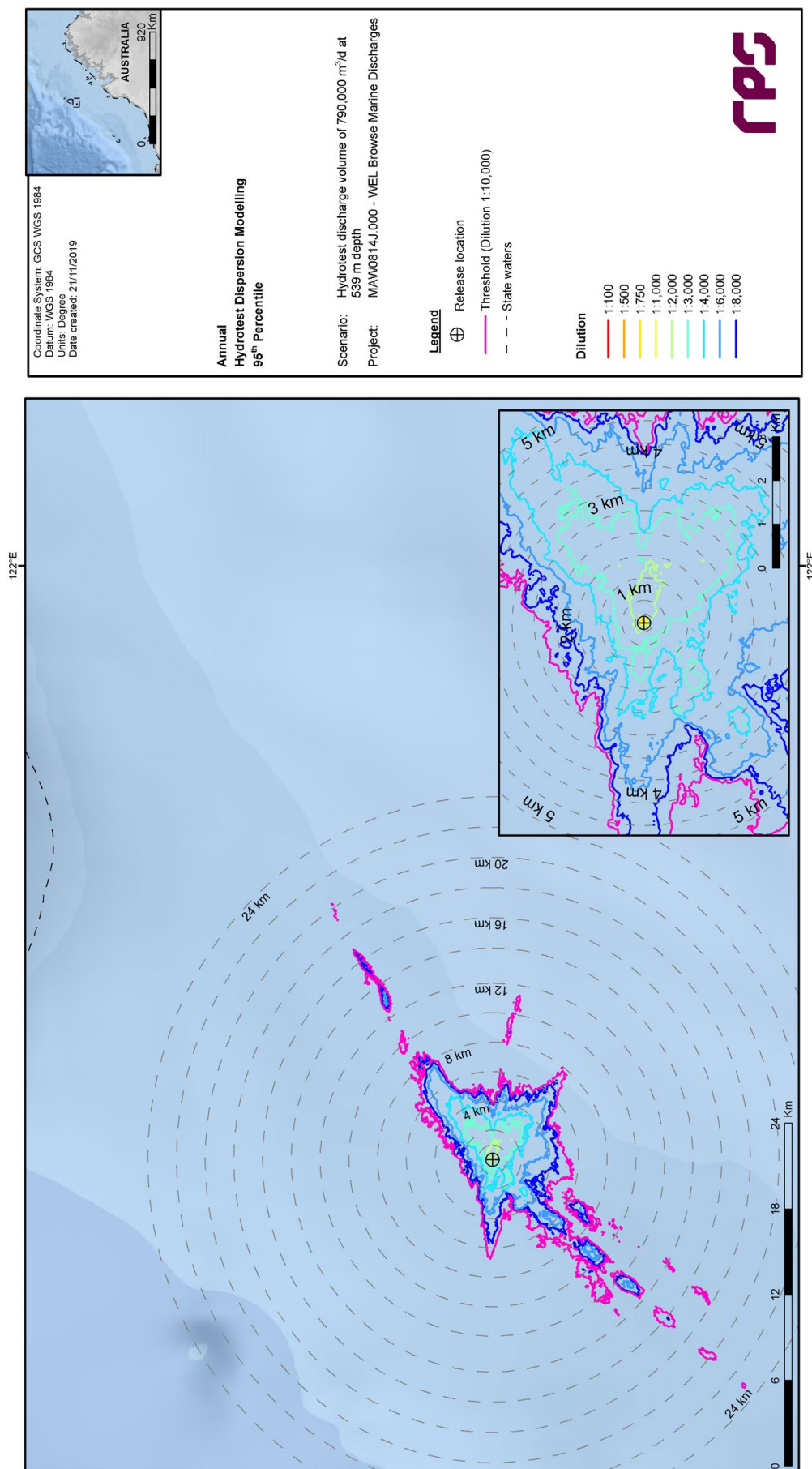
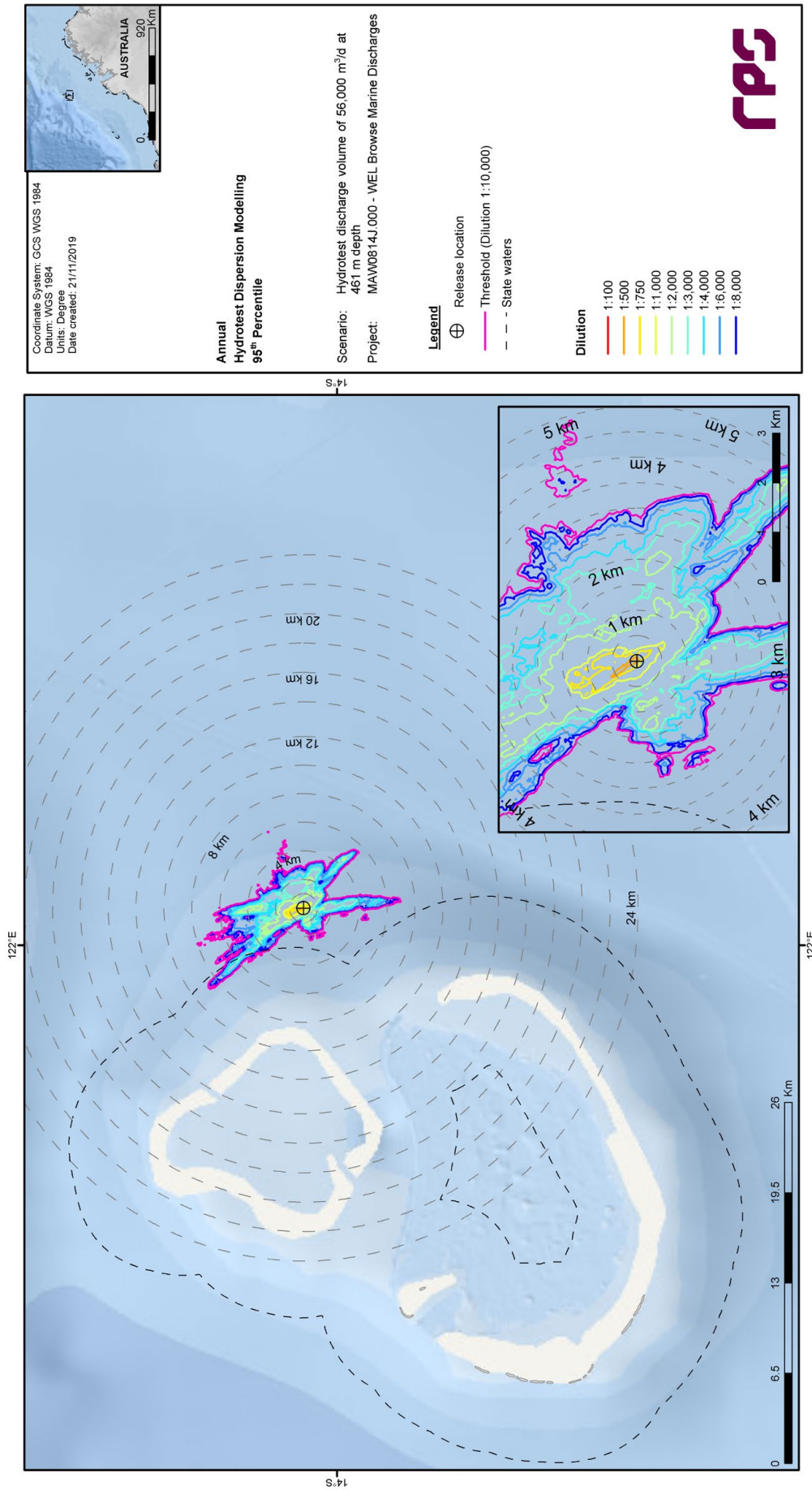


Figure 6-41 Predicted annualised minimum dilutions at the 95th percentile for Scenario 1 (NRC release location), applied to a rolling 48-hour median of the dilution data (note discharge remains at depth)







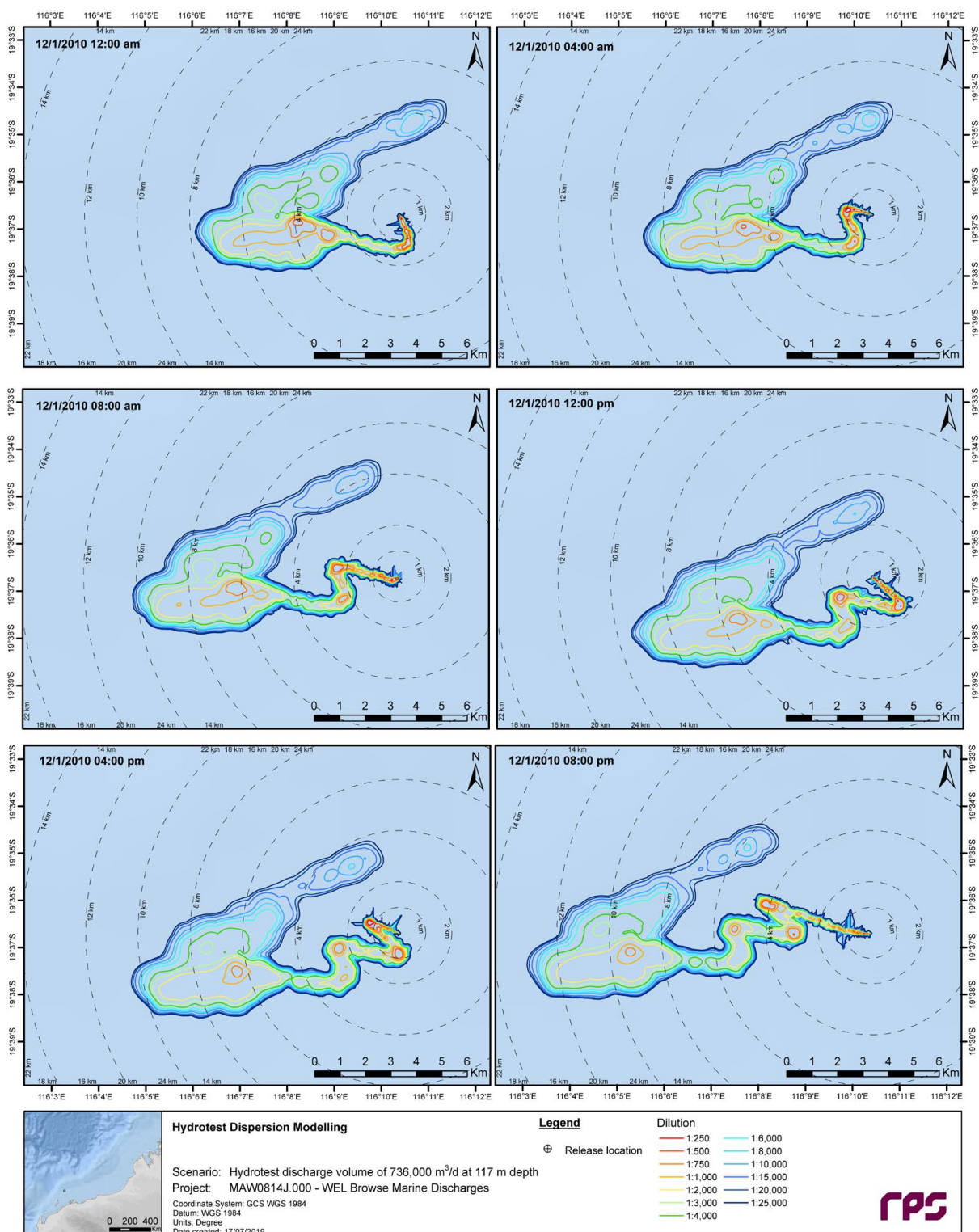


Figure 6-45 Snapshots of predicted dilution levels, at 4-hour intervals from 00:00 to 20:00 on 12 January 2010, for Scenario 1 (NRC 736,000 m³ hydrotest discharge)

6.3.17.4 Environmental Impact

Water quality

Change in water quality

The presence of chemical additives in discharged hydrotest fluids is expected to result in a temporary decline in water quality around the discharge locations. For the BTL and SURF discharges, the plume is expected to travel in close proximity to the seabed which means the temporary change in water quality will be restricted to deep waters. As outlined in [Section 5.2.5.7](#), while there is some evidence of localised intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides, there is no evidence of persistent upwelling or downwelling currents around Scott Reef (Green et al., 2019). Hence, the discharge would be subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the Project Area. In addition, the low toxicity hydrotest fluids will degrade and decay once released. As such no lasting effect on water quality is predicted.

Sediment quality

Change in sediment quality

As the hydrotest discharge plume is expected to travel in close proximity to the seabed, a temporary change in sediment quality may occur. However, as demonstrated by the modelling, the chemical additives will degrade and dilute rapidly following discharge with no predicted accumulation within seabed sediments and as such no lasting effect on sediment quality is predicted.

Plankton communities

Injury or mortality to fauna

Plankton populations within the predicted mixing zones may be affected by hydrotest discharges; however, given the expected rapid dispersion and dilution of the plume by prevailing currents and the temporary nature of the discharge, impacts to plankton are likely to only occur in the immediate area of the discharge plume, over a period of weeks. Given the fast population turnover of open water plankton populations (ITOPF, 2011), the potential impacts are expected to be localised and temporary.

Benthic habitat including epifauna and infauna

Change in sediment quality, change in water quality, injury or mortality to fauna

While the modelling demonstrates that the extent of the area of influence of the hydrotest discharge (associated with the dilution of the biocide additive) is large ([Figure 6-41](#) and [Figure 6-44](#)); the discharge is predicted to be restricted to the sparse deepwater habitats, with impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) not predicted.

Modelling shows that discharge at the NRC and Calliance/Brecknock locations is not predicted to impact high value benthic habitat due to the distance from these locations that the discharge would occur. Modelling also shows that impacts to Scott Reef are not predicted as a result of discharge at the Torosa site due to the proposed depths of the discharge (approximately 461 m). Green et al. (2019b) stated that there is no evidence of persistent upwelling or downwelling currents around Scott Reef and therefore, as demonstrated by the modelling, the plume stays in deep water, following the contours at the base of the reef where benthic habitat is sparse with no sensitive communities recorded ([Section 5.3](#)).

Given the significantly lower volume of hydrotest fluid to be discharged from the flowlines within the State Proposal Area (950 m³ of hydrotest fluid for the TRE flow line and up to approximately 250 m³ for TRF flowline), the depth of the discharge (> 400 m); and the distance of the proposed discharge from Scott Reef it is not predicted that any impacts will occur to Scott Reef benthic communities and habitats from hydrotest discharge in the State Proposal Area.

Furthermore, studies on the dispersion of coral larvae at Scott Reef (Done et al., 2015; Foster and Gilmour, 2018) we examine distance decay among coral communities in a common habitat on northwestern Australian reefs, seeking to better understand the roles of disturbance and coral life history strategies in the changing reefscape. In established communities in 1997, when coral cover and generic richness were uniformly high, there was high similarity (~81 % demonstrates that while there is marked movement of larvae within the reef system itself (broadcast spawning corals), there is no evidence to suggest that those coral larvae that initially dispersed off the reef return to Scott Reef to settle. Therefore, the hydrotest discharge is not likely to impact coral larvae available for local recruitment of corals within the Scott Reef system.

Epifauna and infauna sensitivity to dewatering discharges is expected to be similar to pelagic invertebrate species such as plankton. No sensitive benthic habitats have been identified within the discharge plume given the water depth of the area (>100 m) receives insufficient light to sustain ecologically sensitive primary producers. Discharges of hydrotest fluid may result in temporary and localised impact to epifauna and infauna populations with a temporary decline in abundance. However, recolonization is expected to occur rapidly.

Marine fauna

Injury or mortality to fauna - Fish

Any potential for toxicity to fish would be expected to be limited to deep waters within the mixing zone of the discharge location and therefore will only potentially affect a limited number of individuals. Furthermore, the toxicity threshold concentrations and the subsequent mixing zone have been determined through the application of chronic exposure ecotoxicological tests on marine fauna and therefore given that fish are likely to be transient within the receiving environment adjacent to the discharge location, they are unlikely to be exposed to sufficient concentrations or durations of the discharge constituents to elicit a response. In addition, the predicted toxicity effects on fish within the mixing zone are considered conservative given that the chemical constituents within the BTL and flowlines are likely to be subject to natural degradation following discharge. In addition, fish and other marine fauna have the capacity to adapt their behaviour in response to changes in environmental conditions and can be expected to move away from the discharge if exposed. The depth of the plume and the lack of significant

benthic habitats for demersal fish will also limit the number of fish that may potentially be affected. As such, no lasting effects to fish as a result of hydrotest fluid discharge are predicted.

Injury or mortality to fauna - Other marine fauna

Due to the depth of the discharge plume, it is considered highly unlikely that other marine fauna such as marine turtles or cetaceans will be affected by the discharge of hydrotest water.

Key Ecological Features

Change in sediment quality, change in water quality

Depending on the location of the hydrotest fluid discharge, discharge may occur in (or the discharge plume may enter) the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF, the Continental slope demersal fish communities KEF or the Ancient coastline at 125 m depth contour KEF.

As described above, hydrotest fluid discharges within these KEFs will result only in a temporary (over weeks) change in water and sediment quality with no lasting impacts to marine fauna or high value benthic habitats.

No impacts to reefs associated with the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF are predicted.

Given the above, no impact to the conservation values of these KEFs is predicted.

Table 6-135 provides an assessment of the proposed hydrotest fluids discharge in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-135 Alignment with protection of conservation values of KEFs – hydrotest fluids

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Continental slope demersal fish communities	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Chemical pollution / contaminants - currently identified as 'not of concern'	As described above, hydrotest fluid discharges are not predicted to add to existing or potential pressures or adversely impact the conservation values of these KEFS.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Ancient coastline at 125 m depth contour			

Other protected places

Injury or mortality to fauna

As the hydrotest plume is not predicted to contact Scott Reef, no impacts to the values of the Scott Reef and Surrounds Commonwealth Heritage Place or the Scott Reef Nature Reserve are predicted.

Other users

Changes to the functions, interests or activities of other users – State and Commonwealth managed fisheries

Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that no lasting impacts to marine fauna including fish are predicted, no significant subsequent impact to fisheries is expected.

Changes to the functions, interests or activities of other users – tourism and recreation, scientific studies

As no impact to Scott Reef from the discharge of hydrotest fluid is predicted, no significant impact to the scientific, tourism or recreation is expected.

6.3.17.5 Environmental Risk

There are no anticipated environmental risks in relation to this aspect associated with unplanned project activities.

6.3.17.6 Cumulative Impacts

Impacts resulting from the discharge of hydrotest fluid are expected to be limited to the deepwater mixing zones described in [Section 6.3.17.3](#) with no expected cumulative effects from the other surface discharges and other project activities within the Project Area or from other operational projects within the Browse Basin (i.e. Shell Prelude FLNG facility and INPEX Ichthys LNG Project) given the geographic spread of the activities.

6.3.17.7 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact assessment for the discharge of hydrotest fluids is provided in [Table 6-136](#). The acceptability assessment is provided in [Table 6-137](#).

Table 6-136 Impact assessment summary and adopted controls – Hydrotest Fluids

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact significance level
Water quality (medium value (open waters))	Change in water quality	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	<i>Installation of subsea infrastructure</i>	No lasting effect	Negligible (F)
Sediment quality (medium value (open waters))	Change in sediment quality	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.	+ The subsea infrastructure installation schedule will be optimised to minimise the requirement for discharge and refill of hydrotest fluid.	No lasting effect	Negligible (F)
Plankton (medium value (open water))	Injury or mortality to fauna	Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.	+ Chemicals that may be operationally released or discharged to the marine environment will be subject to Woodside's chemical selection and assessment process and approved prior to use.	No lasting effect	Negligible (F)
Fish (high value species)	Injury or mortality to fauna	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species.		No lasting effect	Slight (E)
Marine mammals (high value species)	Injury or mortality to fauna	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		No lasting effect	Slight (E)
Marine reptiles (high value species)	Injury or mortality to fauna	Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.	+ For flowlines connected to those production manifolds that are located within 3nm of Scott Reef, the discharge of flowline hydrotest fluid will occur from the end of the flowline furthest from Scott Reef, where technically feasible.	No lasting effect	Slight (E)
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in sediment quality Change in water quality	Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No impact expected	
Deepwater benthic communities and habitats (>75 m depth) – (medium value)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry). Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.	+ Future engineering will consider the viability of alternatives to flowline hydrotest fluid discharge in the State Proposal Area, which will be described in a future Environment Plan.	No lasting effect	Negligible (F)
KEFs (medium value)	Change in sediment quality Change in water quality	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		No lasting effect	Negligible (F)
Other protected places (high value)	Injury or mortality to fauna	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		No impact expected	

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact significance level
State and Commonwealth managed fisheries (high value marine user)	Changes to the function interests or activities of other users	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Other users including tourism and recreation, scientific studies (high value user)	Changes to the function interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)

Table 6-137 Acceptability assessment – hydrotest fluids

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts associated with the discharge of hydrotest fluids as: + Dispersion modelling indicates that hydrotest fluids discharged from the BTL will disperse to below toxicity threshold concentrations prior to the 3 nm State waters boundary at Scott Reef (95% of the time based on dispersion modelling results). With the plume staying at depth. + The modelling undertaken is conservative as it was assumed that the residual discharge concentration of chemical additives is the same as the initial dosing concentration with no degradation or decay of the biocide during residence within the pipeline. This approach over represents the residual toxicity of the biocide following discharge, because biocide will degrade and decay prior to discharge.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met.
Conclusion: Acceptable Significant Impacts as defined by the MNES Significant Impact Guidelines Listed threatened species and ecological communities / listed migratory species As described in Table 6-136 no lasting effect is predicted to occur from the discharge of hydrotest fluid to listed threatened and migratory species such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E). Given this, with the application of the proposed controls it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Commonwealth Marine Environment As described in Table 6-136, the potential impact from the discharge of hydrotest fluid to water quality, sediment quality, plankton, deep-water benthic communities and habitats (>75 m depth) and KEFs has been assessed as Negligible (F). Slight (E) impacts may potentially occur to marine fauna, managed fisheries and other users, while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth) and other protected places. As such, with the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environmental (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the impacts of hydrotest discharge against the WA EPA Objectives is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)). In summary:

Marine environmental quality

As described in [Table 6-136](#), the potential impact from the discharge of hydrotest fluid to water quality, sediment quality and plankton has been assessed as Negligible (F).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*to maintain the quality of water, sediment and biota so that environmental values are protected*” will be achieved.

Marine Fauna

As described in [Table 6-136](#), no lasting effect is predicted to occur from the discharge of hydrotest fluid to marine fauna such as fish, marine turtle and marine mammals, with the impact significance level determined to be Slight (E).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*To protect marine fauna so that biological diversity and ecological integrity are maintained*” will be achieved.

Benthic communities and habitats

As described in [Table 6-136](#), the potential impact from the discharge of hydrotest fluid to deepwater benthic communities and habitats (>75 m depth) and KEFs has been assessed as Negligible (F), while no impact is predicted to occur to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*” will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders regarding discharge of hydrotest water in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact and risk assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside’s chemical selection and assessment process, and approved prior to use. Woodside will implement its internal requirement that states Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

Further, Woodside will continue to pursue the dry commissioning of the BTL and inter-field spur line as an option. If deemed technically feasible, dry commissioning of the BTL and inter-field spur line will significantly reduce the volume of hydrotest fluid to be discharged in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Acceptability Assessment

Other requirements

KEFs

As detailed in [Table 6-135](#) the proposed hydrotest fluid discharge will not materially increase existing relevant pressures on the conservation values of KEFs.

Other protected places

Modelling has indicated that hydrotest fluid discharge is not expected to reach the Scott Reef and Surrounds Commonwealth Heritage Place.

Conclusion: Acceptable

6.3.18 Physical Presence (unplanned): Vessel Interactions with Fauna

6.3.18.1 Impact and Risk Overview

[Table 6-138](#) presents an overview of the risks associated with potential vessel interactions with fauna associated with the proposed Browse to NWS Project.

Table 6-138 Vessel interactions with fauna impact and risk overview

Aspect	Physical presence (unplanned): vessel interactions with fauna
Description	Vessel movements during all phases of the proposed Browse to NWS Project have the potential to cause injury or mortality to marine fauna as a result of accidental collisions. During drilling and construction and, project vessels will include barges, tugs, survey vessels, supply vessels, installation and pipelay vessels. During operations project vessels will include supply vessels, tugs, IMR vessels, FCTVs (as discussed below) and condensate tankers.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to vessel interactions with fauna associated with the proposed Browse to NWS Project are Objectives 14, 15 and 16. These objectives are detailed in Table 6-7 .
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-140). + EPBC Regulations 2000: Part 8 Interacting with cetaceans and whale watching - Division 8.1 Interacting with cetaceans + WA <i>Biodiversity Conservation Act 2016</i> (Wildlife Conservation (Specially Protected Fauna) Notice 2018) + WA Environment Protection Authority – Environmental Factor Guideline – Marine Fauna + Australian National Guidelines for Whale and Dolphin Watching 2017 (Commonwealth of Australia, 2017b) + Whale shark 'Industry Code of Conduct' (Department of Parks and Wildlife, 2013) + North-west Marine Parks Network Management Plan (Director of National Parks, 2018) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (Commonwealth of Australia, 2017c) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c).

Aspect	Physical presence (unplanned): vessel interactions with fauna		
Receptors	+ The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <i>Ecological</i> + fish (high value species) + marine mammals (high value species) + marine turtles (high value species)		
Potential impacts	+ There are no anticipated environmental impacts in relation to this aspect associated with unplanned project activities.		
Risk	+ Vessel strike leading to injury or mortality to fauna		
Summary of governing impact evaluation	Magnitude	Impact significance level	Confidence
	n/a	n/a	n/a
Summary of governing risk evaluation	Consequence	Likelihood	Risk rating
	Moderate	Unlikely	Low (C2)

6.3.18.2 Source of Aspect

Vessel movements during all phases of the proposed Browse to NWS Project have the potential to cause injury or mortality to marine fauna as a result of accidental collisions. During drilling and construction and, project vessels will include barges, tugs, survey vessels, supply vessels, installation and pipelay vessels. During operations project vessels will include supply vessels, tugs, IMR vessels, FCTVs (as discussed below) and condensate tankers.

The type and number of vessels in the Project Area (and transiting to and from the Project Area) at any one time, and the duration of presence, will differ depending on the project phase. Vessel presence is expected to be greatest for short term project phases (e.g. drilling and completions, subsea installation including BTL, and commissioning), with the longer-term operational phase requiring fewer vessels.

In addition, in the instance flowlines are installed as towed bundles up to 10 km in length, the movement of these towed bundles have the potential to result in accidental collisions due to their length and limitations in manoeuvrability. Although it is noted that there will be far fewer movements of towed bundles (when compared with traditional installation techniques such as pipelay vessels) which are only required during construction. Towed bundle movements will occur at a significantly slower speed than regular vessel movements.

Vessel movements can affect marine fauna in a number of ways, including the disruption of behaviour (e.g. feeding, nursing, mating, migrating) displacement from habitats due to vessel noise emissions and collisions leading to injury or mortality. Impacts to fauna from vessel noise emissions is discussed in [Section 6.3.8](#).

Vessel speed has been demonstrated as a key factor in collisions with marine fauna (Laist et al., 2001). Large (>80 m), fast moving vessels pose the highest risk. Collisions are difficult to avoid as the vessels are potentially not able to slow down or evade marine fauna upon sighting (Laist et al., 2001). All project vessels will not travel at speeds greater than 12 knots within the State Proposal Area, or 6 knots in the Scott Reef channel, which will reduce the risk of accidental collisions (Laist et al., 2001).

Fast Crew Transfer Vessel (FCTV)

Fast crew transfer vessels (FCTVs) may be used for crew transfer. These FCTVs are capable of travelling at 50 – 55 knots. It is anticipated that one transfer per day would occur during normal operations, with additional transfers during shut downs and major maintenance.

If a FCTV is utilised, Woodside would select a FCTV design which inherently minimises the risk of unplanned interaction with marine fauna. The vessel has no propeller, has a shallow draught (<1 m) and can rapidly slow down, for example reaching dead stop within approximately 150 m from a cruising speed of 30 knots²⁵.

[Figure 6-46](#) provides an indicative route from Broome to the Browse Development Area. It is recognised that the route passes through a number of BIAs for protected marine fauna. The route avoids habitat critical for the survival of a species near Scott Reef, as defined by the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a). The route also avoids habitat critical of the survival of a species near the Lacepede islands during sensitive times (as defined in [Table 6-139](#)). The figure does not present seasonality of marine fauna, which is further discussed below.

25 FCTVs will not travel at speeds greater than 30 knots within sensitive areas (e.g. migratory corridors) during sensitive times (e.g. migration seasons). The maximum allowable speed within the defined sensitive areas may be increased if incorporated engineering controls are able to achieve an equal or greater effectiveness as the speed restriction.

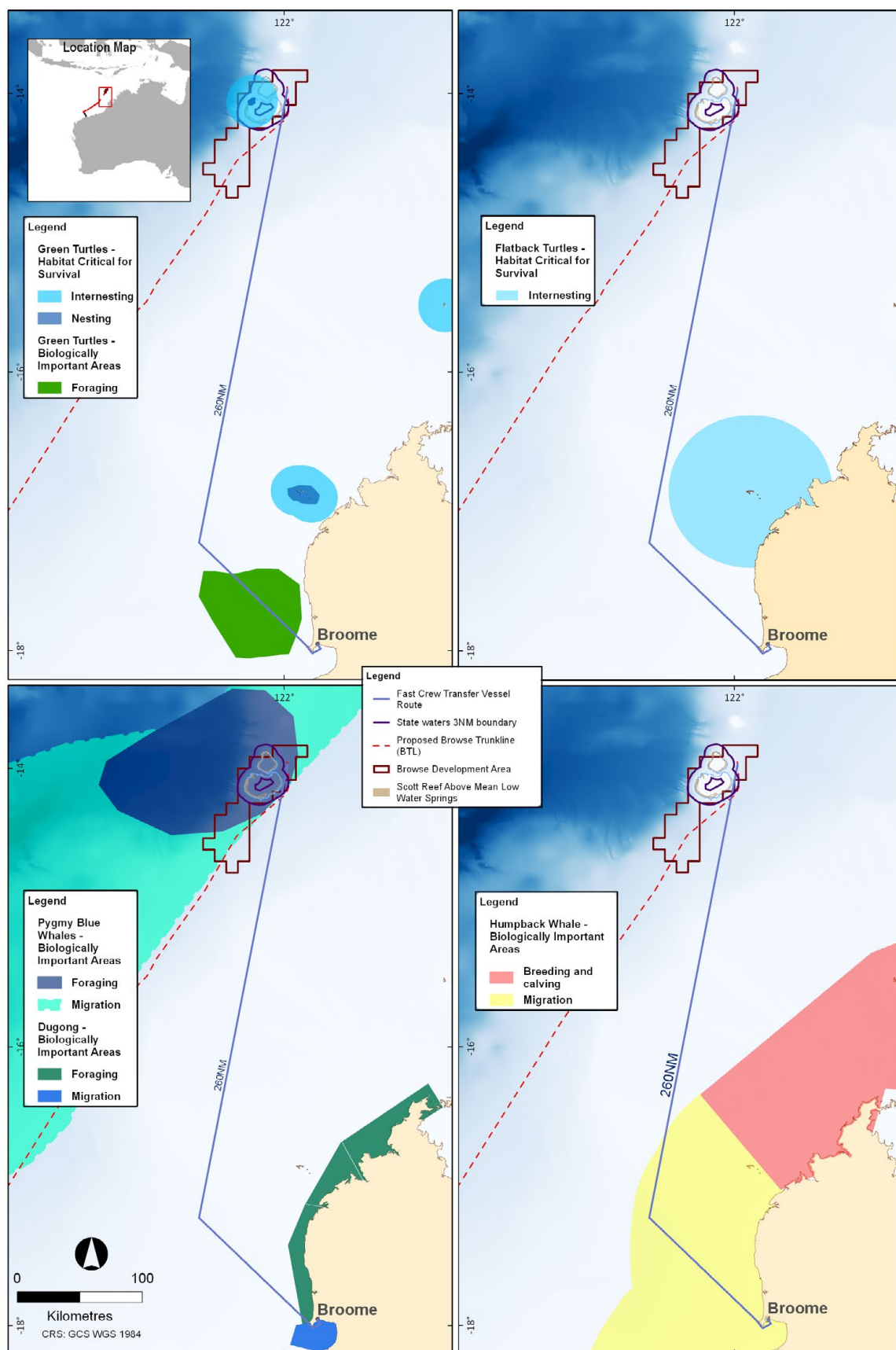


Figure 6-46 Indicative FCTV route in relation regional marine fauna BIAs.

Proposed Management Approach for the FCTV

Recognising that interactions are most likely to coincide with increased fauna presence particularly within BIAs, consideration has been given to control measures beyond standard practice to specifically manage the risk of vessel strike within sensitive areas at sensitive times. In developing this management approach for the potential FCTV, consideration has been given to the National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (Commonwealth of Australia, 2017c).

Objective 3: *Mitigation – reduce the likelihood and severity of mega-fauna vessel collision*, describes a number of key actions under the Strategy:

- + identify best practice mitigation measures and emerging technologies
- + develop and improve mitigation measures
- + encourage innovation and collaboration between research organisations and industry
- + develop a mitigation measures toolkit that provides guidance to stakeholders and managers on what measures are most suited to specific locations, species and vessel types
- + encourage the development and implementation of vessel strike management plans in locations where the relative risk of vessel strike is high, as determined by a risk assessment
- + encourage the use of monitoring programs to measure the success of mitigation measures implemented and identify potential improvements
- + evaluate and review mitigation measures on a regular basis.

There are a number of uncertainties outlined in the *Draft National Vessel Strike Strategy* associated with the selection of additional control measures to manage this specific risk. These uncertainties include:

- + emerging technologies, such as detection controls including front-of-bow detection, aerial/satellite detection, and detection along the path through fixed infrastructure
- + the establishment of any local vessel strike management plan (to be incorporated into subsequent EPs) which would apply to the FCTV
- + changes in scientific understanding of the existing environment, such as the spatial and temporal variability and extent of sensitive receptors.

Given the key actions in the National Strategy for Reducing Vessel Strike around the identification and development of mitigation measures and the implementation of vessel strike management strategies, and the identified uncertainties, an ongoing management approach is required to select appropriate additional control measures to specifically manage vessel strike risk for a FCTV, within sensitive areas at sensitive times. The management approach will follow the Impact and Risk Treatment process outlined in [Section 6.2.3.3](#), giving preference to additional engineering control measures (i.e. detection controls) before considering speed restrictions.

These controls will be applied during the sensitive areas at sensitive times as outlined in [Table 6-139](#). Please note that these sensitive areas and times are indicative, the precise spatial and temporal variability and extent of the sensitive receptors will be subject to approval of the management approach to be included in secondary environmental approvals (e.g. future Environment Plans).

Table 6-139 Sensitive areas and sensitive times for FCTV Proposed Management Approach

Marine Fauna	Sensitive Area	Sensitive Time
Dugong	Foraging Area - coastline	All year
Humpback Whale	Migratory Corridor	Humpback whale migration July – September
Pygmy Blue Whale	Possible Foraging Area (Commonwealth)	Pygmy blue whale migration September – December (southward migration)
	Possible Foraging Area (State)	March – May (northward migration)
Marine Turtles – Green and Flatback	Habitat Critical - Internesting Buffer – Lacepede Island	Green and flatback turtle nesting season October – March
	Habitat Critical - Internesting Buffer – Sandy Islet (Green turtles only)	Green and flatback turtle nesting season November – March

It is recognised that there are engineering controls in various stages of maturity that could be adopted for FCTV activities, either from FCTV commencement, or as they become available in the future. While Passive Acoustic Monitoring (PAM) has often been used to detect cetaceans during seismic activities, Thermal IR and RADAR have been identified in literature as emerging complementary technologies which increase the ability detect marine fauna (Verfuss et al., 2018). The Centre for Whale Research has previously used similar detection technology that is currently available on the market, called the Night Navigator 3, which was found to highly effective. Due to the current level of the proposed Browse to NWS Project definition, no decision on incorporation of engineering controls has been taken, however this will be further considered in the proposed management approach.

Examples of marine traffic moving through the humpback whale migratory corridor include iron ore carriers (15 knots) and LNG carriers (22 knots). Recognising this risk, Woodside would select a FCTV design which is inherently safe in that it has no propeller (i.e. no slice risk), has a shallow draught (<1 m) and can reach dead stop within approximately 150 m from a cruising speed of 30 knots.

The FCTV will comply with the requirements of the EPBC Regulations 2000 – Part 8 Division 8.1 and the National Guidelines for Whale and Dolphin Watching. Travelling at 30 knots, in the event of sighting a whale at the edge of the caution zone, the FCTV can reach dead stop before being within the 100 m no approach zone. This speed is consistent with the advertised speed of whale watching vessels (i.e. Whale Watch Western Australia), which is a similar sized vessel as the proposed FCTV design.

Therefore, a speed restriction of 30 knots will be in place in the defined sensitive areas at sensitive times in [Table 6-139](#). The maximum allowable speed within the defined sensitive areas may be increased if incorporated engineering controls are able to achieve an equal or greater effectiveness as the speed restriction. Furthermore, FCTVs will not travel at speeds greater than 12 knots with the State Proposal Area, or 6 knots in the Scott Reef channel (if entry is even necessary), further reducing the risk of accidental collisions.

6.3.18.3 Environmental Impact

There are no planned vessel interactions with marine fauna as part of the proposed Browse to NWS Project activities and therefore no impacts are expected during any phase of the proposed Browse to NWS Project.

6.3.18.4 Environmental Risk

Risk Event: Vessel strike on marine fauna

Fauna in Project Area that are highly unlikely to co-occur with project vessels

Injury or mortality to fauna - fish

Given the size of the Project Area, a diverse range of fish are likely to inhabit the area; however, in the context of this aspect (unplanned vessel collisions with fauna) the type of fish most likely to be impacted are larger pelagic species, particularly large sharks. [Section 5.3.2.8](#) provides an overview of the fish communities that occur within both the Project Area and the NWMR.

Fish species most vulnerable to collision with vessels are large sharks which frequent the upper portions of the water column. Whale sharks are at particular risk due to their slow swimming behaviour and propensity to spend significant portions of time at the surface. Studies have indicated that whale sharks spend approximately 25% of their time less than 2 m from the surface and greater than 40% in the upper 15 m of the water column (Gleiss et al., 2013; Wilson et al., 2006). Conservation advice for the whale shark (Threatened Species Scientific Committee, 2015f) identifies vessel strike from large vessels as a key threat. However, based on the available information, it is expected that while whale sharks may occur within the Project Area, they are likely to occur in low numbers and as vagrant individuals (Meekan and Radford, 2010; Wilson et al., 2006). Given this, and the proposed vessel speed restrictions, it is considered highly unlikely that a vessel strike on a whale shark will occur.

Other fish are thought to be generally less vulnerable to vessel strike due to size, natural flee responses and preferred habitat use. Smaller fish may be at risk of mortality through being caught in vessel thrusters during station keeping operations. However, the noise emissions generated by the operation of dynamic positioning thrusters will generally deter fish from the vicinity of these operations.

Injury or mortality to fauna - marine mammals (cetaceans other than humpback whales)

Twenty-seven cetacean species have been identified as potentially occurring within the Project Area. Of these, the pygmy blue whale, humpback whale, fin whale, Bryde's whale and sei whale are considered likely to occur within the Project Area. These marine mammals are discussed in [Section 5.3.2.5](#).

Conservation advice for humpback whales, sei whales and fin whales; as well as the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b), each recognise vessel disturbance as key threats to the conservation of the species.

Large whales are more vulnerable to vessel collisions, particularly those species whose behaviour includes extended surface ‘milling’ time (Laist et al., 2001) and which demonstrate a lack of avoidance behaviour to approaching vessels (Nowacek et al., 2004). Cetacean calves and juveniles also have a higher risk of impact (Stevick, 1999), possibly due to less frequent and shorter dives (Szabo and Duffus, 2008).

Pygmy blue whales demonstrate limited behavioural responses to avoiding vessel collisions, with some undertaking slow shallow dives; however, active flee responses from vessels have not been observed (McKenna et al., 2015). While it is acknowledged that pygmy blue whales are vulnerable to vessel collisions, they are not expected to occur in high densities within the Project Area or on the route that vessels will traverse when transiting to and from the Project Area. It is noted that the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b) documents a possible foraging area within the vicinity of the Scott Reef. The plan also recognises vessel disturbance as a key threat to blue whales.

However, while studies indicate that pygmy blue whales pass through the Scott Reef area and that this area represents a potential foraging area for the species (as outlined in Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)), multiple surveys, have failed to observe significant numbers of individuals present or evidence of foraging.

Therefore, co-occurrence of project vessels with pygmy blue whales is considered to be highly unlikely.

With respect to the other large cetacean species that may occur in the Project Area, neither the Bryde’s whale, sei whale or fin whale are expected to occur in large numbers in the Project Area or in the area along the route project vessels would take when transiting to and from the Project Area.

Although spinner dolphins are very agile in the water and often display positive behaviours to the presence of vessels (e.g. bow-riding), there are a significant numbers of recorded vessel collisions with dolphins across Australia (DoEE, 2017). However, it is likely that the majority of such occurrences occur within more confined coastal areas subject to high vessel-traffic, significantly increasing the chance of vessel collision. It is thought that the risk of collision within deeper offshore waters with less vessel traffic, is significantly reduced (DoEE, 2017).

Given the low likelihood of co-occurrence of vessels with these species and the proposed speed restrictions within sensitive areas at sensitive times (Table 6-139), the likelihood of vessel interaction with these species resulting in injury or mortality to fauna is considered highly unlikely, with the subsequent risk rated as low.

Fauna in Project Area that may co-occur with project vessels

Injury or mortality to fauna - humpback whales

Considering the densities, distributions and migratory pathways of the key marine fauna within the Project Area, humpback whales are considered to be the main species at risk from vessel interactions related to the proposed project activities, and in particular the possible use of FCTVs to transfer personnel from Broome to the offshore facilities during operations. A comprehensive review of ship strikes on large whales by Jensen and Silber (2004) revealed that humpback whales were the second highest reported species struck (44 records).

During their annual migration, humpback whales occur in relatively high densities between the Project Area and the Western Australian coast, which represents a migratory BIA for the species (see Section 5.3 for a detailed discussion on humpback whale distribution). Project vessels including FCTVs will traverse this BIA during transit from logistic bases (in Broome and Dampier) and the Project Area (Figure 6-46).

The risk of collision is likely to be higher during the southern migration given the broader migratory corridor and the presence of cow and calf pairs travelling at slower speeds with a higher proportion of time spent at the surface (Bejder et al., 2019; Zoidis and Lomac-MacNair, 2017)2017. Vessel disturbance and strike is identified as a threat to humpback whales within the Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b).

Given this risk to high value fauna, Woodside has developed mitigation measures to reduce the likelihood and severity of potential vessel collision with humpback whales. These measures have been developed in consideration of the National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (Commonwealth of Australia, 2017c).

While research into these potential methods to reduce the risk of vessel collisions is limited in the existing scientific literature, a key action of the National Strategy for Reducing Vessel Strike is to identify and adopt best-practice mitigation measures and emerging technologies and encourage the development of new mitigation measures. It is therefore considered emerging technologies may offer an equivalent reduction in risk to speed reductions and may in future eliminate the need for speed reductions in sensitive areas at sensitive times.

The proposed management approach (outlined above), including engineering controls and speed restrictions, is sufficient to manage the risk of unplanned vessel interaction with humpback whales.

Injury or mortality to fauna - dugongs

As described in [Section 5.3.2.5](#) dugongs are known to inhabit the coastal regions of the Dampier Peninsula, with high concentrations noted at Roebuck Bay adjacent to Broome (RPS, 2010). Dugongs typically spend the majority of time submerged, surfacing on average every 1-4 minutes (Anderson and Birtles, 1978; Cox, 2002; De longh et al., 1997) and typically spending less than 5% of the time resting on the surface (Hodgson, 2004). Threats to dugongs in Australian waters are identified in *The Action Plan for Australian Mammals 2012* (Woinarski et al 2014). Because of their size, dugongs are susceptible to injury or mortality resulting from interaction with vessels, particularly when they rise to the surface to breathe, rest or forage in shallow waters (Woinarski et al 2014). One of the primary responses of dugongs to approaching vessels is to move towards deeper water (Hodgson, 2004).

Similarly, dugongs are susceptible to injury or mortality resulting from interaction with vessels, particularly when they rise to the surface to breathe, rest or forage in shallow coastal waters as opposed to deeper offshore waters.

The proposed management approach (outlined in [Section 6.3.18.2](#)), including engineering controls and speed restrictions, is considered sufficient to manage the risk of unplanned vessel interaction with dugongs, particularly given the likely lower densities of individuals within the proposed FCTV route and the minimal overlap between the proposed route and dugong foraging BIA.

Injury or mortality to fauna - Turtles

Turtles that are known to occur in the NWMR are described in [Section 5.3.2.6](#). The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) recognises vessel strikes as a moderate threat to the Scott Reef – Browse Island green turtle genetic stock. It also defines the area around Scott Reef (including the Torosa FPSO location) as habitat critical to the survival of green turtles, and the area around the Lacepede Islands as an important nesting location for green turtles and flatback turtles.

Turtles may be particularly vulnerable to vessel strike while surfacing to rest or breathe. However, it has been reported that turtles spend a comparatively limited amount of time (3–6%) at the surface, with dives lasting between 15 and 60 minutes in general (Milton and Lutz, 2003). Turtles have been observed to avoid approaching vessels by moving away from the vessel's track (Hazel et al., 2007). Hazel et al. (2007) suggest that this avoidance behaviour is based primarily on visual cues (although the authors acknowledge vessel noise is within range of turtle hearing), and the success of this behaviour in avoiding a vessel strike largely depends on the speed of the approaching vessel and the prevailing water clarity. It is also likely that the propagation characteristics of underwater noise, particularly in high-use areas, would

make it difficult for turtles to determine the direction of an oncoming vessel to elicit an appropriate flee response (Hazel et al., 2007). In the event of a collision, a turtle's carapace provides a level of protection from serious injury, although the type and severity of the injuries would depend on the force of the collision and structure and size of the vessel.

Turtles generally aggregate in shallow coastal areas adjacent to nesting beaches or in areas where sufficient food is available; they are unlikely to be present in high numbers within deep offshore waters of the Project Area. Therefore, vessel interactions with turtles will be primarily restricted to coastal areas and in proximity to offshore nesting beaches (e.g. Scott Reef) where vessel movements would be limited, significantly reducing the likelihood of vessel collision.

The proposed management approach (outlined above), including engineering controls and speed restrictions, is sufficient to manage the risk of unplanned vessel interaction with marine turtles, particularly as the proposed FCTV route will avoid habitat critical for flatback turtles around the Lacepedes during sensitive times and habitat critical for green turtles around Sandy Islet.

Summary

While within the Browse Development Area, project vessels will predominately travel at relatively slow speeds in accordance with standard maritime practices and nominated speed restrictions; and as such do not demonstrate a significant risk to marine fauna, particularly within the context of existing regular commercial shipping within the broader region.

While the risk of general vessel collisions with marine fauna within the Project Area is considered to be low, the use of FCTVs between the mainland and the FPSO facilities during the operations phase of the proposed Browse to NWS Project will require additional management measures to mitigate for the increased risk associated with this vessel type. The strategy for applying these management measures is described above and will ensure the FCTV does not present a significant increase in the vessel strike risk that is already presented by routine marine traffic

Considering of the total extent of available habitat, distribution of key receptors, vessel routes, and the application of mitigation measures such as speed reductions, it is considered unlikely that collisions will occur between humpback whales and project vessels (and highly unlikely for the other cetaceans, fish and marine turtle assessment). If a collision does occur, this would result in localised impacts on a small number of individuals. However, this is not anticipated to result in population level impacts.

Assessment against EPBC Act recovery and conservation plans and advices

Table 6-140 provides an assessment of the risks associated with unplanned vessel interactions with fauna in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-140 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – unplanned interaction with fauna

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice Objectives and actions	Assessment
Cetaceans and other Marine Megafauna	National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (Commonwealth of Australia, 2017c)	Objective 3: Mitigation – reduce the likelihood and severity of mega-fauna vessel collision.	It is considered that the proposed management approach (Section 6.3.18.2) will reduce the likelihood and severity of project vessels colliding with marine fauna. As such, it is considered that the proposed activities are not inconsistent with the National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (Commonwealth of Australia, 2017c).
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Vessel strike from large vessels identified as a key threat. Management action: + Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea) and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath.	As described above, it is considered highly unlikely that a vessel strike on a whale shark will occur as a result of the proposed activities with the associated risk being deemed low.
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Vessel strikes as a moderate threat to the Scott Reef – Browse Island green turtle genetic stock. Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	As described above, it is considered highly unlikely that a vessel strike on a marine turtle will occur as a result of the proposed activities with the associated risk being deemed low. Therefore, there is a high level of confidence that any impacts will not compromise the long-term recovery objectives for marine turtles or result in the displacement of the Scott Reef – Browse Island green turtle genetic stock, from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Fauna	Relevant plan(s)/ conservation advice	Plan/Advice Objectives and actions	Assessment
Pygmy Blue Whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Vessel collisions are listed as a moderate risk to pygmy blue whales with the following actions relevant: + Ensure all vessel strike incidents are reported in the National Ship Strike Database + Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented.	As described above, the risk of vessel strikes on whales (including pygmy blue whales) has been considered in the assessment and mitigation measures such as vessel speed restrictions applied. While considered highly unlikely to occur, any vessel strike on a whale species will be reported in the National Ship Strike Database. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback Whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Conservation advices recognise vessel disturbance as key threats to the conservation of these species.	
Sei Whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale		
Fin Whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale		

6.3.18.5 Cumulative Impacts

Vessel movements will occur through all phases of the proposed Browse to NWS Project, as well as general shipping and vessel movements during operations at facilities in the region such as Shell's Prelude FLNG facility and INPEX's Ichthys LNG Project. The majority of vessel movements associated with each facility will occur within open oceanic waters and will be in close proximity to each development's specific infrastructure, therefore it is not anticipated that there will be overlap between vessel movements associated with other operational facilities. There will be increased supply vessel movements from local ports such as Broome. However, such increases in vessel movements are not significant in the context of the normal operations at such ports and therefore no significant cumulative impacts are anticipated.

6.3.18.6 Impact and Risk Assessment Summary and Acceptability Assessment

As vessel interaction with fauna is an unplanned activity, no impact is expected. A summary of the risk assessment for the unplanned vessel interaction with fauna is provided in [Table 6-141](#). The acceptability assessment is provided in [Table 6-142](#).

Table 6-141 Risk assessment summary and adopted controls – unplanned vessel interactions with fauna

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Fish (high value species)	Injury or mortality to fauna	Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.	<i>Project vessel operations</i> + Project vessels will only enter the channel between north and south Scott Reef during construction/installation, IMR, contingent activities, decommissioning and emergency situations + Project vessels will not travel at speeds greater than 12 knots with the State Proposal Area, or 6 knots in the Scott Reef channel.	Moderate	Highly unlikely	Low (C1)
Marine mammals (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.	+ FCTV will operate under a FCTV Management strategy (to be detailed in subsequent Environment Plans as required) which will describe the appropriate additional control measures to manage vessel strike risk for the FCTV. Subject to the potential for technological innovation and additional engineering controls, FCTVs will not travel at speeds greater than 30 knots in sensitive areas at sensitive times (Table 6-139). + Interactions between vessels and whale sharks will be not be inconsistent with the Whale Shark Code of Conduct (DPaW, 2013), whereby unless in an emergency situation vessels will not knowingly travel at speeds greater than eight knots within 250 m of a whale shark and not intentionally approach closer than 30 m of a whale shark.	Moderate	Unlikely	Moderate (C2)
Marine turtles (high value species)		Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.	+ Vessels will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale and Dolphin Watching whereby: + Vessels will not knowingly travel greater than six knots within 300 m of a whale or 100 m of a dolphin. + Vessels will not knowingly approach closer than 100 m to a whale or 50 m to a dolphin (except if bow riding). + Vessels will not knowingly restrict the path of cetaceans. + Vessels will take direct routes where practicable. + FCTVs design will intrinsically reduce the risk of vessel strikes, including a shallow vessel draught (i.e. approximately 1 m or less) and no propeller. + FCTV will have trained vessel crew as a marine fauna observer ²⁶ .	Moderate	Highly unlikely	Low (C1)

²⁶ Marine fauna observer – a dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations for whale and marine turtles

Table 6-142 Acceptability assessment – unplanned vessel interactions with fauna

Acceptability Assessment
<i>Certainty in Assessment</i> Woodside have a high level of certainty with respect to the assessment of the potential impacts associated with vessel interactions with fauna as: + Studies have adequately characterised the marine fauna populations and distributions that may potentially be impacted by such vessel interactions. + vessel movement.
<i>Principles of ESD</i> With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
<i>Significant Impacts as defined by the MNES Significant Impact Guidelines</i> <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-141, the risk of unplanned vessel interaction with fauna resulting in injury mortality to fauna presents a Low risk to fish and marine turtles, and a Moderate risk to marine mammals (noting this rating is driven by the risk to humpback whales from the FCTVs, with risk to other marine mammals considered to be Low. The Moderate risk rating for humpback whales is driven by the potential Moderate consequences to high value fauna. It should be noted however that with the implementation of the proposed controls, it is unlikely that such an event would occur. As such no significant impacts to listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable
<i>WA EPA Environmental Objectives</i> An assessment of the impacts of vessel interactions with fauna against the WA EPA Objective is presented in the State Proposal ERD (Chapter 10, Appendix B). <u>Marine fauna</u> As described in Table 6-141, the risk of unplanned vessel interaction with fauna resulting in injury mortality to fauna presents a Low risk to fish and marine turtles, and a Moderate risk to marine mammals (noting this rating is driven by the risk to humpback whales from the FCTVs, with risk to other marine mammals considered to be Low. It should be noted however that risk to marine fauna within State waters including the State Proposal Area will be considerably lower as vessel movements in the State Proposal Area will be temporary and limited to construction and project support vessels including those required for IMR activities. Vessel movements within coastal State waters (near the Broome and Dampier logistics bases) will be limited to supply vessels and FCTV. Vessels will not travel at speeds greater than 12 knots within the State Proposal Area, or 6 knots in the Scott Reef channel, further reducing the risk of accidental collisions. Vessel movements within coastal State waters (near the Broome and Dampier logistics bases) will be limited to supply vessels and FCTV. Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors, and the WA EPA environmental objective “<i>To protect marine fauna so that biological diversity and ecological integrity are maintained.</i>” will be achieved. Conclusion: Acceptable
<i>External context</i> To date there have been no specific matters raised by stakeholders, regarding vessel interactions with marine fauna within the Project Area. Conclusion: Acceptable

Acceptability Assessment

Internal context

This impact and risk assessment has been undertaken in accordance with Woodside's Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)) The proposed Browse to NWS Project will be executed in accordance with Woodside's Health, Safety and Environmental Management System.

Conclusion: Acceptable

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-140](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation Management Plan for the Blue Whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (Commonwealth of Australia, 2015b)
- + Conservation Advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee, 2015b)
- + Conservation Advice *Balaenoptera borealis* sei whale (Threatened Species Scientific Committee, 2015c)
- + Conservation Advice *Balaenoptera physalus* fin whale (Threatened Species Scientific Committee, 2015d)

Conclusion: Acceptable

6.3.19 Physical Presence (unplanned): Invasive Marine Species

6.3.19.1 Impact and Risk Overview

[Table 6-143](#) presents an overview of the risks associated with the unplanned introduction of invasive marine species (IMS) as a result of the proposed Browse to NWS Project.

Table 6-143 Invasive Marine Species Impact and Risk Overview

Aspect	Physical presence (unplanned): invasive marine species
Description	Potential risks associated with unplanned introduction of IMS from proposed project activities to the Project Area and in particular the State Proposal Area and/or nearby receptors. Non-indigenous Marine Species (NIMS) are species which are translocated into a recipient environment where they are not historically found. Invasive marine species are NIMS that are translocated into a marine environment where they have the potential to establish and disrupt the natural balance of marine ecosystems. Not all NIMS that are translocated to a receiving location will survive through to establishment and only a subset of these species that become established will impact on social/cultural, human health, economic and/or environmental values are considered IMS (Wells, 2018). IMS can be introduced through a variety of natural and human mediated vectors. The key pathways for introduction of IMS to the Project Area is within biofouling on external surfaces of vessels and within internal niche areas and systems, and through vessel's ballast water. The vectors for translocation are via project vessels, MODU(s) and FPSO facilities from international waters, and the translocation by project vessels and MODUs from locations within Australian waters.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning

Aspect	Physical presence (unplanned): invasive marine species
Environmental objectives	The environmental objectives in relation to invasive marine species associated with the proposed Browse to NWS Project are Objectives 6, 8, 10, 14, 17, 18, 19, 20 and 21. These objectives are detailed in Table 6-7 .
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. + Commonwealth <i>Biosecurity Act</i> 2015 + <i>Aquatic Resources Management Act</i> 2016 (WA) + OPGGS (Environment) Regulations 2009 (OPGGS (E) Regulations) + International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 (BWM Convention) + International Maritime Organization - Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (Biofouling Guidelines) + Australian ballast water management requirements version 7 (Commonwealth of Australia, 2017d) + Anti-fouling and In-water Cleaning Guidelines (Commonwealth of Australia, 2015d) + National biofouling management guidelines for the petroleum production and exploration industry (Commonwealth of Australia, 2009) + National System for the Prevention and Management of Marine Pest Incursions (the National System) + WA DoF Biofouling Biosecurity Policy + Aquatic Biosecurity Policy + North-west Marine Parks Network Management Plan (Director of National Parks, 2018) + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <u>Ecological</u> + benthic habitats + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna + fish (high value species) + KEFs (high value) + AMPs (high value) + State marine parks and nature reserves + other protected places (high value). <u>Socio-economic</u> + managed fisheries (high value users) + scientific studies, tourism and recreation (high value users)
Potential impacts	+ There are no anticipated environmental impacts in relation to this aspect associated with unplanned project activities

Aspect	Physical presence (unplanned): invasive marine species		
Risk	Introduction and establishment of IMS leading to: + change in ecosystem dynamics + changes to the functions, interests or activities of other users		
Summary of governing impact evaluation	Magnitude n/a	Impact significance level n/a	Confidence n/a
Summary of governing risk evaluation	Consequence Major	Likelihood Remote	Risk rating Moderate (B0)

6.3.19.2 Source of Aspect

Pathways of introduction

There is a potential for NIMS to be translocated into the marine environment of the Project Area during installation, commissioning and support operations. Vessels will be used throughout all stages of the proposed Browse to NWS Project. Vessels used may be mobilised from within or outside Australian waters.

All vessels are inherently subject to some level of marine fouling. Organisms attach to the vessel hull, particularly in areas where organisms can find a good surface (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests, etc.). Previously, ballast water discharges from commercial vessels were thought to be the most significant mechanism for the translocation of NIMS, however research suggests that more NIMS translocations are attributable to vessel biofouling more than any other mechanism (Hewitt et al., 1999, 2004; Mineur et al., 2007).

NIMS may establish within the shallower parts Project Area (<75m depth) where available substrate and light could facilitate establishment and growth, under several scenarios:

- + NIMS could be present as biofouling on project vessels/MODUs or infrastructure and be translocated to the Project Area and transferred directly to the seafloor or subsea structures where they establish.
- + NIMS could be present in ballast water and translocated to the Project Area where they are transferred directly to the seafloor or subsea structures where they establish.

If NIMS are translocated to the Project Area via the mechanisms above, they could be subsequently transferred between project vessels/MODUs/ infrastructure and by extension to the marine environments beyond the Project Area (including ports).

Ballast water

Ballast water is carried in ships' ballast tanks to improve stability, balance and trim. It is taken up or discharged when cargo is unloaded or loaded, or when a ship needs extra stability in adverse weather. When a ship takes on

ballast water, plants and animals that live in the ocean are also picked up. Ballast water exchange involves the substitution of water in ship's ballast tanks using either a sequential, flow-through, dilution or other exchange method, potentially releasing ballast water at a location foreign to where it was taken on. Ballasting and de-ballasting a vessel is essential in achieving maximum vessel performance through a range of functions such as vessel propulsion, stress reduction on ship hull, stability and manoeuvrability, among others.

Release of unmanaged ballast water could transfer a range of NIMS into a recipient environment, depending on the location that ballast water was taken onboard. The major vector pathways for the introduction of marine pest species into Australia are ballast water carried in vessels and biofouling on vessels (or internal parts of the vessel that are exposed to sea water) (DAWR, 2018). A study done by Gollasch et al. (2002) on 1508 samples identified a total of 990 different species within the ballasts of ships. The species varied in taxa from fungi, bacteria, algae and protozoans to small fish and invertebrates at varying life stages.

Ballast water has been recognised as a major pathway for introducing IMS into new environments, giving rise to adoption of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention), which is given effect through the Commonwealth *Biosecurity Act 2015*. The Ballast Water Convention aims to prevent the spread of IMS from one region to another, by establishing standards and procedures for the ballast water management, including phasing out the use of ballast water exchange. In Australian waters, vessels are required to demonstrate compliance to Australian Ballast Water Management Requirements (Commonwealth of Australia, 2017d) which outlines approved methods of ballast water management in line with the Ballast Water Convention, including:

- + use of a ballast water management system
- + ballast water exchange conducted in an acceptable area

- + use of low risk ballast water (such as fresh potable water, high seas water or freshwater from an on-board fresh water production facility)
- + retention of high-risk ballast water on board the vessel
- + discharge to an approved ballast water reception facility.

Vessels may be required to ballast (e.g. take on or discharge water) within the Project Area. Should this be the case, ballast water will be managed via the acceptable methods detailed in the Australian Ballast Water Management Requirements (Commonwealth of Australia, 2017c) and in accordance with the *Biosecurity Act 2015*.

Biofouling

Biofouling can be defined as the accumulation of living organisms on artificial surfaces by adhesion, growth and reproduction (Cao et al., 2011). Surfaces commonly affected by biofouling on vessels include internal niches and areas subjected to low turbulence, such as seawater intakes and sea chests.

Biofouling poses a risk to biosecurity if organisms are translocated from a donor location and become established in a recipient location. For this to occur, Lewis et al. (2010) suggest that biofouling organisms must be successful in the following process:

- + colonise a vessel (or other infrastructure) in donor location
- + survive translocation from the donor to the recipient location
- + adults, offspring and/or fragments transfer from the vessel to the surrounding recipient environment
- + survive and colonise available substrata or habitat in the recipient location
- + undergo ongoing reproduction in the recipient location to establish a viable population.

Biofouling usually begins as a biofilm (e.g. bacteria, diatoms and cyanobacteria) gradually developing to support a range of taxa, including; algae, sessile animals (e.g. barnacles), mobile benthic and epibenthic organisms (e.g. worms, starfish and crabs) along with commensals, parasites and pathogens. Biofouling may occur on the FPSO facilities, BTL and inter-field spur line trunkline and the subsea infrastructure over time.

Establishment of IMS

Although there is a potential for IMS to establish themselves in a foreign environment via ballast water and biofouling, not all IMS that enter Australian waters

and are released into the marine environment are successful in establishing a population. For successful establishment to occur, a NIMS must first enter the ballast during water uptake and/or establish on a vector (e.g. hull), survive translocation from donor to recipient region, and then successfully be transferred, colonise and spread in the recipient environment to establish a new viable population. The following biotic and abiotic factors can influence the survival probability of translocated NIMS and establish IMS:

Biotic:

- + presence of natural predators
- + level of physical disturbance (disturbed environments are typically more susceptible)
- + dispersion rate
- + reproductive rate
- + diet type
- + level of environmental adaptability
- + level of competitive strength
- + level of similarity of source and receiving environment
- + level of injury received throughout voyage or removal
- + sedimentation rates (fouling organisms).

Abiotic:

- + water depth
- + environmental conditions (i.e. salinity, nutrient concentration, water temperature, light availability, etc.)
- + transport conditions (i.e. vessel ballast water age, vessel speeds, etc.).

Notably, the majority of species introduced to an area outside of their natural range will not survive to establish or subsequently become invasive or a pest (Wells et al., 2009; Bax et al., 2003) marine industries (including fishing and tourism. The discharge of marine organisms into oceanic, higher saline environments, for example, may lead to salinity and temperature 'shock' which can be fatal to some species (Molina and Drake, 2016). Notably, many species cannot survive transport in the ballast water tank conditions due to the lack of available light and the physical water quality properties within the tanks.

Assessment of project specific pathways

FPSO facilities

The FPSO facilities are likely to be built within a ship yard in Asia and subsequently transported to the Project Area for hook-up, commissioning and operation. The FPSOs will be risk assessed, inspected and if required cleaned outside of Australian waters prior to arrival on site. Given this, and as the FPSOs will be in deep oceanic waters and a significant distance from Scott Reef (approximately 8 km for the Torosa FPSO) it is considered that the likelihood of IMS becoming established at these locations is remote.

Construction support vessels, installation vessels, IMR Vessels and MODU

It is likely that the construction support vessels and installation vessels (e.g. pipelay vessel), IMR vessels and MODUs will transit to site from international waters, which increases the risk of IMS translocation to the Project Area. Project vessels will be subject to the risk assessment process outlined below.

Operations vessels

Project vessels during operations (including FCTVs and supply vessels) will regularly travel between the Project Area and Australian mainland ports, with occasional international travel. Vessels originating from international waters (i.e. with an increased risk of IMS translocation to the Project Area), will be subject to a thorough risk assessment process as outlined below. Vessels arriving from within Australian waters (most often from Port of Broome and Port of Dampier) also present some risk (albeit a low risk) of translocating IMS due to the frequency of travel to the Project Area, especially when originating from ports where IMS is known to be established. Such domestic Project vessels will also be subject to the risk assessment process outlined below.

Overview of the risk assessment process

As described above, project vessels will be subject to a risk assessment process that addresses relevant risk factors such as vessel type and origin, dry dock and/or inspection history, details of antifouling system applied (e.g. age and suitability), internal treatment system (e.g. presence or absence of marine growth prevention system (MGPS)), the periods of layup/inactivity since last dry dock and the vessels operating profile. One of the key factors is the time a vessel spends in a location, which increases the likelihood of colonisation or uptake in a source, and release in a recipient location. This is due to increased propagule pressure, which is a combination of the frequency of colonisation events and the magnitude of these events. Based on the outcome of the risk assessment process, management measures will be implemented commensurate to the risk (e.g. time restrictions, cleaning etc.). This process aligns with the approach adopted by WA Department

of Primary Industries and Regional Development (e.g. Vessel Check tool) and has been proven effective in minimising the potential for IMS introduction. Woodside has successfully implemented this process for several large construction projects and ongoing operations over the last decade.

6.3.19.3 Environmental Impact

The introduction of IMS is considered an unplanned event for the purposes of the proposed Browse to NWS Project and, as such, no environmental impacts are expected.

6.3.19.4 Environmental Risk

Risk Event: Introduction and establishment of an IMS at Scott Reef

Once an IMS is established, they have the potential to impact on native species diversity and abundance in a variety of ways which may result in changes to ecosystem dynamics. This can occur via:

- + Competition for natural resources: IMS may compete with native species for available resources (e.g. food, shelter) and, assuming native species are unable to attain the resource elsewhere, result in a reduction in survival probability. Displacement of native species is more likely to occur should IMS occupy a similar niche or use similar resources.
- + Reduced natural resources: Due to lack of evolutionary equilibrium, an IMS may drastically reduce resources in an area due to lack of natural predators, abundant food source or other resource.
- + Predation: As organisms within the recipient environment have not co-evolved with the IMS, native prey species are more vulnerable to predation if the IMS is predatory due to a lack of adaptive response strategies. Reduction in species abundance as a product of increased predation may also impact on population dynamics and distribution of native species with cascading impacts throughout the ecosystem. Predation of native species may improve survivability of other native species as a product of decreased pre-existing ecosystem stresses such as interspecific competition or predator-prey interactions. This may have further flow on effects to existing environment and may not necessarily be a positive impact.
- + Change nutrient cycling processes: Establishment of IMS can result in local changes in nutrient cycles as a product of variations in nutrient uptake. Alteration of available nutrients can impact the species who use them, with cascading impacts throughout the wider ecosystem.

- + Change in habitat: Establishment of IMS may change habitat composition leading to creation of new habitats, or fragmentation of existing habitats. A new habitat type may allow other native species to increase distribution or range, influencing population process of existing species. In species with limited dispersal, habitat fragmentation can result in isolation of subpopulations with secondary impacts to population genetics, population dynamics, species distribution, ecosystem processes, resource consumption and nutrient cycling processes.
- + Spread of disease: IMS may be a virus or pathogen, or may be vector to viruses, bacteria or pathogens. The introduction of disease through IMS could have devastating effects to native species which lack inherent resistance to introduced diseases. A decrease in native species abundance can have knock on effects at the ecosystem level through processes related to predator-prey interactions or competition for resources.

Benthic habitats

Change in ecosystem dynamics

The majority of the Project Area, as outlined within [Section 5.3.1](#) consists of deep offshore open waters, away from shallow habitats, that are not conducive to the settlement and establishment of IMS, due to the lack of benthic light (required to support the photosynthetic processes required for many NIMS) or suitable hard substrates to allow attachment and growth.

The primary receptors with respect to IMS in the context of the proposed Browse to NWS Project are shallow-water marine habitats, species and ecosystem function at Scott Reef. Shallow water marine habitats, such as coral reefs, are considered susceptible to the introduction and subsequent establishment of IMS due to the availability of light and complex habitats. IMS introduced to shallow water marine habitats are, therefore, much more likely to successfully establish than those introduced to deep oceanic waters.

Sites subject to existing disturbance such as Scott Reef are also considered to be more susceptible to IMS. This includes artificial structures (e.g. the two shipwrecks at Scott Reef; [Section 5.4.3.2](#)), sites effected by coral bleaching and/or extreme weather events (as described for Scott Reef in [Section 5.3.1.3](#)), and those areas impacted by tourism or fishing (e.g. tourism and Indonesian fishers at Scott Reef). The cumulative pressure of these disturbances may lead to weakened ecosystem function and reduced resilience to external pressures such as IMS. Note, an IMS surveillance program at Scott Reef is proposed to be undertaken, with a survey completed prior to the commencement of the proposed Browse to NWS Project activities in the State Proposal Area to verify baseline condition, and periodic surveys over the life of the proposed Browse to NWS Project.

Given this sensitivity and the regional significance of Scott Reef, the consequence of the introduction and successful establishment of an IMS has been determined to represent a consequence level of Major, (due to the potential for regionally significant impacts to high value habitat). However, given the legislative and Woodside management controls in place to prevent translocation and establishment of IMS in the Project Area it is considered that the likelihood that IMS would be introduced, establish a self-sustaining population and cause environmental impacts to sensitive ecological communities within the vicinity of Project Area, including the State Proposal Area (e.g. Scott Reef) is remote.

Marine fauna

Change in ecosystem dynamics - fish

A change in ecosystem dynamics as a result of the establishment of IMS at Scott Reef would potentially have significant effects on site attached fish that are dependent on the reef as a result of competition for natural resources, predation and spread of disease. While the consequence of such an event would be 'major, the 'remote' likelihood of such an event means that this risk is determined to be Moderate.

Key Ecological Features

Change in ecosystem dynamics

The Continental slope demersal fish communities and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs overlap with the Browse Development Area, while the BTL traverses the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF and the Ancient coastline at 125 m depth contour KEF.

The Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012) identifies invasive species as pressure of potential concern for Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF and the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF, a pressure of less concern for The Continental slope demersal fish communities KEF.

As described above, while the likelihood of occurring is considered remote, the establishment of an IMS in the Scott Reef shallow water benthic habitat (<75 m bathymetry) would potentially have major consequences on ecosystem dynamics. The same applies to Rowley Shoals, although, the likelihood would be even less, given the short duration and significantly few project vessels that will enter the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF.

Given the water depths of the Continental slope demersal fish communities KEF and the Ancient coastline at 125 m depth contour KEF, the likelihood of an IMS establishing within these KEFs is considered remote.

Table 6-144 provides an assessment of the risk posed by the introduction and establishment of IMS in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-144 Alignment with protection of conservation values of KEFs – invasive marine species

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Invasive species – of potential concern	Given the existing Woodside and legislative controls in place that minimise the introduction of IMS and noting the deepwater habitats of the KEFS, it is considered that even if IMS were introduced, the likelihood that it would become established is remote. Therefore, there is a high level of confidence that the establishment of IMS within these KEFs will not result in an adverse impact to marine ecosystem function or integrity with in the KEFs; or any reduction in to the conservation values of the KEFs will occur.
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals			
Continental slope demersal fish communities		Invasive species – of less concern	
Ancient coastline at 125 m depth contour		Invasive species – not of concern	

Australian marine parks

Change in ecosystem dynamics

The proposed BTL route traverses the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley Marine Parks. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park National Park Zone. Rationale for the route selection of the BTL is provided in [Chapter 3](#). The North-west Marine Parks Network Management Plan (Director of National Parks, 2018) outlines the objectives of the Multiple Use Zone (VI) multi use zones traverse by the BTL as “to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species”. Invasive marine species is identified as a threat to AMPs in the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

As described above, the introduction and establishment of an IMS in an AMP would potentially have major consequences on ecosystem dynamics. However, given the water depths where the proposed project activities will occur and the distance to any shallow water habitats where IMS could potentially establish a viable population, the likelihood of that occurring is considered remote.

Summary

Table 6-145 provides an assessment of the risk posed by the introduction and establishment of IMS in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018)

State marine parks and nature reserves

Change in ecosystem dynamics

The significant distance from the Project Area to any State marine parks means that the likelihood of the introduction and establishment of IMS within a State marine park resulting from activities associated with the proposed Browse to NWS Project is remote. Given the Scott Reef Nature Reserve encompasses an area above mean low tide springs, establishment of an IMS on the reserve from the proposed activities is not credible, nevertheless, an assessment of the risk has been undertaken for Scott Reef’s shallow benthic habitats and surrounds.

Table 6-145 Alignment with the North-west Marine Parks Network Management Plan – invasive marine species

Australian Marine Park	Relevant plan(s)	Australian Marine Park objectives	Assessment
Argo-Rowley Terrace Marine Park Multi Use Zone (VI)	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	Given the existing Woodside and legislative controls in place to control the introduction of IMS from project vessels, there is a high level of confidence that the activities can be managed to ensure there is no establishment of IMS within the AMPs and hence will not result in an adverse impact to marine ecosystems, habitats or native species such that the conservation values of the AMPs would be reduced. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
Kimberley Marine Park Multi Use Zone (VI)			
Mermaid Reef Marine Park National Park Zone (II)		The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	The proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park, with no project vessels proposed to enter the park. As such, there is no anticipated risk of IMS introduction within the AMP and therefore no likely affect in ecosystems, habitats or native species in the AMP will occur. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

Other protected places**Change in ecosystem dynamics**

Given the water depths in the Scott Reef and Surrounds Commonwealth Heritage Place, the introduction and establishment of IMS that the introduction of IMS from activities associated with the proposed Browse to NWS Project is not considered credible.

Other users**Changes to the functions, interests or activities of other users – managed fisheries**

The Northwest Slope Trawl Fishery (Commonwealth) and the Pilbara Trawl Fishery (State) overlap the Browse Development Area. The establishment of IMS may cause changes to the target prey abundance, distribution or behaviour of commercial fish species, and in turn result in impacts to the activities of commercial fisheries and traditional Indonesian fishers under MOU 74. In addition, IMS may also transport pathogens and or disease harmful to target species.

The likelihood of project activities resulting in the translocation and establishment of IMS to locations where fishing activity occurs (i.e. due to distance from shore and water depth) is remote and therefore the likelihood that commercial fishing activities will be negatively affected is also considered remote.

Changes to the functions, interests or activities of other users – tourism and recreations, scientific studies

The successful establishment of IMS at Scott Reef and subsequent impacts to biota, would negatively impact the tourism and recreation values of the Reef. As discussed above, the likelihood of this establishment occurring is considered remote.

6.3.19.5 Cumulative Impacts

The establishment of IMS is not a planned activity. As such there are no predicted cumulative impacts associated with IMS.

6.3.19.6 Impact and Risk Assessment Summary and Acceptability Assessment

There are no environmental impacts predicted as there is no planned introduction of IMS. A summary of the risk assessment associated with the unplanned introduction of IMS is provided in [Table 6-146](#). The final acceptability assessment is provided in [Table 6-147](#).

Table 6-146 Risk assessment summary and adopted controls – physical presence (unplanned): invasive marine species

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
Shallow water benthic communities and habitats (<75 m depth) - (high value habitat)	Introduction and establishment of IMS leading to change in ecosystem dynamics	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Objective 8: To not result in the establishment of a known or potential invasive marine species (IMS). Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	+ Compliance with in force Commonwealth and State Ballast water and biofouling legislation. This includes Biosecurity Act 2015, Australian Ballast Water Management Requirements and relevant State legislative requirements. + No project vessels will enter the state Rowley Shoals Marine Park or Mermaid Reef Australian Marine Park unless required for SOLAS. + Project vessels and MODUs will be subject to a risk assessment process to assess the likelihood of introducing IMS when transiting to the Project Area. Based on the outcomes of risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented. + Internationally sourced Project vessels and MODUs required within 3 nm of Scott Reef (State Proposal Area) for longer than 48 hours will be inspected by an experienced IMS expert/marine scientist for IMS; and cleaned where required ²⁷ . + For the FPSOs the following adaptive management framework will be implemented during construction of FPSO facilities: + a biofouling management plan will be developed by an experienced IMS expert/marine scientist and describe a monitoring, inspection and cleaning schedule. + the biofouling management plan will be implemented during the construction, with the actions adapted based on the findings of monitoring/inspection events. + FPSO facilities will be inspected by an experienced IMS expert/marine scientist prior to entry into Australian waters. + IMS surveillance program will be undertaken at Scott Reef, consisting of a baseline survey prior to the commencement of activities in the State Proposal Area, and periodic surveys over the life of the proposed Browse to NWS Project.	Major	Remote	Moderate (BO)
Deepwater benthic communities and habitats (>75 m depth) - (medium value)				Minor	Remote	Low (DO)
Fish (high value species)		Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.		Major	Remote	Moderate (BO)

²⁷ Subject to confirmation, vessel/rig may be permitted re-entry within Scott Reef State waters (3 nm) without re-inspection provided its movements outside Scott Reef State waters at stationary or at slow speeds (less than three knots) in waters less than 50 metres deep do not exceed a period totalling greater than seven accumulative days prior to returning to Scott Reef State waters (3 nm).

Receptor	Risk Event	Environmental objective	Adopted controls	Consequence	Likelihood	Risk Rating
KEFs (medium value)		Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		Major	Remote	Moderate (B0)
AMPs (medium value)		Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		Major	Remote	Moderate (B0)
State marine parks and reserves (high value)				Major	Remote	Moderate (B0)
Other protected places (high value)				Major	Remote	Moderate (B0)
Managed fisheries (high value user)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing.		Major	Remote	Moderate (B0)
Other users including tourism and recreation and scientific studies (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is necessary for the execution of the Browse to NWS Project.		Major	Remote	Moderate (B0)

Table 6-147 Acceptability assessment – physical presence (unplanned): invasive marine species

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts and risks associated with invasive marine species as: + Woodside will comply with all regulatory requirements and will apply a vessel risk-based assessment to mitigate and manage any potential impacts of IMS. + The proposed controls are standard controls widely employed in industry and proven to mitigate the potential risks effectively.
Principles of ESD There is no planned introduction of IMS. With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities / listed migratory species</u> As described in Table 6-146, the risk of the unplanned introduction of an IMS presents a Moderate risk to listed threatened and migratory species. This risk rating is driven by the potential Major where regional impacts affecting species at a population level could occur. It should be noted however that with the implementation of the proposed controls, the likelihood that such an event would occur is considered remote. As such no significant impacts to listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>Commonwealth marine environment</u> As described in Table 6-146, the risk of an unplanned hydrocarbon release presents a Low risk to deepwater benthic communities and habitats (>75 m depth), and a Moderate risk to shallow water benthic communities and habitats (<75 m depth), marine fauna, KEFs, AMPs, other protected places and managed fisheries. As above, these risk ratings are driven by the potential Major consequences where regional impacts affecting the marine environment and users could occur. As above however, with the implementation of the proposed controls, the likelihood that such an event would occur is considered remote. As such no significant impacts to the Commonwealth Marine Environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

Marine environmental quality

As described in [Table 6-146](#), the risk of the unplanned introduction of an IMS presents a Low risk to deep water benthic communities and habitats (>75 m depth), and a Moderate risk to shallow water benthic communities and habitats (<75 m depth) and marine fauna. This risk rating is driven by the potential Major where regional impacts affecting species at a population level could occur. It should be noted however that with the implementation of the proposed controls, the likelihood that such an event would occur is considered remote.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors will be achieved, and the WA EPA environmental objective *“To maintain the quality of water, sediment and biota so that environmental values are protected”* will be achieved for the State Proposal.

Benthic communities and habitats

As described in [Table 6-146](#) the risk of the unplanned introduction of an IMS presents a Low risk to deep water benthic communities and habitats (>75 m depth) and a Moderate risk to shallow water benthic communities and habitats (<75 m depth). As above, the Moderate risk rating is driven by the potential Major consequences where regional impacts affecting the marine environment and users could occur. As above however, with the implementation of the proposed controls, the likelihood that such an event would occur is considered remote.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors will be achieved, and the WA EPA environmental objective *“To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained”* will be achieved for the State Proposal.

Marine fauna

As described in [Table 6-146](#), the risk of the unplanned introduction of an IMS presents a Moderate risk to marine fauna.

As above, these risk ratings are driven by the potential Major consequence where regional impacts affecting the marine fauna within the State Proposal Area and other State waters including adjacent to the mainland could occur. As above however, with the implementation of the proposed controls, the likelihood that such an event would occur is considered remote.

Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors will be achieved, and the WA EPA environmental objective *“To protect marine fauna so that biological diversity and ecological integrity are maintained”* will be achieved for the State Proposal.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders regarding IMS in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact and risk assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2](#)) The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Further, Woodside will implement the requirements of its internal IMS Management Plan.

Conclusion: Acceptable

Acceptability Assessment

Other requirements

Key Ecological Features

As detailed in [Table 6-144](#), risks associated with the introduction and establishment of IMS will not materially increase existing relevant pressures on the conservation values of the KEFs.

AMPs

As detailed in [Table 6-145](#), the proposed activities are considered to be not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Other Protected Places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.3.20 Production Activities: Seabed Subsidence

6.3.20.1 Impact and Risk Overview

[Table 6-148](#) presents an overview of the potential impacts and risks from seabed subsidence associated with the proposed Browse to NWS Project.

Table 6-148 Seabed subsidence Impact and Risk Overview

Aspect	Production activities: seabed subsidence
Description	Production activities through the extraction of naturally high-pressured reservoir fluids, will cause a reduction in the reservoir's pressure, which has the potential to result in the compaction of the geological layers overlying the reservoir leading to potential gradual subsidence (sinking) of the seabed within the field location.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	Operations
Environmental objectives	The environmental objectives in relation seabed subsidence associated with the proposed Browse to NWS Project are Objectives 6, 10, 11, 12, 13, 16, 18, 19 and 21. These objectives are detailed in Table 6-7 .
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-149). + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + WA EPA Environmental Factor Guideline - Coastal Processes (EPA, 2016e) + WA EPA Environmental Factor Guideline - Marine Fauna (EPA, 2016b) + WA EPA Environmental Factor Guideline - Benthic Communities and Habitats (EPA 2016c) + WA EPA Technical Guidance - Protection of Benthic Communities and Habitats (EPA 2016d) + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a).

Aspect	Production activities: seabed subsidence		
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. Ecological + benthic habitats: + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deepwater communities and habitats (>75 m depth) (medium value habitat) + fauna: + seabirds and migratory shorebirds (high value species) + marine reptiles (high value species) + State Marine Parks and nature reserves (high value) Socio-economic + other users: + tourism and recreation (high value users) + scientific studies (high value users) + marine archaeology (high value)		
Potential impacts	+ Change in habitat + Changes to the functions, interests or activities of other users + Change in heritage values		
Risk	+ Given peer reviewed modelling studies undertaken and verification monitoring for seabed subsidence planned there is no anticipated environmental risks in relation to this aspect associated with seabed subsidence resulting from production activities.		
Summary of governing impact evaluation	Magnitude	Impact significance level	Confidence
	Slight	Minor (D)	High
Summary of governing risk evaluation	Consequence	Likelihood	Risk rating
	N/A	n/a	n/a

6.3.20.2 Source of aspect

Subsea subsidence may manifest as a result of production activities, through the extraction of hydrocarbons from the Torosa reservoir causing a reduction in the reservoir's pressure.

The phenomenon of subsidence due to oil and gas production is considered rare and is mostly imperceptible or low magnitude. Only a few reported instances are known in the industry worldwide (Nagel, 2001). Instances where higher magnitude production-induced subsidence has been recorded are likely related to specific geologic conditions at these locations. These have included reservoirs located in the offshore North Sea region (44 cm/year at Ekofisk), onshore California (22 cm/year at Wilmington and up to 20 cm/year at South Belridge), offshore Malaysia (M3), offshore Indonesia (Arun) and offshore Oman (4.5 cm/year at Yibal) (Nagel, 2001).

6.3.20.3 Seabed Subsidence Modelling

It is estimated for the proposed Browse to NWS Project that the average vertical seafloor movement is a total of approximately 5.4 cm (range 2.6 – 8.9 cm) over 40 years based on modelling; this is equivalent to 0.06-0.22 cm/year.

Subsidence associated with oil and gas extraction is a physical response of the seabed due to pressure reduction inside the reservoir. Woodside has modelled the magnitude of potential subsidence and associated horizontal movements for the Browse reservoirs (Woodside, 2014). Analyses took into account a range of parameters, including the geological/fault structure of the reservoir, its spatial dimensions, the hydrocarbon reservoir thickness and its depth, reservoir temperature and pressure as well as pore compressibility in the reservoir. These analyses were supported by field measurements and laboratory tests on core samples obtained from exploration wells within the Browse reservoirs.

Average subsidence was predicted to occur over a radius of about 10 km centred on a point in deep water on the eastern side of North Scott Reef. The magnitude of subsidence is predicted to diminish away from this point up to 18 km. Beyond 20 km, the magnitude of subsidence would be virtually nil (Woodside, 2012).

This analysis has been peer reviewed by Baker Hughes GMI Geomechanics Services (Hughes, 2012)²⁸ who concluded that the method and supplied data was appropriate. The DoEE sought further independent review by CO2 Geological Storage Solutions Pty Ltd (CGSS) (CGSS, 2012)²⁹ who found that the report conclusions were reasonable. Woodside therefore has a high level of confidence that any production related subsidence at Scott Reef will be less than 10 cm over field life.

6.3.20.4 Environmental Impact

The predicted environmental impact of seabed subsidence at Scott Reef is presented below. This assessment is based on the peer reviewed modelling results described above with a maximum subsidence of less than 10 cm over field life.

Benthic communities

Change in habitat

An increase in water depth at light dependent benthic communities around Scott Reef, in particular coral habitats, could alter or restrict the area available or suitable for these communities to inhabit. No effect on the sparse deepwater habitats (<75 m water depth) of the Browse Development Area are predicted as there are no light dependent benthic communities present in these areas.

Potential impacts of subsidence on corals at Scott Reef are dependent on the rate of coral accretion expected at Scott Reef over the life of the proposed Browse to NWS Project. Analyses of cores taken from the margin of Scott Reef (Collins et al., 2009) indicated that Scott Reef has previously experienced sea level changes, with five growth phases identified over the past 400,000 years, each 30 to 50 m thick, corresponding to episodes of sea level rise through time. Based on these analyses, vertical accretion rates of corals at Scott Reef were found to vary from 1.4 to 3.5 mm/yr. The modelled subsidence rates compared against the likely coral accretion rates at Scott Reef indicate that coral communities would successfully adapt to sea level changes associated with production activities at Torosa, with predicted subsidence well within natural vertical accretion rates observed.

A study by AIMS (2012)³⁰ to assess the potential impacts of subsidence on Scott Reef's coral habitats and Sandy Islet in the context of climate change has been undertaken (Cooper et al., 2010; AIMS, 2012). The assessment was conducted based on the following information:

- + the range of subsidence derived from Woodside's modelling studies
- + historical coral accretion rates at Scott Reef (Collins et al., 2009)
- + sea level change predictions (IPCC, 2007)
- + coral growth rates under the influence of climate change induced increases in sea temperature and increased ocean acidity due to increased atmospheric CO2 concentration.

AIMS (2012) assessed the impact of net sea level rise (from subsidence and climate change induced sea level rise) and its predicted impacts on reef flat habitat (0 to 5 m depth), shallow water coral habitats (5 to 30 m), deepwater coral habitat (30 to 70 m) and Sandy Islet, for three scenarios (worse case, intermediate case and best case).

Overall the study concluded that minor seabed subsidence over the life of the Torosa reservoir affecting a part of Scott Reef and Sandy Islet is not predicted to significantly contribute to sea level changes and predicted associated impacts.

Reef flat habitat

Reef flat benthic habitat represents a harsh environment for the establishment and growth of benthic primary producers due to wave exposure, periodic exposure at spring low tide and the occasional elevated water temperatures. Corals in this habitat have low cover (less than 5%) and comprise stunted hardy robust forms due to tidal exposure and storm impacts (Smith et al., 2006). Similarly, seagrass is not abundant on the reef flat; however, macroalgae (*Halimeda* spp.) is commonly present within this zone. The AIMS (2012) study predicted the following impacts to reef flats at Scott Reef:

- + Worst case: Any significant changes in reef flat coral communities due to adaptation to increased mean sea level and climate change related effects would occur regardless of the maximum predicted subsidence and as such the impact to reef flat corals contributed by production-induced subsidence would be negligible.

28 Hughes (2012) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

29 CGSS (2012) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

30 AIMS (2012) available at: <https://www.woodside.com.au/our-business/burup-hub/index-of-previous-browse-studies>

- + Intermediate case: It is considered that the change in wave exposure and water depth conditions would not be enough to elicit any perceptible changes to reef flat coral communities on its own. Conditions associated with this level of subsidence are unlikely to result in significant adverse impacts to reef flat corals.
- + Best case: Reef flat benthic habitats would be expected to continue to be limited in their upward growth by sea levels. As such no adverse impacts to reef flat corals are predicted.

Shallow water coral

Shallow water coral habitats are the most diverse coral habitats at Scott Reef. They are also susceptible to natural impacts such as thermally induced coral bleaching and cyclone damage, as demonstrated by past recent disturbances (Gilmour et al., 2018; Gilmour et al., 2019; [Chapter 10, Appendix D.2](#)). The AIMS (2012) study predicted the following impacts to shallow water corals at Scott Reef

- + Worst case: There is potential for increased wave action to occur, however, it is unlikely that increased wave exposure would adversely impact shallow water corals on its own. Any significant impacts to shallow water corals will arise due to cyclone, bleaching and ocean acidification effects, which, under this scenario, are assumed to have the potential to occur regardless of subsidence.
- + Intermediate case: The magnitude of change is not expected to result in a change in hydrodynamic or light conditions affecting reef morphology or community composition and structure.
- + Best case: Alterations to hydrodynamic conditions at Scott Reef would be negligible.

Deepwater coral

Deepwater coral habitats at Scott Reef, including sheltered deepwater coral assemblage habitat, have not been susceptible to thermally induced bleaching and cyclone damage. The AIMS (2012) study predicted the following impacts to deepwater corals at Scott Reef

- + Worst case: Deepwater corals can photo-acclimatise to changes in light conditions over short time scales by changing the density of zooxanthellae and/or changing the concentration of photosynthetic pigments. Given the gradual nature of the subsidence over 40 years, corals would be able to photo-acclimatise, and impacts are not predicted.
- + Intermediate case: Impacts to deepwater corals are not expected as changes in irradiance would have negligible effects on the photo-physiology of corals.
- + Best case: Impacts to deepwater corals are not expected as changes in irradiance would have negligible effects on the photo-physiology of corals.

Marine fauna

Marine turtles - change in habitat

Sandy Islet is an unvegetated, 4.5 m high, linear-shaped sandy cay with a sandy spit at its southern end, serving as an important turtle nesting ground (identified as habitat critical to turtle survival) and used for roosting by seabirds. Habitat modification is highlighted within the Recovery Plan for Marine Turtles in Australia (2017-2027) as a high threat to the Scott Reef – Browse Island genetic green turtle stock (Commonwealth of Australia, 2017a).

A reduction in the area of Sandy Islet could impact marine turtles, through a reduction in available or suitable nesting locations, thereby impact nesting success rates. Scott Reef and Sandy Islet have experienced considerable natural variability in sea level over different time scales. For example, the tidal regime at Scott Reef is semi-diurnal with a maximum daily range of approximately 4 m. Similarly, sea levels can temporarily vary by tens of centimetres in response to large-scale oceanographic and atmospheric processes, such as the passage of mesoscale ocean eddies and inverse barometer effects with the passing of cyclonic and anticyclonic pressure systems. During El Nino years, up to 20 to 30 cm increases in sea levels occur from the eastern Pacific Ocean to the eastern Indian ocean. Satellite data (ToPEX/Poseidon) from 1992 to 2009 show intra- and inter-annual sea level variability in the vicinity of Scott Reef to be from 30 cm below to 40 cm above MSL (Cooper et al., 2010). Given the natural variability in sea level at Scott Reef described above, nesting turtles (primarily green turtles) demonstrate the ability to cope with variability in the sea level at Sandy Islet.

The AIMS (2012) study concluded that with worst case net sea level rises there is potential for wave action at high tide to reduce the height of the islet. This could affect the stability of Sandy Islet due to erosional processes associated with increased wave height, and thus impacts to availability of turtle nesting habitat. These impacts would still occur in the absence of subsidence albeit over a slightly longer time period, with the most important factor influencing the persistence of the islet being the frequency of Category five cyclones. The study concluded that for the worst-case scenario, given the highly variable nature of sea level rise, cyclone occurrence and sediment dynamics, it is not possible to reliably predict the timing or just how much earlier any major changes to Sandy Islet might occur. The AIMS (2012) study concluded that impacts to Sandy Islet from the intermediate and best-case scenarios would be negligible.

Given the above, no significant change is predicted in terms of available turtle nesting locations or nesting success as a result of seabed subsidence.

Seabirds and migratory shorebirds - change in habitat

Sandy Islet is used for roosting by seabirds and supports minor seabird breeding colonies including for the little tern. Scott Reef is recognised as a resting BIA for the little tern. The Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a) identify habitat loss, degradation or modification as key threats to migratory shorebirds. As discussed above, no significant change to the size of Sandy Islet is predicted

as a result of seabed subsidence, therefore no significant impacts to seabirds are expected.

Assessment against EPBC Act recovery and conservation plans and advices

Table 6-149 provides an assessment of seabed subsidence in relation to objectives and actions of the relevant EPBC Act recovery and conservation plans and advices.

Table 6-149 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – seabed subsidence

Fauna	Relevant plan(s)/ conservation advice	Plan/advice objectives and actions	Assessment
Migratory shorebirds	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)	Protection of important habitats for migratory shorebirds throughout the EAAF.	No significant change to the size of Sandy Islet is predicted as a result of seabed subsidence. As such the habitat is protected and objective met.
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)	Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Studies have indicated that no significant change in terms of available turtle nesting locations or nesting success as a result of seabed subsidence will occur. Therefore, there is a high level of confidence that seabed subsidence will not result in displacement of the Scott Reef – Browse Island green turtle genetic stock, from identified habitat critical to their survival, or adversely affect the breeding cycle of marine turtles in the BIA at Scott Reef. Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia(2017-2027) (Commonwealth of Australia, 2017a).

State marine parks and nature reserves and other protected places

Change in habitat

As described above, seabed subsidence will not result in significant impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry) Sandy Islet or fauna that utilise Sandy Islet. As such, impacts to the values of the Scott Reef Nature Reserve are not predicted. No State marine parks will be affected by seabed subsidence.

Other users

Changes to the functions, interests or activities of other users

As no significant change to the size of Sandy Islet and no significant impacts to Scott Reef shallow water benthic habitat (<75 m bathymetry), or fauna that utilise Sandy Islet are predicted, no impact to the tourism and recreation or scientific studies values of Scott Reef are expected to occur as a result of seabed subsidence.

Maritime archaeology

Change in heritage values

Given the magnitude of predicted subsidence (in the order of less than 10 cm), no adverse impact to the shipwrecks on Scott Reef are expected to occur.

6.3.20.5 Environmental Risk

Given peer reviewed modelling studies undertaken and monitoring planned, there are no anticipated environmental risks in relation to this aspect associated with seabed subsidence resulting from production activities.

6.3.20.6 Cumulative Impacts

Potential subsidence associated with the project activities is forecast to be gradual (0.06-0.22 cm/year) and highly localised, with effects predicted to extend no further than approximately 20 km from the affected reservoir. Therefore, given the distance between other developments and reservoirs to the Browse Development Area, no cumulative impacts associated with subsidence at Torosa and Scott Reef are expected.

6.3.20.7 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the impact assessment for seabed subsidence is provided in [Table 6-150](#). The final acceptability assessment is provided in [Table 6-151](#).

Table 6-150 Impact assessment summary and adopted controls – Seabed Subsidence

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
Shallow water benthic communities and habitats (<75 m depth) (high value habitat)	Change in habitat	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m bathymetry).	<u>Production activities</u> + Further modelling of likely subsidence will be conducted based on known reservoir performance during operations. + Based on the revised modelled subsidence estimates, further investigation would be initiated into any potential short term and longer-term biological and ecological implications for Scott Reef and Sandy Islet.	Slight	Minor (D)
Deepwater communities and habitats (>75 m depth) (medium value habitat)	Change in habitat	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.	This would include further engagement with appropriate scientific organisations to provide expert opinion and advice on potential impacts to the Scott Reef, if required as a result of higher than predicted subsidence rates.	No lasting effect	Negligible (F)
Seabirds and migratory shorebirds (high value species)	Change in habitat	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population.	+ Verification monitoring for seabed subsidence will be undertaken.	No lasting effect	Slight (E)
Marine turtles (high value species)	Change in habitat	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		No lasting effect	Slight (E)

Receptor (sensitivity)	Impact	Environmental objective	Adopted controls	Magnitude	Impact Significance Level
State marine parks and nature reserves (high value)	Change in habitat	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		Slight	Minor (D)
Other users including tourism and recreation and scientific studies, (high value users)	Changes to the functions, interests or activities of other users	Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		No lasting effect	Slight (E)
Maritime archaeology (high value)	Change in heritage values	Objective 19: To not have a substantial adverse impact on heritage values.		No impact expected	

Table 6-151 Acceptability assessment – seabed subsidence

Acceptability Assessment
Confidence in assessment Woodside have a high level of certainty with respect to the assessment of the potential impacts associated with seabed subsidence as: + Independently verified modelling studies have demonstrated that the magnitude of predicted subsidence will in the order of less than 10 cm + A study by AIMs (2012) concluded that minor seabed subsidence over the life of the Torosa reservoir affecting a part of Scott Reef and Sandy Islet is not predicted to significantly contribute to sea level associated impacts and the reef system has a high capacity to adapt to change. + Verification monitoring for seabed subsidence will be undertaken during operations.
Principles of ESD With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant Impacts as defined by the MNES Significant Impact Guidelines Listed threatened species and ecological communities / listed migratory species As described in Table 6-150, no lasting effect is predicted to occur to listed threatened or migratory species such as seabird and migratory shorebirds and, marine turtle as a result of seabed subsidence, with the impact significance level determined to be Slight (E). Given this, it is predicted that the nominated environmental objectives for each of these fauna species will be achieved. As such, no significant impacts to the listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted Commonwealth Marine Environment As described in Table 6-150, the potential impact of seabed subsidence on deepwater benthic communities and habitats (>75 m depth) has been assessed as Negligible (F). Slight (E) impacts may potentially occur to, marine fauna (as discussed above) and maritime archaeology. Minor (D) impacts may occur to shallow water benthic communities and habitats (<75 m depth). Given this, it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such no significant impacts to the Commonwealth marine environmental (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

Marine fauna

As described in [Table 6-150](#), no lasting effect is predicted to occur to marine fauna such as seabird and migratory shorebirds and, marine turtle as a result of seabed subsidence, with the impact significance level determined to be Slight (E).

Given this, it is considered that the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*To protect marine fauna so that biological diversity and ecological integrity are maintained.*” will be achieved.

Benthic communities and habitats

As described in [Table 6-150](#), the potential impact of seabed subsidence on deepwater benthic communities and habitats (>75 m depth) has been assessed as Negligible (F). Slight (E) impacts may potentially occur to, marine fauna (as discussed above) and maritime archaeology. Minor (D) impacts may occur to shallow water benthic communities and habitats (<75 m depth).

Given this, it is considered that the nominated environmental objectives for these receptors, and the WA EPA environmental objective “*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*” will be achieved.

Conclusion: Acceptable

External context

To date there have been no specific matters raised by stakeholders regarding subsea subsidence in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

This impact assessment has been undertaken in accordance with Woodside’s Risk Assessment Procedure and Environment Impact Assessment Guideline ([Section 6.2.3.4](#)). The proposed Browse to NWS Project will be executed in accordance with Woodside’s Health, Safety and Environmental Management System.

Conclusion: Acceptable

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-151](#), the proposed activities are considered to be not inconsistent with the actions and objectives of:

- + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)
- + The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a).

Conclusion: Acceptable

6.3.21 Unplanned Hydrocarbon Releases

6.3.21.1 Impact and Risk Overview

Table 6-152 presents an overview of the potential impacts and risks from an unplanned release of hydrocarbons associated with the proposed Browse to NWS Project.

Table 6-152 Unplanned hydrocarbon releases impact and risk overview

Aspect	Unplanned hydrocarbon releases
Description	Unplanned hydrocarbon releases include the potential for both gas and liquid hydrocarbons to be unintentionally be released into the marine environment. Activities and facilities associated with proposed Browse to NWS Project which may result in the unplanned discharge of gas or liquid hydrocarbons to the marine environment are: + drilling and completion operations + commissioning + hydrocarbon extraction + hydrocarbon processing + gas export + condensate offtake + project vessel and MODU operations + helicopter operations + decommissioning. Large hydrocarbon spills have the potential to result in significant impacts on a regional scale. As such, the risk of unplanned hydrocarbon release will be the subject of comprehensive engineering design and management measures to reduce the risk of an event occurring, and extensive hydrocarbon spill response planning to reduce the spatial and temporal impact in the highly unlikely event that a large spill occurs.
Area	Project Area, Browse Development Area, State Proposal Area
Project stage	All - drilling and completions, installation, commissioning, operations and decommissioning
Environmental objectives	The environmental objectives in relation to the unplanned release of hydrocarbons associated with the proposed Browse to NWS Project are Objectives 1, 2, 3, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21. These objectives are detailed in Table 6-7 .

Aspect	Unplanned hydrocarbon releases
Policy and guidelines	The following policy and guidelines are relevant to the assessment of this aspect. In addition, a number of EPBC Act conservation advices for protected fauna have been considered (Table 6-159). + Commonwealth <i>Navigation Act 2012</i> + Commonwealth <i>Protection of the Sea (Prevention of Pollution from Ships) Act 1983</i> + Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 + Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 + Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 + Commonwealth <i>Underwater Cultural Heritage Act 2018</i> + WA <i>Emergency Management Act 2005</i> + WA <i>Pollution of Waters by Oil and Noxious Substances Act 1987</i> + IOPER Guiding Principles for Regulating Oil Spill Response Preparedness for Offshore Petroleum November 2014 + IOGP 2019 Report 594 – Source Control Emergency Response Planning Guide for Subsea Wells + IMO International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) May 1995 + NOPSEMA Oil pollution risk management (Guidance note GN1488 Rev 2) February 2018 + NOPSEMA Oil spill modelling (Bulletin #1) April 2019 + Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012) + North-west Marine Parks Network Management Plan (Director of National Parks, 2018) + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a) + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a) + Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b) + AMSA National Plan for Maritime Environmental Emergencies 2014 (2019 Edition) + State Hazard Plan – Maritime Environmental Emergencies (MEE) (Department of Transport, 2018) + Oil Spill Contingency Plan 2015 (Department of Transport, 2015) + WA EPA Environmental Factor Guideline - Benthic Communities and Habitats + WA EPA Technical Guidance - Protection of Benthic Communities and Habitats + WA EPA – Environmental Factor Guideline – Marine Fauna (EPA, 2016b) + WA <i>Biodiversity Conservation Act 2016</i> (Wildlife Conservation (Specially Protected Fauna) Notice 2018).

Aspect	Unplanned hydrocarbon releases
Receptors	The following receptors have been identified as potentially being impacted as a result of the proposed Browse to NWS Project (Table 6-2). A detailed description of each of these receptors is provided in Chapter 5. <i>Physical</i> + sediment quality (medium value (open waters)) + water quality (medium value (open waters)) <i>Ecological</i> + plankton (medium value (open water)) + benthic habitat and communities + shallow water benthic communities and habitats (<75 m depth) (high value habitat) + deep water communities and habitats (>75 m depth) (medium value habitat) + coastal habitats + saltmarsh (high value habitat) + mangroves (high value habitat) + shoreline habitats (high value habitat) + fauna + seabirds and migratory shorebirds (high value species) + fish (high value species) + marine mammals (high value species) + marine reptiles (high value species) + KEFs (medium value) + AMPs (medium value) + State marine parks and nature reserves (high value) + other protected places (high value) <i>Socio-economic</i> + State and Commonwealth managed fisheries (high value marine user) + other users + tourism and recreation (high value user) + scientific studies (high value user) + shipping (medium/high value users) + industry (low value users) + settlements (medium value users) + aboriginal and indigenous heritage (high value users) + marine archaeology (high value)
Potential impacts	+ No impacts from planned activities have been identified in relation to this aspect
Risks	Unplanned hydrocarbon spill resulting in: + change in sediment quality + change in water quality + injury or mortality to fauna + changes to the functions, interests or activities of other users + change in heritage values

Aspect	Unplanned hydrocarbon releases		
Summary of impact evaluation for governing impact	Magnitude	Impact significance level	Confidence
	n/a	n/a	n/a
Summary of risk evaluation for governing risk	Consequence	Likelihood	Risk rating
	Catastrophic	Highly unlikely	High (A1)

6.3.21.2 Source of Aspect

There are various sources of potential unplanned hydrocarbon releases associated with the proposed Browse to NWS Project. This section provides a general description of the sources. More details will be provided in secondary environmental approvals (i.e. activity-specific Environment Plans) and associated Oil Pollution Emergency Plans (OPEPs) that will be prepared for the proposed Browse to NWS Project and submitted for regulatory approval before activities commence.

Drilling or Completion operations

During drilling or completion operations, a loss of well control (LOWC) could result in an uncontrolled subsea release of hydrocarbons (i.e. unstabilised condensate) resulting from an over-pressurised reservoir and barrier failure. The major causes of a LOWC are identified as equipment failure, dropped objects, intersection with shallow gas and human error.

Commissioning

During commissioning, hydrocarbons from the reservoirs (gas and unstabilised condensate) will be introduced into the subsea infrastructure. There is a risk of leaks in the newly installed infrastructure that would result in the loss of hydrocarbons to the marine environment. It should be noted that the planned hydrotesting (Section 6.3.17) to assess integrity and detect leaks will significantly mitigate this risk. In addition, there will also be a series of production chemical and fuel import activities that will last for extended durations to reach operational and storage volumes.

Hydrocarbon extraction, processing and export

During operations, hydrocarbons extracted from the reservoir will flow from the wellheads via the christmas trees and manifolds through the flowlines to the FPSO facilities. Equipment failure could result in hydrocarbon leaks or the loss of containment of reservoir hydrocarbons (gas and unstabilised condensate) from production flowlines.

It is also possible that failure of down-well barriers or physical damage to a completed well could result in a loss of control of a production well.

On the FPSO, the condensate will be separated from the gas stream before the gas is processed and compressed for export via the BTL to the existing NWS JV infrastructure. During this process, structural failure of the subsea infrastructure, FPSO facilities, individual

equipment (e.g. cranes, flare tower), the BTL or the inter-field spurline could result in unplanned release of hydrocarbons. This could include loss of containment from subsea infrastructure such as pipeline, flowlines, risers, the BTL or inter-field spurline; or the FPSO, including non-process hydrocarbon inventories (fuel tanks) and condensate storage tanks. Potential causes of structural failure could include internal corrosion, external corrosion, equipment failure, extreme weather, seismic events/seabed instability and dropped objects fire/explosion event.

Condensate offtake

Every two to four weeks during operations, stabilised condensate will be loaded onto condensate tankers using flexible hoses. Condensate tankers will be positioned astern of the FPSO facility and supported by tugs as required. During offtake, vessel collision (between the condensate tanker and the FPSO or project vessel), or the rupture of condensate offtake hoses, could result in the loss of stabilised condensate to the marine environment.

Project vessel and MODU operations

Project vessels will be used during all phases of proposed Browse to NWS Project throughout the Project Area. Project vessels will not use heavy fuel oil or intermediate fuel oil. Unplanned hydrocarbon releases could occur during project vessel and MODU operations due to bunkering failure (where the partial or total failure of a bulk transfer hose or fittings results in loss of containment) or the rupture of a vessel fuel tank (as a result of a collision between project vessels or between a project vessel and a third-party vessel such as commercial fishing or shipping vessels).

For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmental receptor, several factors must align:

- + Vessel interaction must result in a collision.
- + The collision must have enough force to penetrate the vessel hull.
- + The collision must be in the exact location of the fuel tank.
- + The fuel tank must be full, or at least have a volume of fuel in the tank such that the level of the fuel is higher than the point of penetration.

6.3.21.3 Hydrocarbon Spill Modelling

Spill Scenarios

Risk assessments using specific and historic spill data were undertaken to identify worst-case credible spill scenarios that could arise from the proposed Browse to NWS Project. The following information was reviewed as part of the risk assessment:

- + events that could result in a hydrocarbon spill

- + the likelihood of these spill events
- + the resulting spill volumes released to the marine environment.

The worst-case credible spill scenarios evaluated for the proposed Browse to NWS Project are presented in [Table 6-153](#). It should be noted that unstabilised condensate is condensate that has not yet been processed on board via the FPSO topsides facilities.

Table 6-153 Evaluation of possible proposed Browse to NWS Project worst-case credible spill scenarios

Scenario	Description of worst-case scenario	Credibility of spill scenario
Loss of well containment (well blowout)	A well blowout from the TRA-C well within the State Proposal Area releasing hydrocarbons in proximity to Scott Reef. It is estimated that approximately 142,154 m ³ of unstabilised Torosa condensate could be released.	Credible Scenario selected for spill modelling
Loss of containment from production flowlines	Loss of the entire contents of the TRD/TRE combined flowline (considered worst-case due to its length and proximity to Scott Reef). It is estimated that 25 m ³ of unstabilised Torosa condensate could be released.	Credible Scenario not selected for further assessment (i.e. spill modelling) due to the relatively small volume of condensate that could be lost compared to other credible spill scenarios at a nearby location.
Catastrophic loss of FPSO structural stability	Foundering (sinking) of the FPSO and rupture of multiple cargo tanks.	Not credible Due to the design of the FPSO, which will comply with MARPOL Annex 1 (Regulations for the Prevention of Pollution by Oil) Regulation 28 (Damage Stability), the foundering of the FPSO and loss of Browse condensate from multiple cargo tanks is not considered to be a credible scenario. This is consistent with (AMSA, 2015) guidance for credible spill scenarios.
FPSO loss of station	Loss of station resulting in the impact of the Torosa FPSO on Scott Reef and rupture of multiple cargo tanks.	Credible Scenario not selected for spill modelling – see further details below.
Loss of hydrocarbons from a cargo tank on either the FPSO or a condensate tanker	Loss of the entire volume of a single cargo tank of stabilised Torosa condensate from the FPSO or a condensate tanker. It is estimated that approximately 18,000 m ³ could be released.	Credible Scenario selected for spill modelling
Loss of hydrocarbons during condensate offtake	Loss of the entire hose inventory (i.e. the contents of the hose) due to failure of the hose or couplings, as well as additional stabilised Torosa condensate pumped through the offtake hose during the time taken to react to the spill. It is estimated that approximately 768 m ³ of condensate could be released.	Credible Scenario selected for spill modelling

Scenario	Description of worst-case scenario	Credibility of spill scenario
Loss of containment from the process equipment on the FPSO topsides	The LP Separator has the largest inventory, which would result in a maximum release of 165.3 m ³ of unstabilised condensate.	Credible Scenario not selected for further assessment (i.e. spill modelling) due to the relatively small volume of condensate relative to the worse cases presented for this location.
Loss of containment from diesel bunkering	Loss of containment during diesel bunkering to the FPSO or other vessels due to the partial or total failure of the bulk transfer hose or fittings. It is estimated that the partial or total failure of a bulk transfer hose or fittings during bunkering, combined with a failure in procedure to shutoff fuel pumps for a period of up to five minutes, could result in approximately 8 – 13 m ³ of marine diesel being released.	Credible Scenario not selected for further assessment due to the relatively small volume of marine diesel that could be lost compared to other credible spill scenarios.
Loss of containment from the BTL	A pipeline rupture resulting in an uncontrolled subsea release of dry gas (methane) from the BTL. It is estimated that 850,000 m ³ of dry gas could be released.	Credible Scenario not selected for spill modelling due to the lack of liquid hydrocarbons that could be released. See further details below.
Loss of containment from an activity vessel	Loss of containment due to a collision between activity vessels, with the maximum volume that could be released estimated to be 2,000 m ³ of marine diesel from the rupture of a single tank on the pipelay vessel or fuel tanker in proximity to Rowley Shoals (the most sensitive receptor along the BTL route).	Credible Scenario selected for spill modelling

These scenarios were based on spill locations and volumes applicable to a range of spill events deemed to be representative, as described in [Section 6.3.21.2](#). Spill volumes were determined based on a review of hydrocarbon volumes likely to be stored within equipment, infrastructure and vessels, as well as expected volumes from reservoirs. To determine the worst-case credible spill volumes, equipment and the maximum inventory of indicative vessel types were considered, along with loading/unloading rates and reaction times for spill detection/mitigation. Design features incorporated into infrastructure and equipment, which would inherently reduce the likelihood of a spill occurring, were also factored in where applicable.

Further detail – FPSO loss of station

The scenario “FPSO loss of station” refers to the risk of an FPSO mooring system failure resulting in grounding of a FPSO, rupture of multiple cargo tanks, and subsequent release of condensate onto Scott Reef. If this were to occur, the potential consequence would be a significant spill at Scott Reef, causing environmental impact to the reef. The impact of a potential spill to a Scott Reef receptor would be similar in nature and scale to a well blowout in close proximity to Scott Reef, such as the TRA-C well or the loss of hydrocarbons from a cargo tank on either the FPSO or a condensate tanker. The nature of an FPSO loss of station event means that it is not able to be modelled following the standard approach. In particular, the Environment that May Be Affected (EMBA) is typically defined using a stochastic modelling approach, in order to identify receptors that may be impacted under different metocean conditions. It is not reasonable to apply a stochastic approach to a FPSO loss of station scenario, as this is only considered credible under cyclonic conditions and not under the full range of metocean conditions applied during stochastic modelling.

The likelihood of the FPSO loss of station scenario is considered to be remote. The FPSO mooring system is designed to maintain FPSO station, including in cyclonic metocean conditions up to and including the 1 in 10,000 year sea state. Once off station, the typical drift speed of an FPSO is approximately 8 knots, which is unlikely to be sufficient to have enough impact force to rupture the hull of the FPSO if the FPSO were to drift into Scott Reef. The FPSO design is based on cargo tanks as centre tanks only, with ballast tanks as wing tanks. Furthermore, the FPSO has a draft of approximately 16 m. The central location of the cargo tanks and the draft of the FPSO makes direct impact to FPSO hull cargo tanks from a collision with Scott Reef inherently unlikely.

If FPSO loss of station and subsequent grounding were to occur, grounding would most likely occur on the nearest face to the FPSO, which is the eastern side of Scott Reef. The well blowout modelling at the TRA-C well also occurred near the eastern side of Scott Reef,

in regional terms, and the total volume of condensate released in a well blowout significantly exceeded two cargo tank volumes of the FPSO.

Therefore, as it is not reasonable to apply stochastic modelling, the remote likelihood of the event and the impact of a spill being assessed as similar to Scott Reef as the well blowout scenario (which is also the governing scenario for a risk assessment of an accidental hydrocarbon release in proximity to Scott Reef), a hydrocarbon loss of containment resulting from FPSO loss of station has not been modelled or considered further.

Further detail – loss of containment from the BTL

The scenario “Loss of containment from the BTL” refers to a dry gas subsurface release related to the proposed BTL (located at seabed depths that range between approximately 125 m and 400 m). If a pipeline rupture occurred, the majority of the methane gas released would immediately dissolve into the water column (methane is highly soluble in water), with a small proportion expected to reach the sea surface and ‘flash-off’ on exposure to the atmosphere.

Studies show methane oxidation in deep water, and water column characteristics like pynoclines (stratification of the water column due to differences in density) and thermoclines (stratification of the water column due to differences in water temperature), limit the amount of methane that is transported upwards to the sea surface. Even in relatively shallow water depths (less than 100 m water depths) only minor amounts of methane are actually released to the atmosphere (Deimling et al., 2015; Gentz et al., 2014; Schmale et al., 2010). Given stratification occurs year round within the Browse Development Area ([Section 5.2.5.7](#)), it is expected that methane would be effectively trapped within cooler deeper waters, should a rupture or leak occur in the BTL. In this scenario, it is expected that any transfer of methane to warmer surface waters would be restricted and, therefore, air-sea exchange would be limited (Gentz et al., 2014).

Gentz et al. (2014) found approximately 80% of methane dissolution occurs below the water column stratification, such as with a pynocline, and that methane levels return to background concentrations rapidly above the pynocline. Methane dissolved in the water column is also subject to microbial oxidation, which further restricts transfer of methane into the upper surface water layer and the atmosphere (Gentz et al., 2014; Valentine et al., 2001). When methane is oxidised it forms water and carbon dioxide. Dissolved methane and carbon dioxide exist naturally in water and pose no risk to the marine environment.

Following the 2012 gas leak from the Elgin platform in the North Sea, monitoring of water and sediment (Webster et al., 2012a,b) and fish health (Webster et al., 2012b,c) found no evidence of hydrocarbon contamination above background levels. Although the sea temperatures were colder than those in the Project Area, natural processes such as microbial oxidation would be expected to occur in the Project Area which would greatly reduce any dry gas release to the atmosphere or impacts to the marine environment.

Given this, changes in the chemistry of the water column or sediment from a gas release are expected to be localised, short-term and not significant to any sensitive receptor or environmental aspect. Therefore, potential impacts from this scenario are not considered further and potential environmental impacts from hydrocarbon releases will be sufficiently addressed through impact assessment of other scenarios.

Hydrocarbon Spill Modelling

As it is not practicable for spill modelling to be undertaken at every potential spill location within the Project Area, a subset of the scenarios have been selected to be modelled.

As per [Table 6-153](#), the following credible hydrocarbon spill scenarios were selected for risk assessment:

- + Scenario 1: A long-term (77-day) uncontrolled release of 142,154 m³ of unstabilised Torosa condensate from the TRA-C well (13° 58' 12.5" S, 121° 58' 37.7" E), with a 5-day surface release phase followed by a 72-day subsea release phase, representing loss of containment after a loss of well control. Note that the 77-day period for an uncontrolled release has been estimated based on early information regarding rig mobilisation time and relief well drill time. This estimate may be further refined under subsequent EPs.
- + Scenario 2: A medium-term (24-hour) uncontrolled surface release of 18,000 m³ of stabilised Torosa condensate at the Torosa FPSO location (13° 58' 15.1" S, 122° 01' 28.5" E), representing loss of containment after a vessel cargo tank rupture.
- + Scenario 3: A short-term (instantaneous) surface release of 768 m³ of stabilised Torosa condensate at the Torosa FPSO location (13° 58' 15.1" S, 122° 01' 28.5" E), representing loss of containment after a vessel offtake system failure.
- + Scenario 4: A short-term (instantaneous) surface release of 2,000 m³ of marine diesel near the Rowley Shoals (17° 16' 52.8" S, 119° 39' 30.8" E), representing loss of containment after a vessel fuel tank rupture.

Smaller minor spills, such as the loss of containment from FPSO topsides or loss during diesel bunkering, were also identified as a source of risk as they also have the potential to occur during the proposed Browse to NWS Project. However, the selected scenarios for spill modelling are considered to be representative of worst-case credible spill scenarios and, therefore, determine the overall hydrocarbon spill risk associated by the proposed Browse to NWS Project.

Hydrocarbon Characteristics

Condensate

For condensate release scenarios, multiple oil characteristics have been modelled, which describe how the fluid is expected to behave in different scenarios. During a release of unstabilised Torosa condensate, less dense components exposed to a sudden change in pressure flash off as gases, leaving behind a liquid spill that is denser than the original fluid. The greater the change in pressure, the more light components flash off, and the denser/heavier components remain in liquid. The change in pressure at surface is much greater than the change in pressure at seabed (due to the pressure exerted in deep water) and, therefore, unstabilised Torosa condensate released at surface is expected to be denser (and have a higher proportion of low volatility components) than unstabilised Torosa condensate released at seabed.

During the stabilisation process, the condensate is treated to allow the lighter components to be retained in the liquid, through a series of controlled changes in temperature and pressure. Stabilised Torosa condensate is typically stored in near-atmospheric conditions. If a release of stabilised Torosa condensate were to occur, there would be relatively little flashing off of lighter components. The remaining liquid is expected to be less dense (and have a higher proportion of high volatility components) than unstabilised Torosa condensate.

Marine Diesel

Marine Diesel is a blend of distillates and heavy fuel oil, but with a very low fuel oil content. Marine diesel has low viscosity and is readily dispersed across the sea surface and in the water column. It is relatively toxic but dissipates and evaporates relatively rapidly. Depending on the proportion of heavy fuel oil, elements of the marine diesel may persist in the environment longer than distillate-only diesel.

Characteristics of condensate and marine diesel are summarised in [Table 6-154](#).

Table 6-154: Characteristics of the oil types used for modelling of Scenarios 1-4

Oil Type	Density (g/cm ³)	Viscosity (cP)	Component	Volatile (%)	Semi-Volatile (%)	Low Volatility (%)	Residual (%)	Aromatics (%)
			Boiling point (°C)	<180 C ₄ -C ₁₀	180-265 C ₁₁ -C ₁₅	265 - 380 C ₁₆ -C ₂₀	>380 >C ₂₀	Of whole oil <380 BP
Unstabilised Torosa Condensate (seabed)	0.780 at 20 °C	1.092 at 20 °C	% of total	14.5	39.9	20.7	24.9	26.2
			% aromatics	2.5	8.8	14.9	-	-
Unstabilised Torosa Condensate (surface)	0.813 at 25 °C	2.519 at 25 °C	% of total	1.0	15.5	32.7	50.8	26.9
			% aromatics	0.2	3.1	23.6	-	-
Stabilised Torosa Condensate	0.780 at 20 °C	1.092 at 20 °C	% of total	57.0	21.0	8.0	14.0	19.6
			% aromatics	10.3	4.3	5.0	-	-
Marine Diesel	0.829 at 25 °C	4.000 at 25 °C	% of total	6.0	34.6	54.4	5.0	3.0
			% aromatics	1.8	1.0	0.2	-	-

Modelling methodology

Quantitative hydrocarbon spill modelling was undertaken by RPS, on behalf of Woodside, using a three-dimensional hydrocarbon spill trajectory and weathering model SIMAP (Spill Impact Mapping and Analysis Program) (RPS, 2019b; [Chapter 10, Appendix D.5](#)). SIMAP is designed to simulate the transport, spreading and weathering of specific hydrocarbon types under the influence of changing meteorological and oceanographic forces (RPS, 2019b).

Stochastic modelling was carried out for the five governing credible hydrocarbon release scenarios, whereby SIMAP was applied to repeatedly simulate the defined scenarios using different randomly-selected conditions. Stochastic modelling simulations provide insight into the probable behaviour of a potential spill under the meteorological conditions expected to occur. Stochastic modelling simulations are used to define the EMBA. The models predict the most probable path and transport rates for unplanned releases using historical wind and ocean current data. The model runs many single trajectories (e.g. 100 scenarios per release location per season, including summer, winter and transitional), varying the start time (and hence prevailing wind and current conditions). This approach ensures that the predicted transport and weathering of a hydrocarbon slick is subjected to a range of oceanic conditions.

Deterministic modelling was also carried out to provide probable examples of single worst-case credible spill events, rather than the statistical representation of 100 spill events as represented by stochastic modelling and presented for the EMBA.

[Table 6-157](#) and [Table 6-158](#) provide the summarised results from hydrocarbon spill modelling for Scenarios 1 through 4.

Hydrocarbon exposure thresholds

The outputs of the quantitative hydrocarbon spill modelling were used to assess the extent of potential environmental risk should a credible hydrocarbon spill scenario occur, by delineating which receptors could be exposed to hydrocarbon levels exceeding selected hydrocarbon threshold concentrations.

The outer extent of all points where selected hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as the Environment that May Be Affected (EMBA). The thresholds selected for informing the EMBA and the rationale for their selection is provided in [Table 6-155](#). Further details of the EMBA are discussed later in this chapter.

Table 6-155: Summary of thresholds selected for determining the EMBA from the quantitative hydrocarbon spill risk modelling results

Parameter	Exposure Thresholds	Justification
Surface hydrocarbon	1 g/m ²	The surface threshold of ≥ 1 g/m² is based on the relationship between film thickness on the sea surface and appearance and represents a 'rainbow' presented as a range of colours (Bonn Agreement, 2015). This threshold has been used to approximate ranges of socio-economic effects for condensate and marine diesel, and to identify potential additional socio-economic receptors which may be affected from an unplanned hydrocarbon release <i>outside</i> of the defined EMBA (e.g. AMPs). This concentration is considered a suitable threshold for the extent to which socio-economic effects may occur (NOPSEMA, 2019), however, the threshold is considered below levels which would cause ecological impacts, and instead represents potential for visual amenity impacts. Additional receptors identified at this concentration have been identified in Table 6-158 and, where relevant, impacts are described in Section 6.3.21.5.
	10 g/m ²	The surface threshold of ≥ 10 g/m² is based on the relationship between film thickness on the sea surface and appearance and represents a 'dull metallic colour' (Bonn Agreement, 2015). Thresholds for registering biological impacts resulting from contact of sea surface slicks have been estimated by different researchers at 10–25 g/m² (French et al., 1999; Koops et al., 2004; National Oceanic and Atmospheric Administration, 1996) which are asked by oil spill responders as well as those assessing potential impacts, are: (1. Potential impacts of surface slick concentrations in this range for floating hydrocarbons may include harm to seabirds through ingestion from preening of contaminated feathers, or the loss of the thermal protection of their feathers. The 10 g/m² threshold is the reported level of oiling to instigate impacts to seabirds and is also applied to other wildlife, although it is recognised that 'unfurred' animals, where hydrocarbon adherence is less, may be less vulnerable. 'Oiling' at this threshold is taken to be of a magnitude that can cause a response from the most vulnerable wildlife such as seabirds. Due to weathering processes, sea surface hydrocarbons decrease in toxicity due to change in their composition over time. Potential impacts to shoreline sensitive receptors may be markedly reduced in instances where there is extended duration until contact. This threshold of 10 g/m² of floating oil has been selected to inform the EMBA.

Parameter	Exposure Thresholds	Justification
Dissolved aromatic hydrocarbon	50 ppb (condensate) 500 ppb (marine diesel)	Dissolved aromatic hydrocarbons are the soluble component of the released hydrocarbon present throughout the water column. Dissolved aromatics are generally considered to represent the bioavailable form of oil that dictates toxicity in the water column. The thresholds represent potential toxic effects, particularly sublethal effects to highly sensitive species. <u>Condensate</u> Woodside has undertaken ecotoxicology testing on a number of condensates obtained during exploration and production activities, including for the Browse Basin (Calliance, Brecknock and Torosa gas fields) unweathered condensate (ESA, 2009). The ecotoxicity tests were undertaken on the six species representing six major taxonomic groups of ecological relevance, focusing on the early life stages of test organisms, when organisms are typically at their most sensitive: + Sea urchin (<i>Heliocidaris tuberculata</i>) + Rock oyster (<i>Saccostrea commercialis</i>) + Marine micro-alga (<i>Isochrysis aff. galbana</i>) + Marine macro-alga (<i>Hormosira banksia</i>) + Penaeid prawn (<i>Penaeus monodon</i>) + Barramundi fish (<i>Lates calcarifer</i>). The laboratory-based ecotoxicology tests used a range of Water Accommodated Fractions (WAF) hydrocarbon concentrations to expose the different test organisms. The range of no observed effect concentrations (NOEC) for the organisms tested ranged from 1280 ppb to 77,310 ppb. NOPSEMA (2019) allows use of ecotoxicology testing to justify project specific thresholds. However, it also recommends a generic exposure threshold of 50 ppb as appropriate for approximating potential toxic effects, particularly sublethal effects to sensitive species. As such, this threshold, while considered highly conservative given the above, has been selected for informing the EMBA.

Parameter	Exposure Thresholds	Justification
		<i>Diesel</i> Woodside has undertaken ecotoxicology testing on Marine Diesel Oil (Ecotox Services Australia, 2013), on a broad range of taxa of ecological relevance for which accepted standard test protocols are well established. These ecotoxicology tests are focused on the early life stages of test organisms, when organisms are typically at their most sensitive. The nine ecotoxicology tests were conducted on seven mainly tropical-subtropical species representatives from six major taxonomic groups. The seven species were tested for chronic (function of life) effects of immobilisation, early life stage development/growth and acute toxicity (i.e. mortality). The laboratory-based ecotoxicology tests used a range of water accommodated fraction (WAF) concentrations to expose the different test organisms. For each ecotoxicology test, samples of the WAF were analysed to determine the TPH concentration of the solution. The reported NOECs for organisms tested ranged from 520 ppb to 3500 ppb. For seven of the nine tests, no statistically significant effect on the test organisms was observed even at the highest WAF concentration used in the testing. Based on these ecotoxicology tests, a conservative threshold of 500 ppb has been adopted. This 500 ppb threshold is below the lowest NOEC for the most sensitive organism tested. These thresholds are calculated based on exposure of organisms to dissolved aromatic hydrocarbons for periods of 1 to 96 hours and are, therefore, conservative when used for instantaneous contact.

Parameter	Exposure Thresholds	Justification
Entrained hydrocarbon	100 ppb (condensate) 500 ppb (marine diesel)	Entrained hydrocarbons are present in the water column as buoyant microbubbles of hydrocarbons and are a potential source of soluble (dissolved) hydrocarbons. It is noted that entrained hydrocarbons are less biologically available to organisms through absorption into their tissues than dissolved aromatic hydrocarbons and, therefore, adoption of a threshold based on toxicity data is a conservative approach. Condensate The condensate threshold concentration value for entrained hydrocarbons (i.e. 100 ppb) is considered highly conservative and has been set with reference to the entrained exposure values recommended in NOPSEMA Bulletin #1 Oil Spill Modelling (2019), and is considered highly conservative in the context of ecotoxicity tests results from Torosa condensate. The threshold concentration of entrained hydrocarbons that could result in a biological impact cannot be determined directly using available ecotoxicity data for WAF of oil hydrocarbons. However, it is likely this data specific to dissolved oil hydrocarbon represents a worst-case scenario. This is because entrained oil hydrocarbons are less biologically available to organisms through absorption into their tissues than dissolved hydrocarbons. The selected threshold of 100 ppb is an order of magnitude below the NOEC for the six sensitive organisms tested in relation to dissolved hydrocarbons and is, therefore, considered to be conservative, and has been selected for informing the EMBA. Diesel The entrained threshold for diesel has been selected with reference to the ecotoxicology test results for marine diesel (i.e. lowest NOEC 520 ppb (Ecotox Services Australia, 2013). As described above, entrained droplets may contain soluble compounds and hence have the potential for generating elevated concentrations of dissolved hydrocarbons. However, the potential for physical and chemical effects from direct contact with entrained oil droplets, which are less biologically available, is more applicable. An entrained threshold of 500 ppb, consistent with the threshold for toxicity from dissolved components is, therefore, also considered to be conservative and has been selected for informing the EMBA.
Shoreline	100 g/m ²	Accumulated hydrocarbons are defined as a detectable hydrocarbon level representing the build-up of hydrocarbons on shorelines that may result from all three hydrocarbon fates (surface, entrained and dissolved). Owens and Sergy, (1994) defined accumulated hydrocarbon <100 g/m² as having an appearance of a stain on shorelines. French-McCay (2009) defined accumulated hydrocarbons ≥100 g/m² to be the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat. A threshold of ≥100 g/m² has been adopted as the threshold for shoreline accumulation. This threshold has been selected to inform the EMBA for shoreline accumulation for condensate and marine diesel.

Weathering characteristics

Table 6-156 outlines the predicted weathering characteristics and persistence of unstabilised and stabilised Torosa condensate and marine diesel. For all hydrocarbon types, the influence of entrainment will regulate the degree of mass retention in the environment. The following describes the likelihood for entrainment and dissolution of hydrocarbons to occur for each of the four scenarios.

During the subsea release phase of Scenario 1, high pressure and low temperatures experienced at the depths in the Browse Development Area are likely to cause released gas to combine with water to form hydrates. The hydrates may rise through the water column and, upon reaching shallower water depths, are likely to decompose into methane and water. Unstabilised condensate is likely to be released as small oil droplets. The small oil droplets rapidly transported to the sea surface by the rising gas plume would be susceptible to re-entrainment into the wave mixed layer under typical wind conditions. It is likely that the bulk of

the oil mass would remain entrained in the water column until degradation processes occurred. Due to the weak buoyancy of the oil droplets, the formation of floating slicks is unlikely and, therefore, only a small fraction of the volatile compounds is likely to be exposed to the atmosphere. Considering the spill volume and low levels of evaporation expected, there is a high potential for dissolution of soluble aromatic compounds.

During the surface release of Scenarios 2, 3 and 4, floating hydrocarbons may be susceptible to entrainment into the wave-mixed layer under typical wind conditions. Evaporation rates in the first 24 hours of exposure to the atmosphere may be significant, given the significant proportions of volatile compounds in the oils (41-78%) (**Table 6-156**). The low-volatility fraction of the oils (8-54%) would take longer durations (days) to evaporate, and the residual fraction of 5-14% is expected to persist in the environment until degradation processes occur. Considering the spill volumes, there is a low to moderate potential for dissolution of soluble aromatic compounds.

Table 6-156: Summary of weathering behaviour of hydrocarbons from quantitative modelling

Hydrocarbon type	% Evaporation 24 hours after a spill	% Evaporation within a few days of a spill	% Expected to persist in the marine environment
Unstabilised Torosa condensate	11-54%	21-33%	25-51%
Stabilised Torosa condensate	78%	8%	14%
Marine Diesel	41%	54%	5%

Table 6-157: Summarised results from hydrocarbon spill modelling for Scenarios 1 through 4 – Extents of contact and maximum concentrations

Scenario	Model Parameter	Summary
Scenario 1: A long-term (77-day) uncontrolled release of 142,154 m ³ of unstabilised Torosa condensate from the TRA-C well, with a 5-day surface release phase followed by a 72-day subsea release phase, representing loss of containment after a loss of well control.	Floating	+ Exposures above the threshold are predicted to occur within 143 km from the source.
	Entrained	+ Exposures above the threshold are predicted up to around 863 km from the source. + The maximum entrained oil concentration for any receptor is predicted as 23,600 ppb at Scott Reef North. + Concentrations above 25,000 ppb are expected to extend from the sea surface to depths of around 20 m.
	Dissolved	+ Exposures above the threshold are predicted up to around 673 km from the source. + The maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 13,900 ppm at Scott Reef North. + Concentrations above 10,000 ppb are expected to extend from the sea surface to depths of around 20 m.
	Shoreline	+ A maximum accumulated volume of 827 m ³ (across all receptors) and a maximum local accumulated concentration of 34.3 kg/m ² is predicted at Scott Reef.
Scenario 2: A short-term (24-hour) uncontrolled surface release of 18,000 m ³ of stabilised condensate at the Torosa FPSO location, representing FPSO cargo tank or condensate tanker loss of containment.	Floating	+ Exposures above the threshold are predicted to occur within 126 km from the source.
	Entrained	+ Exposures above the threshold are predicted up to around 890 km from the source. + The maximum entrained oil concentration for any receptor is predicted as 30,500 ppb at Scott Reef North. + Concentrations show that concentrations above 25,000 ppb are expected to extend from the sea surface to depths of around 20 m.
	Dissolved	+ Exposures above the threshold are predicted up to around 517 km from the source. + The maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 12,700 ppb at Scott Reef North. + Concentrations above 10,000 ppb are expected to extend from the sea surface to depths of around 15 m.
	Shoreline	+ A maximum accumulated volume of 212 m ³ (across all receptors) and a maximum local accumulated concentration of 9.5 kg/m ² is predicted at Scott Reef.

Scenario	Model Parameter	Summary
Scenario 3: A short-term (instantaneous) surface release of 768 m ³ of stabilised condensate at the Torosa FPSO location, representing loss of containment after a vessel offtake system failure.	Floating	+ Exposures above the threshold are predicted to occur within 67 km from the source.
	Entrained	+ Exposures above the threshold are predicted up to around 242 km from the source. + The maximum entrained oil concentration for any receptor is predicted as 6,400 ppb at Scott Reef North. + Concentrations show that concentrations above 15,000 ppb are expected to extend from the sea surface to depths of around 15 m.
	Dissolved	+ Exposures above the threshold are predicted to be found up to around 203 km from the source. + The maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 1,800 ppb at Scott Reef North. + Concentrations above 1,000 ppb are expected to extend from the sea surface to depths of around 10 m.
	Shoreline	+ A maximum accumulated volume of 8 m ³ (across all receptors) and a maximum local accumulated concentration of 0.7 kg/m ² is predicted at Scott Reef.
Scenario 4: A short-term (instantaneous) surface release of 2,000 m ³ of marine diesel near the Rowley Shoals, representing loss of tank inventory from a fuel tanker.	Floating	+ Exposures above the threshold are predicted to occur within 82 km from the source.
	Entrained	+ Exposures above the threshold are predicted to around 371 km from the source. + The maximum entrained oil concentration for any receptor is predicted as 167,600 ppb. + Concentrations above 25,000 ppb are expected to extend from the sea surface to depths of around 20 m.
	Dissolved	+ Exposures above the threshold are predicted to around 43 km from the source. + The maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 2,200 ppb. + Concentrations above 2,000 ppb are expected to extend from the sea surface to depths of around 10 m.
	Shoreline	+ Total maximum accumulated volume of 6 m ³ (across all receptors) and a maximum local accumulated concentration of 491 g/m ² is predicted at Rowley Shoals – Mermaid Reef AMP.

Environment that may be affected

The weathering of surface entrained and dissolved hydrocarbons differs due to the influence of the metocean mechanism of transportation, therefore, the EMBA considers the potential spatial extent of the three different hydrocarbon fates. The EMBA also includes areas that are predicted to experience shoreline contact with hydrocarbons above threshold concentrations.

Based on the modelling outcomes, the EMBA was derived from the outer extent of the combined spill scenarios at a threshold above the level detailed in [Table 6-155](#).

Given Scenario 4 (instantaneous releases from vessels) was modelled for a specific point (near Rowley Shoals) selected near sensitive environmental receptors (i.e. worst case/conservative approach), the trajectory modelling results for those scenarios were extrapolated/extended along the length of the BTL to inform the EMBA.

The EMBA covers a larger area than that likely to be affected during any one single spill event, as the model was run for a variety of weather and metocean conditions (100 simulations in total). The EMBA, therefore, represents the combined total extent of all locations where hydrocarbon thresholds could be exceeded, as determined from all modelling runs.

Surface and accumulated shoreline hydrocarbon concentrations are expressed as grams per square metre (g/m^2), with entrained and dissolved aromatic hydrocarbon concentrations expressed as parts per billion (ppb).

[Figure 6-47](#) to [Figure 6-50](#) present contour maps showing individual EMBA's for Scenarios 1 - 4 based on the stochastic modelling results. The contour maps do not represent a single hydrocarbon spill (floating slick or water column plume at any one point in time). Instead, the contour maps are a composite of a large number of potential slick and plume paths combined into one area. The largest area (the entrained hydrocarbons contour for Scenario 1) has been used to inform the overall EMBA around the Scott Reef region, while the largest area for Scenario 4 (the entrained hydrocarbons contour) has been used to inform the overall EMBA around the Rowley Shoals region.

[Figure 6-51](#) to [Figure 6-54](#) present examples of quantitative deterministic hydrocarbon spill modelling results for Scenarios 1, 2, 3 and 4. This provides a representative example of the extent and trajectory of a potential spill resulting from each of these unplanned scenarios. The images, which represent the progression of an individual spill event over a period of several weeks, illustrate the transition of the spilled hydrocarbon above threshold levels in different phases, from initial floating hydrocarbons to shoreline accumulated hydrocarbons. This information can be used to inform planning and response actions in the event of a spill. As stated elsewhere, the deterministic spill events illustrated are one of many used to inform the areal extent of the wider EMBA. [Table 6-158](#) summarises the worst-case probabilities for contact at each relevant location and identified environmental sensitive receptor(s) and the associated aspects of that receptor that may be impacted by each of the credible spill scenarios. Greyed cells in [Table 6-158](#) identify the relevant physical, ecological and socio-economic aspects for each receptor/location; a 'y' in this cell indicates a potential for this aspect to be impacted if the location/environmental receptor is contacted, while a dash (-) indicates the aspect would not be impacted.

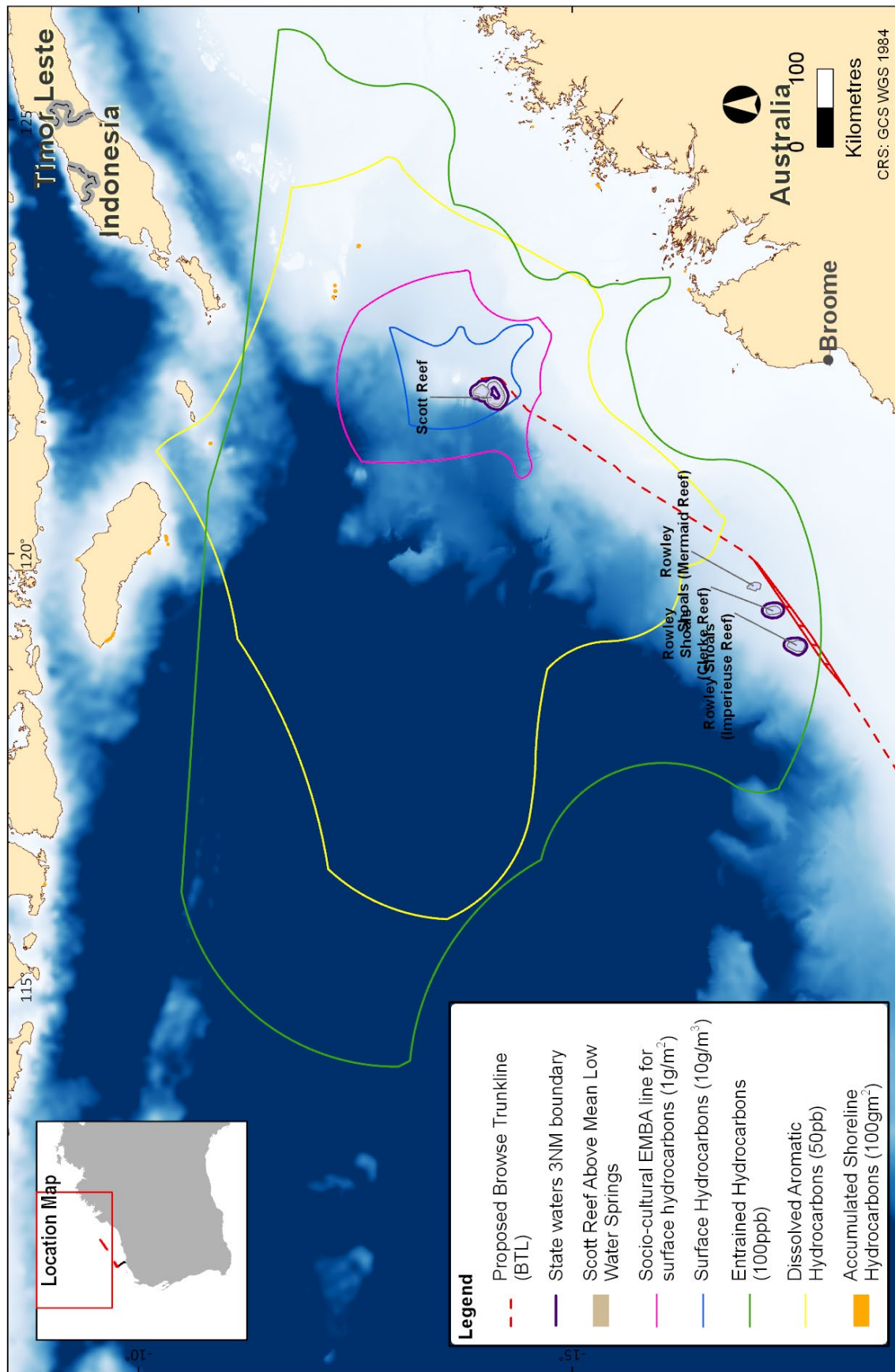


Figure 6-47: Scenario 1 (loss of well containment) – EMBA

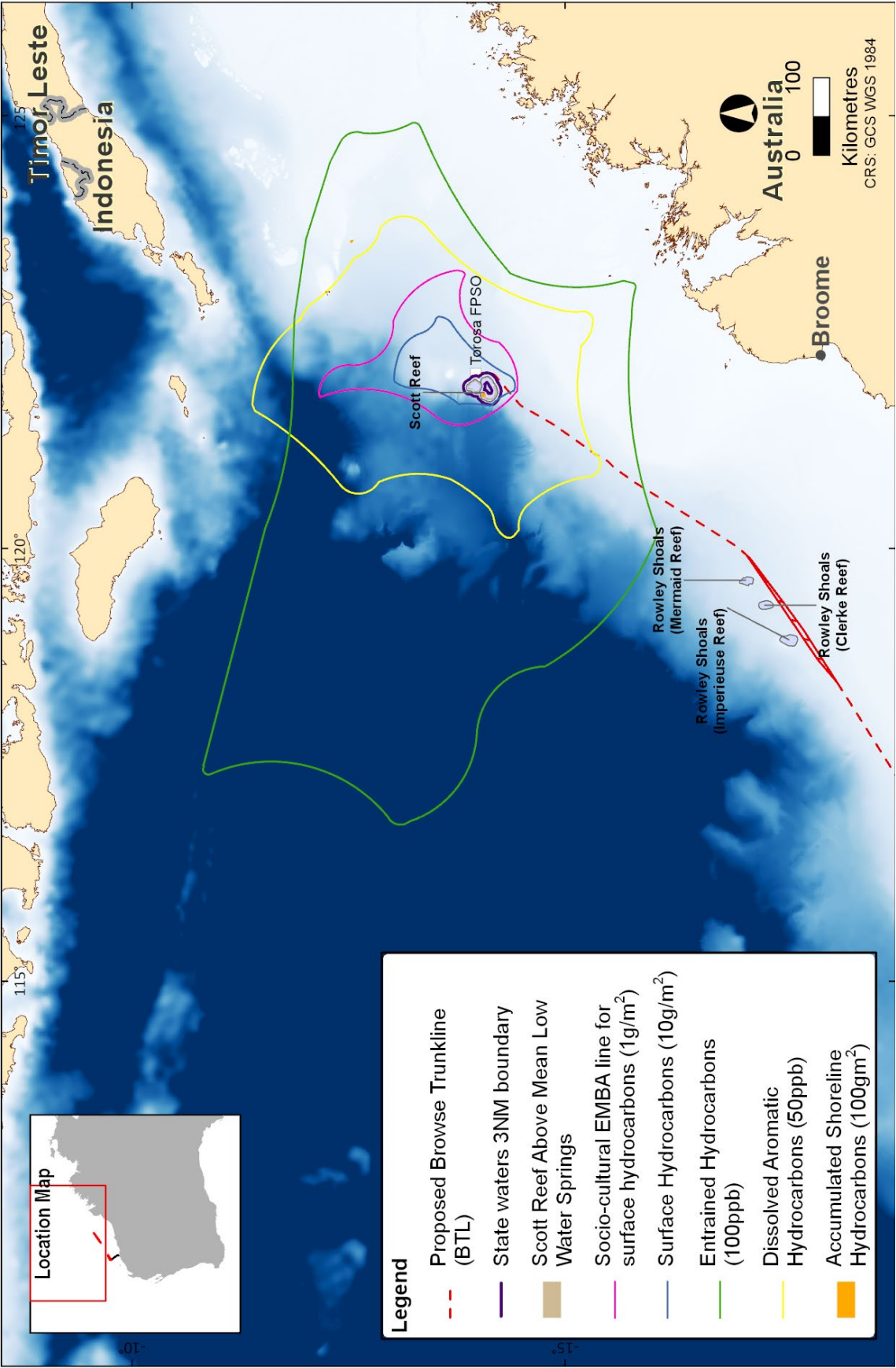


Figure 6-48: Scenario 2 (FPSO cargo tank or condensate tanker loss of containment) – EMBA

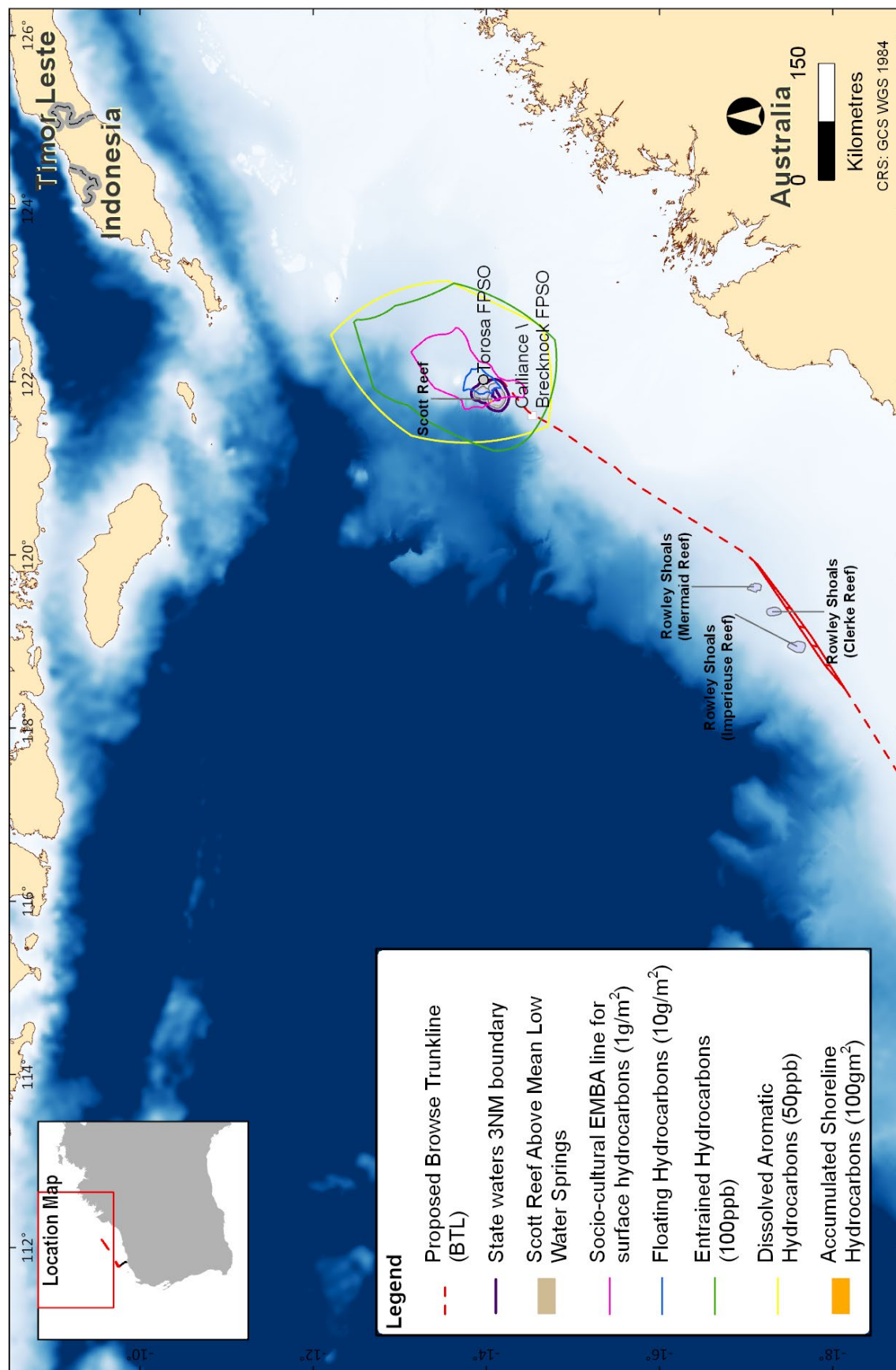


Figure 6-49: Scenario 3 (loss of containment during condensate offtake operations) – EMBA

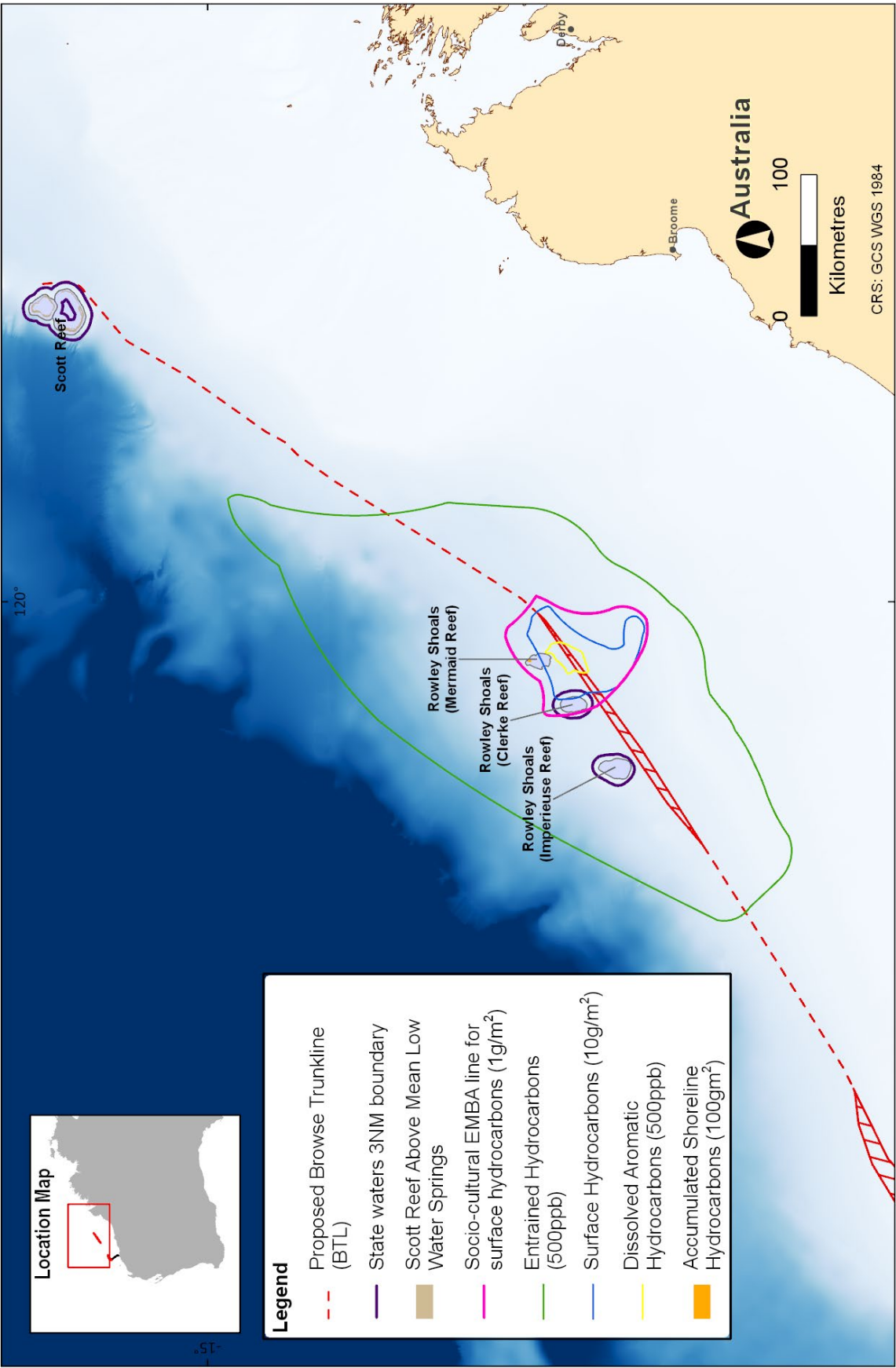


Figure 6-50: Scenario 4 (vessel fuel tank inventory loss due to vessel collision) - EMBA

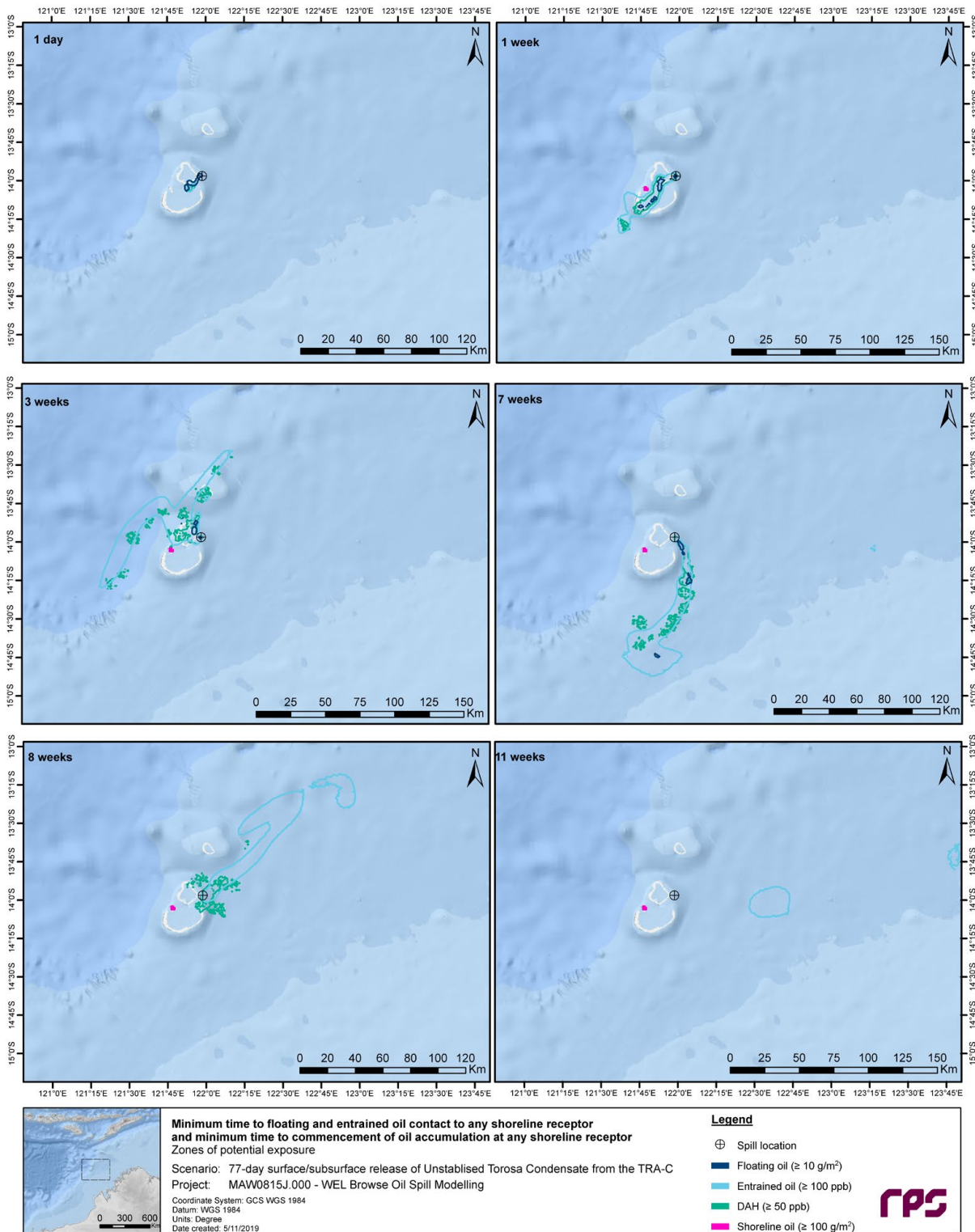


Figure 6-51: Scenario 1 (loss of well containment) example deterministic spill extent – minimum time to floating oil and entrained oil contact to any shoreline receptors and minimum time to commencement of oil accumulation at any shoreline receptor

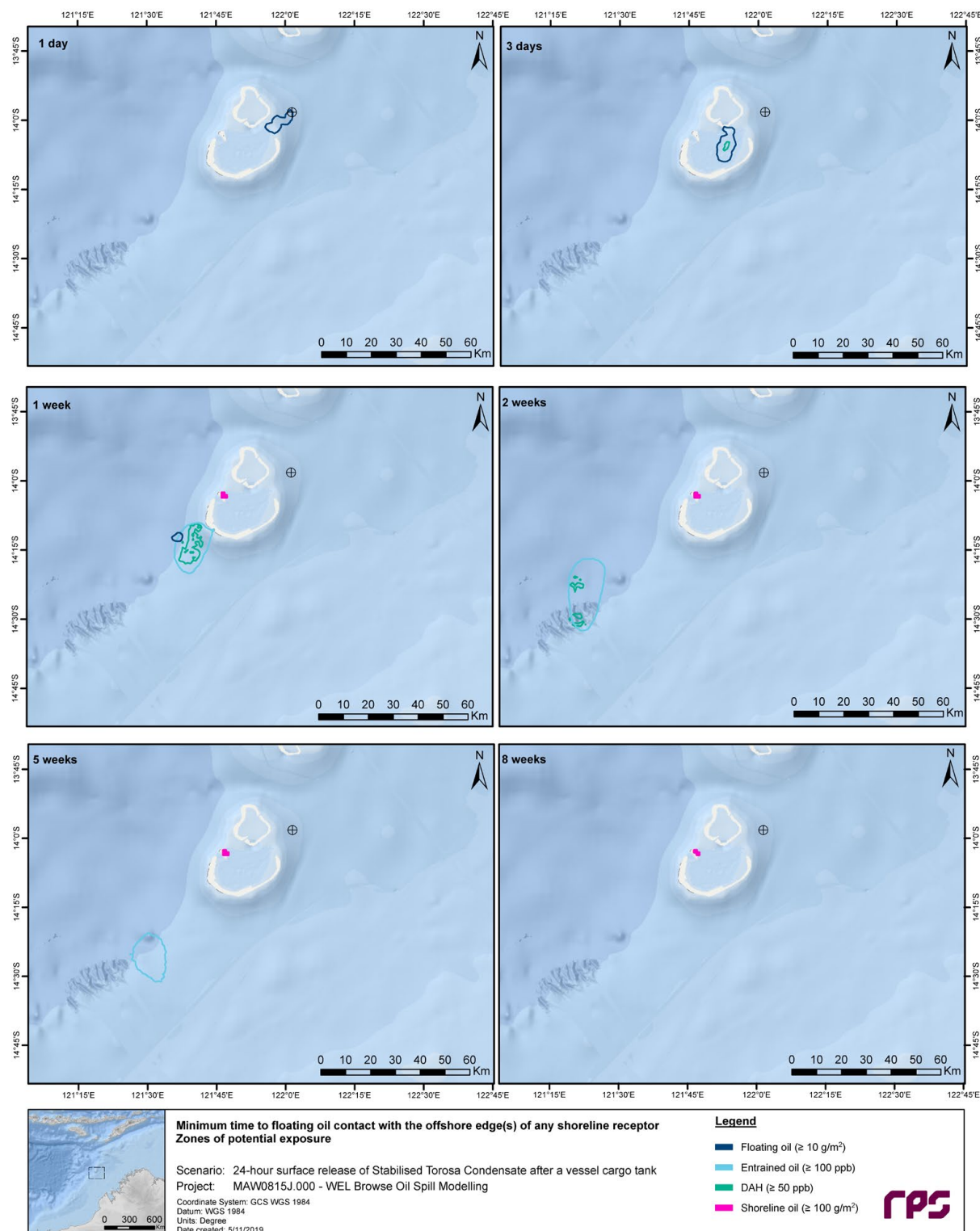


Figure 6-52: Scenario 2 (FPSO cargo tank or condensate tanker loss of containment) - example deterministic spill extent - minimum time to floating oil contact to offshore edges of any shoreline receptors

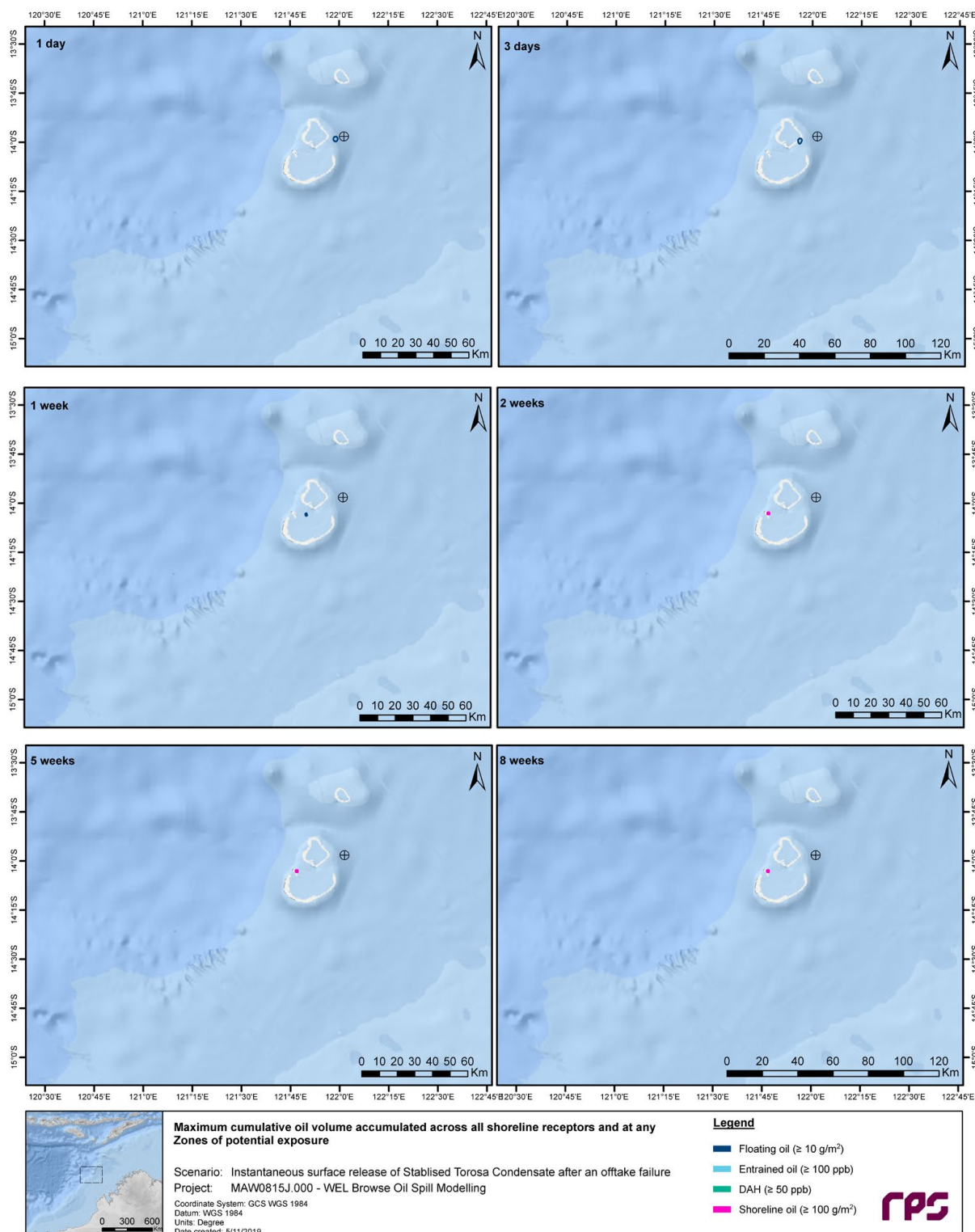


Figure 6-53: Scenario 3 (loss of containment during condensate offtake operations) - example deterministic spill extent - maximum cumulative oil volume accumulated across all shoreline receptors

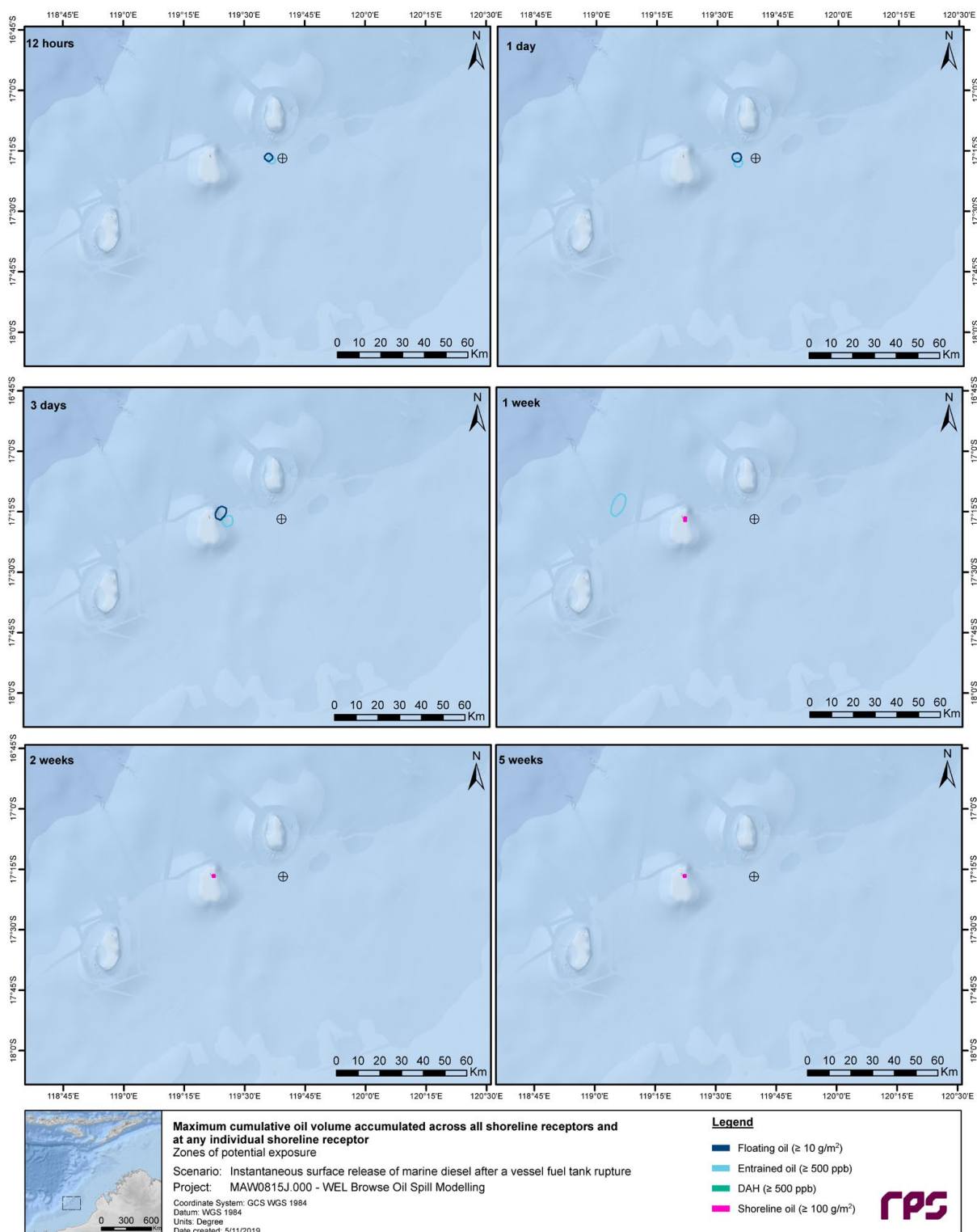


Figure 6-54: Scenario 4 (vessel fuel tank inventory loss due to vessel collision) - Example deterministic spill extent - maximum cumulative oil volume accumulated across all shoreline receptors

Table 6-158: Summarised results from hydrocarbon spill modelling for Scenarios 1 through 4 – key receptor locations and sensitivities with potential hydrocarbon spill contact. Environmental, social, cultural, heritage and economic aspects that are associated with each location or receptor are shown as greyed cells. Note that impacts relate to the type of hydrocarbon that is expected to reach a location as well as the characteristics of the aspect (e.g. locations which are only predicted to be contacted by shoreline accumulation will not have impacts to open ocean associated aspects)

[illegible]

Environmental setting	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WMO0000P010055394))														Probability of Hydrocarbon contact (Condensate/ Marine Diesel)															
	Physical		Biological										Socio-economic and Cultural																	
			Marine Primary Producers			Protected Species							Other Species		Fisheries – commercial	Fisheries – traditional	Tourism and recreation	Protected Areas/Shipwrecks	Offshore oil and gas infrastructure (topside and subsea)											
	Water Quality	Sediment Quality	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Spawning/nursery areas	Open water – productivity/upwelling	Non biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging significant nesting beaches)	Sea snakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident/demersal Fish						
Location/Receptor name	Modelled Scenario ¹	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)		
		Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)		
		Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	
		Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)	Open water – (pristine)
Remote oceanic reef systems, submerged Shoals and Banks	Rowley Shoals (including State MPs and AMP)	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		S3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		S4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barracouta Shoal	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Eugene McDermott Shoal	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

[illegible]

Environmental setting	Location/Receptor name	Modelled Scenario ¹	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Management Procedure (WMO00POP.GI0055394))																				Probability of Hydrocarbon contact (Condensate/ Marine Diesel)																																																																																																																																																																																																																																																																																																																	
			Physical	Biological										Socio-economic and Cultural																																																																																																																																																																																																																																																																																																																										
				Marine Primary Producers			Protected Species							Other Species		Fisheries – commercial	Fisheries – traditional	Tourism and recreation	Protected Areas/Heritage – European and Indigenous/Shipwrecks	Offshore oil and gas infrastructure (topside and subsea)																																																																																																																																																																																																																																																																																																																				
				Open water – (pristine)	Open water – (pristine)	Sediment Quality	Spawning/nursery areas	Open water – productivity/upwelling	Non biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales						Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and interesting areas and significant nesting beaches)	Sea snakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident/demersal Fish																																																																																																																																																																																																																																																																																																										
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6.3.21.4 Environmental Impact

There are no anticipated environmental impacts in relation to this aspect associated with planned or routine project activities. The environmental risk (i.e. a change to the environment resulting from an unplanned event or incident) is discussed below.

6.3.21.5 Environmental Risk

Likelihood of a major hydrocarbon release

In undertaking this risk assessment of a potential major hydrocarbon release, the spill likelihood was evaluated using Blowout and Well release Frequencies based on SINTEF offshore blowout database 2012 (Scandpower, 2013). This uses data from 1991-2010 to determine likelihood for well blowouts and releases. For a gas well, the SINTEF calculated probability of blowout during drilling and completion is 2.93×10^{-4} . The SINTEF data supports a likelihood of 'Highly unlikely' for a well blowout with potential to result in the worst case credible spill. However, the dataset does not account for Woodside and Industry Process Safety Improvements since the Gulf of Mexico Macondo event and is, therefore, likely to be conservative. The SINTEF data set is January 1991 – December 2010, whilst the Macondo blowout occurred in April 2010. Significant strengthening of barriers is now in place post the data set period, including, but not limited to:

- + Revised and more stringent API 53 Subsea BOP requirements are in force.
- + Competency assessments of offshore personnel is now more stringent for both Woodside and drilling contractors, for example, through implementation of improvements to well control training as recommended by IOGP and requirements for Woodside personnel in safety critical roles to complete the Process Safety Management training requirements.
- + The Woodside barrier installation and verification process has been revised, including acceptance criteria and change control management.

Overview

The Project Area and EMBA overlap a number of sensitive environmental, social and economic receptors, including protected and culturally significant areas. Depending on its severity (i.e. volume, hydrocarbon type and location), a hydrocarbon release resulting from the proposed Browse to NWS Project would have the potential to impact water and sediment quality and alter habitats. This could subsequently alter fauna behaviour, cause fauna injury or mortality, impact the aesthetic value of an area and alter the function, interests and activities of other users.

Sediment quality

Change in sediment quality

In the event of a hydrocarbon release, sediment quality within offshore and nearshore waters (seabed sediments, offshore islands and the mainland) could be affected. Studies of hydrocarbon concentrations in deep sea sediments surrounding and at distance from the Macondo well following the blowout of the Deepwater Horizon indicated that hydrocarbons were incorporated into sediments (Romero et al., 2015). Proposed mechanisms for hydrocarbon contamination of sediments included deposition of hydrocarbons and direct contact between submerged plumes and the seabed (Romero et al., 2015).

In the event of a major hydrocarbon release at the seabed (Scenario 1), modelling indicated that a pressurised release of condensate would generate a cone of rising gas that would entrain droplets and transport them to the surface. Marine sediment quality would be reduced as a consequence of hydrocarbon contamination in the immediate release site for a medium to long-term period and over a larger area as a result of the entrained and dissolved hydrocarbons, as discussed below.

Entrained and dissolved hydrocarbons (at or above the defined thresholds) could potentially contact shallow, nearshore waters of islands and mainland coastline and hydrocarbons may accumulate (at or above the ecological threshold) at a range of nearshore receptors ([Table 6-158](#)). Stochastic modelling results indicated that:

- + Scenario 1 had a high probability of affecting sediments associated with Scott Reef and Seringapatam Reef, but a low probability of contacting sediments of the Argo-Rowley Terrace Marine Park, Kimberley Marine Park, Rowley Shoals (including associated marine parks), Barracouta Shoal, Eugene McDermott Shoal, Heywood Shoal, Hibernia Reef, Vulcan and Goeree Shoals, Fantome Bank, Cartier Island, Browse Island, Ashmore Reef and Indonesia ([Table 6-158](#)).
- + Scenario 2 had a moderate probability of affecting Scott Reef and Seringapatam Reef sediments and a low probability of contacting sediments associated with Ashmore Reef (including the AMP), Eugene McDermott Shoal, Heywood Shoal, Vulcan Shoal and Goeree Shoal ([Table 6-158](#)).
- + Stochastic modelling predicted low potential for Scenario 3 to contact sediments at Scott Reef and Seringapatam Reef.
- + Scenario 4 had a moderate potential to contact sediments associated with the Argo-Rowley Terrace Marine Park and Rowley Shoals (including associated marine parks) ([Table 6-158](#)).

Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, including adherence to sediment and deposition on shores or seabed habitat. Where shoreline contact occurs, toxic constituents of the hydrocarbon release may accumulate within marine sediment. This may result in subsequent impacts to high value benthic habitats and communities (which is described in the sections below).

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact regional sediment quality. However, the occurrence of hydrocarbon spills is considered highly unlikely and the extent of impacts would depend on exposure concentration, duration and degree of weathering of the hydrocarbons.

Water quality

Change in water quality

In the event of a hydrocarbon release, water quality would be affected, due to hydrocarbon exposure and subsequent contamination. This is described in terms of the biological effect concentrations. These effect concentrations are defined by the hydrocarbon thresholds ([Table 6-155](#)) for each of the hydrocarbon fates and inform their predicted extents in [Table 6-157](#) and [Table 6-158](#).

The highly-mixed, open water location of the Project Area would result in rapid dispersion and evaporation of high-volatile components of released hydrocarbons. Unstabilised Torosa condensate, stabilised Torosa condensate and marine diesel all have varying proportions of volatile and persistent (e.g. low-volatile, residual) components, as described in [Sections 6.3.21.3](#). Persistent components tend to physically entrain into the upper water column in the presence of moderate winds (i.e. >12 knots) and breaking waves but may refloat to the surface if these conditions abate. In the highly unlikely event that a substantial spill occurred, the heavier components could remain entrained or remain on the sea surface for an extended period and travel significant distances from the source, albeit at low levels.

It should be noted that the ambient water quality of the Project Area may be influenced by the presence of natural hydrocarbon seepage from the seabed. In a 2017 study, CSIRO (2017) identified multiple seeps of varying intensity across the Browse Basin. Importantly, the study concluded that in the event of an incident, the low baseline concentrations recorded during the study would permit the BTEX compounds and PAHs introduced during the incident to be distinguished from background concentrations.

[Table 6-156](#) summarises the weathering behaviour for each of the modelled hydrocarbon types (RPS, 2019, [Chapter 10, Appendix D.5](#)).

Fate and extent of a spill depends on the hydrocarbon released. Entrained hydrocarbons that result from a potential spill could travel between 242 and 863 km from the release location depending on the scenario. Depending on the scenario, concentrations of entrained hydrocarbons of 15,000 to 25,000 ppb would be expected to extend from the sea surface to depths of around 20 m.

Dissolved hydrocarbons could travel between 43 and 673 km, depending on the scenario, and concentrations of dissolved hydrocarbons of 1000 to 10,000 ppb would be expected to extend from the sea surface to depths of around 20 m.

Floating hydrocarbons would travel significantly smaller distances of between 82 and 143 km. Changes in water quality have the potential to result in short-term to long term impacts on multiple high value habitats and protected and migratory species on a regional scale. For example, in scenario 1, concentrations of entrained hydrocarbons of 23,600 ppb are predicted to occur at North Scott Reef ([Table 6-157](#)).

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact regional water quality. However, the occurrence of hydrocarbon spills is considered highly unlikely and the extent of impacts would depend on the exposure concentration, duration and degree of weathering of the hydrocarbons.

Plankton

Injury or mortality to fauna

Primary production by plankton (supported by upwelling events) is an important component of the marine food web. Plankton communities generally consist of a mix of phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton (e.g. crustaceans such as copepods) and meroplankton (the eggs and larvae of fish and invertebrates). Productivity hotspots identified within the EMBA include the waters surrounding Scott Reef and a number of areas within the Kimberley AMP ([Section 5.3.1.1](#)).

Plankton have the potential to be impacted by exposure to hydrocarbons through smothering and coating, restriction of sunlight through the upper water column, and exposure to dissolved and entrained hydrocarbons. Any surface and subsea hydrocarbon release could impact plankton populations, as they are widely dispersed throughout the water column. Exposure may result in sublethal and lethal effects from restriction of respiration, decreased rates of photosynthesis (Tomajka, 1985), changes in behaviour or changes in species composition that make them more susceptible to predation (Batten et al., 1998), as well as from the toxicity of the hydrocarbons themselves.

For zooplankton and meroplankton, such as fish, coral, invertebrate eggs and larvae, direct effects of contamination may include toxicity, suffocation, changes in behaviour or environmental changes that make them more susceptible to predation (Villanueva et al., 2008).

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact plankton communities, particularly in productivity hotspots in waters surrounding Scott Reef (for Scenarios 1, 2 and 3) and the Kimberley AMP (for Scenarios 1 and 2). However, the occurrence of hydrocarbon spills is considered highly unlikely and significance of the impact would depend on the specific parameters of the release. Given the wide spread nature and rapid turn-over of plankton populations leading to relatively quick recovery times of plankton, communities would be expected to recover relatively quickly (within weeks or months) (ITOPF, 2011). Therefore, impacts would be restricted to short-term, with no lasting effects even for worst-case credible spill scenarios.

Benthic habitats

Change in water quality - coral

Scott Reef is the closest coral habitat to hydrocarbon release locations for Scenarios 1 to 3 and, therefore, the most vulnerable. The shallow coral habitats are most vulnerable to hydrocarbon coating by direct contact with surface slicks during periods when corals are tidally-exposed, particular during spring low tides. Coral communities have the potential to be impacted from exposure to floating hydrocarbons through smothering and coating, and exposure to dissolved and entrained hydrocarbons. This may result in sublethal and lethal effects from restriction of feeding and respiration as well as from toxicity of the hydrocarbons to the individual coral colonies and species within the different coral habitats and communities of Scott Reef. This particularly applies to branching corals which are reported to be more sensitive than massive corals (Shigenaka, 2001).

Exposure to dissolved and entrained hydrocarbons (≥ 50 ppb and 100 ppb, respectively) has the potential to result in lethal or sub-lethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals) and reef flat (intertidal corals). Sub-lethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri and Heyward, 2000).

Should a hydrocarbon release occur at the time of coral spawning (at potentially affected coral locations), there is the potential for a significant reduction in successful fertilisation and coral larval survival, due to the sensitivity of early life stages of corals to hydrocarbon exposure (Negri and Heyward, 2000).

Studies have shown that corals in tropical shallow water reefs are at increased risk of hydrocarbon pollution due to the presence of ultraviolet light (Negri et al., 2016, Nordborg et al., 2017). This is based on Laboratory studies, such as for the branching coral *Acropora tenuis* coral larvae which were shown to be more sensitive to hydrocarbons (e.g. heavy fuel oil, diesel and light crude oil fractions) in the presence of ultraviolet light (Negri et al., 2016; Nordborg et al., 2018) partially due to the absence of studies that adequately assess toxicity to relevant coral reef species. Here we experimentally tested the acute toxicity of condensate, representing a fraction of light crude oil, to coral (*Acropora tenuis*). Exposure to light crude oil fractions with ultraviolet light increased the inhibition of larvae metamorphosis by 40% compared to exposure to light crude oil fractions without ultraviolet light (Negri et al., 2016). Similarly, ultraviolet light doubled the toxicity of dissolved HFO effects on larval settlement success (Nordborg et al., 2017).

A review of research into the effects of hydrocarbons on corals and coral reefs found that reported impacts to corals ranged from no detectable impacts to a variety of impacts including coral tissue loss, increased coral mortality, changes in the abundance and diversity of coral communities, physiological changes, sublethal effects (e.g. increased mucous production and decreased growth rate) and changes in reproduction (Turner and Renegar, 2017). The review found that experiments examining the impacts of hydrocarbons on corals in situ found exposure to hydrocarbons resulted in slight (not significant) reductions in coral cover but exposure to chemically dispersed hydrocarbons resulted in significant impacts to coral communities, with both coral cover and growth affected (Turner and Renegar, 2017).

Reef flat habitat is considered the coral habitat most vulnerable to direct exposure from surface hydrocarbons (NOAA, 2010). Scott Reef has extensive reef flat habitat (0-4 m depth). However, compared to other coral habitats, the reef flat habitat at Scott Reef has the lowest coral cover (less than 5%) and lowest diversity due to the harsh conditions for coral growth resulting from daily tidal and periodic high wave action exposure, as well as cyclone and coral bleaching events.

Below 4 m water depths, coral colonies would be generally not directly contacted by surface slicks on the overlying waters (Shigenaka, 2001, NOAA, 2010). Although not subject to smothering by surface hydrocarbons, these shallow water subtidal corals may be subject to exposure to soluble toxic compounds that dissolve from hydrocarbon droplets (dissolved and entrained hydrocarbons) in the upper water column by wave action on surface hydrocarbons (IPIECA, 1992; NOAA, 2010).

The model predicted higher probabilities of exposure to surface hydrocarbons across the southern portion of North Scott Reef, Sandy Islet and its surrounding reef

flats and the north-western and north-eastern portions of South Scott Reef. Given the minimum contact times (in the order of a few hours for Scenario 1) to reach the closest parts of reef flat habitats at North Scott Reef and potential for exposure to surface, dissolved and entrained hydrocarbons above threshold concentrations, there is potential for near total coral mortality in the worst affected areas of tidally exposed reef flats and the potential for sublethal stress and significant incidence of coral mortality among the most sensitive species in deeper subtidal communities (predicted exposure to 20 m depth).

Studies have demonstrated that Scott Reef is a 'self-sustaining' coral community, with mass coral spawning known to only occur twice a year (Section 5.3.1.3). This makes hydrocarbon exposure from an unplanned hydrocarbon release at either of these predicted annual spawning events of particular high ecological impact on vulnerable coral larvae, as it is likely to result in the failure of recruitment and settlement of new coral population cohorts. However, it should also be noted that due to the short and discrete spawning periods, the vulnerability of coral plankton stages to surface hydrocarbons would be largely confined to a period of up to three weeks after spawning events.

Quantitative spill modelling predicted that a number of shallower reef and lagoon habitats could be contacted in Scenarios 1 to 4. Depending on the specific scenario, coral habitats predicted to be contacted by floating hydrocarbons include Scott Reef, Seringapatam Reef and the Rowley Shoals (within the Argo-Rowley Terrace AMP) (Table 6-158). Additional locations which may be contacted by dissolved and entrained hydrocarbons at a lower probability include Barracouta Shoal, Eugene McDermott Shoal, Heywood Shoal, Hibernia Reef, Vulcan and Goeree Shoals, Fantome Bank, Browse Island, Cartier Island AMP, Ashmore Reef AMP and the Kimberley AMP. Of these areas, Scott Reef is considered to be the most vulnerable, given its proximity to release locations for Scenarios 1 to 3 and predicted contact volumes and probabilities for contact by each hydrocarbon fate. However, the occurrence of hydrocarbon spills is considered highly unlikely and the extent of impacts would depend on exposure concentration, duration and degree of weathering of the hydrocarbons.

Change in water quality - seagrass and macroalgae

Seagrass and macroalgae toxicity effects can occur when soluble fractions of hydrocarbons are absorbed into tissues (Runcie et al., 2010). The potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that lower the content of soluble aromatic components before contact occurs. Exposure to entrained hydrocarbons may result in mortality, depending on actual entrained aromatic hydrocarbon concentrations and duration of exposure.

Physical contact with entrained hydrocarbon droplets could cause sub-lethal stress, leading to reduced growth rates and reduced tolerance to other stress factors (Zieman et al., 1984).

Although water depths within the Project Area and EMBA are generally too deep to provide suitable conditions for these intertidal and subtidal communities, quantitative spill modelling did predict that a number of shallow habitats could be contacted for Scenarios 1 through 4. Areas predicted to be reached by entrained hydrocarbons that may comprise these habitats include Scott Reef and Seringapatam Reef, with a high probability of impact from Scenario 1, and a low (3%) probability of entrained hydrocarbons impacting Browse Island from Scenario 1. Seagrass and macroalgal beds in the intertidal and subtidal zone within these receptors may be susceptible to impacts from entrained hydrocarbons. At lower probabilities Ashmore Reef (Scenario 1 and 2), Cartier Island (Scenario 1 and 2) and Kimberley AMP (Scenario 1) were also predicted to have the potential to be contacted (Table 6-158).

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact localised intertidal and subtidal communities of seagrass and macroalgae at Scott Reef, Seringapatam Reef and, to a lesser extent and likelihood, Browse Island, Cartier Island, Ashmore Reef and Kimberley AMPs. However, the occurrence of hydrocarbon spills is considered highly unlikely and the extent of impacts would depend on exposure concentration, duration and degree of weathering of the hydrocarbons.

Change in water quality - shoreline habitats

Hydrocarbons that contact sandy shores may be incorporated into fine sediments through mixing in the surface layers from wave energy, penetration down worm burrows and root pores (vegetated shorelines). Hydrocarbons in the intertidal zone can adhere to sand particles, however, high tide may remove some or most of the hydrocarbons from the sediment particles. Accumulated hydrocarbons $\geq 100 \text{ g/m}^2$ could impact the survival and reproductive capacity of benthic epifaunal and infaunal invertebrates living in intertidal habitat (French-McCay, 2009). Impacts to socio-economic receptors are discussed below.

The impact of hydrocarbons on rocky shores would be largely dependent on the incline and energy levels received at shoreline rocky environments. On steep/vertical rock faces on wave exposed coasts there is likely to be no impact from a spill event because the high energy of the waves would wash hydrocarbons from the steep slopes of the rocks. However, a gradually sloping boulder shore in calm water can potentially trap large amounts of hydrocarbon (IPIECA, 2000). The impact of the spill on marine organisms along the rocky coast would depend on the toxicity and

weathering of the hydrocarbons. Similar to sandy shores, accumulated hydrocarbons $\geq 100 \text{ g/m}^2$ could affect the epifauna along rocky coasts and impact the reproductive capacity and survival of such biota.

Tidal flats are susceptible to potential impacts from hydrocarbons as they are typically low energy environments and, therefore, trap hydrocarbons. The extent of exposure is influenced by the neap and spring tidal cycle and seasonal highs and lows affecting mean sea level. Potential impacts to tidal flats include heavy accumulations covering these areas at low tide. It is unlikely that hydrocarbons would penetrate the water-saturated sediments, although hydrocarbons can penetrate sediments through animal burrows and root pores (where vegetated).

The proximity of a potential spill to the coast would influence hydrocarbon volumes and concentrations that reach the shoreline. Furthermore, hydrocarbons would weather over time, with only between 5% and 51% of the initial volume remaining after a few days following a worst-case credible spill scenario. The modelling predicted potential hydrocarbon accumulation at shorelines at defined thresholds at Scott Reef, Ashmore Reef, Cartier Island, and Rowley Shoals ([Table 6-158](#)). Maximum accumulated volumes and minimum times to contact for the worst-case credible spill scenarios to these sensitive receptors are:

- + Scott Reef: minimum time to contact of 39 hours (Scenario 2); maximum accumulated volume of 824 m^3 (Scenario 1).
- + Ashmore Reef: minimum time to contact of 23 days; maximum accumulated volume of 157 m^3 (Scenario 1).
- + Cartier Island: minimum time to contact of 35 days (Scenario 2); maximum accumulated volume of 38 m^3 (Scenario 1).
- + Rowley Shoals: minimum time to contact of 4 days (Scenario 4); maximum accumulated volume of 25 m^3 (Scenario 1).

The modelling also demonstrated that localised areas of coastline in the Buccaneer and Bonaparte Archipelagos and Lalang-garram/Camden Sound MP within the Kimberley, as well as in Indonesia and Timor Leste, could receive hydrocarbons above the accumulated threshold (Scenario 1 only). However, these areas are only predicted to be contacted at 3% or less probabilities and no dissolved, entrained or floating hydrocarbons are predicted to reach these locations. Given maximum accumulated volumes and minimum time to contact for these receptors (between 6 and 14 m^3 and 98 to 100 days for the locations along the Kimberley coast and 7 and 52 m^3 and 72 to 99 days for international shorelines) hydrocarbons would be significantly weathered and unlikely to reach the receptor at the modelled volumes. Given this and the initial low likelihood of a spill occurring, no impacts are predicted to these shorelines.

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact shoreline habitats at Scott Reef, Ashmore Reef, Cartier Island and Rowley Shoals. However, the occurrence of hydrocarbon spills is considered highly unlikely and the extent of impacts would depend on exposure concentration, duration and degree of weathering of the hydrocarbons.

Fauna

Injury or mortality to fauna - seabirds and migratory shorebirds

Seabirds and migratory shorebirds have the potential to be impacted by exposure to hydrocarbons through direct contact while at or breaking through the water surface (e.g. feeding, resting or moulting), coating and contamination of feathers, ingestion and vapour inhalation particularly during self-cleaning/preening of feathers, and ingestion from contaminated prey. This may result in sublethal and lethal effects such as irritation and external injury to eyes, skin and cavities, damage to internal airways and organs, immune system and reproductive success, loss of buoyancy of feathers and insulation leading to drowning or lethal heat loss, and loss of mobility leading to starvation/dehydration or becoming easy prey.

Seabirds and shorebirds are particularly vulnerable to hydrocarbon spills given their high potential for exposure with the sea surface or shoreline where they feed, rest or moult. While impacts to birds can occur in offshore open waters, the most pronounced impacts are often experienced if spills reach coastal waters near major seabird colonies, where intensive feeding occurs during the breeding season. Bird feeding methods typically involve complete or partial submersion of the bird, making them highly susceptible to exposure. As most fish in the water column survive beneath surface hydrocarbons, foraging seabirds, which typically do not exhibit avoidance behaviour, continue to feed within waters exposed to surface hydrocarbons. In contrast, migrant shorebirds and waders that feed along shorelines are generally less susceptible to severe exposure and associated physical effects (Scholz et al., 1992, French-McCay, 2009).

Exposure to surface hydrocarbons can result in lethal or sublethal physical and toxic effects. Physical contact with surface hydrocarbons and associated vapours may cause irritation and injury to a bird's eyes, skin, and mouth cavities. Hydrocarbons will also adhere to feathers, causing them to matt and lose their insulating, buoyancy and water repelling properties.

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. 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.

Offshore waters of the Project Area and EMBA are potential foraging grounds for seabirds. For Scenarios 1 to 4, modelling predicted floating hydrocarbons above threshold concentrations could reach distances of between 67 km to 143 km from the spill source. Locations predicted to be contacted include Scott Reef and Seringapatam Reef (Scenarios 1 through 3) and Rowley Shoals (Scenario 4) ([Table 6-158](#)). Shoreline accumulation above outlined thresholds was predicted at Scott Reef (92% probability), Ashmore Reef (18%), Cartier Island (22%), and Rowley Shoals (8%).

Several important habitats for seabirds and migratory shorebirds occur in the EMBA, in particular at Ashmore Reef and Cartier Island, Browse Island, islands along the Kimberley coastline (such as the Lacepede Islands) and Rowley Shoals. These areas are used by birds for breeding/nesting, roosting and resting, and waters surrounding these areas are used for foraging. However, in the unlikely event that hydrocarbons reach these locations, it is predicted that they would be significantly weathered and likely to be less toxic than in areas closer to potential release locations, thereby further reducing the likelihood of any significant impacts on nesting, roosting or resting and foraging seabirds or shorebirds at these locations.

Scott Reef also supports minor seabird breeding colonies, including for the little tern. BIAs for nine bird species overlap the EMBA (white-tailed tropicbird, wedge-tailed shearwater, roseate tern, red-footed, little tern, lesser frigatebird, lesser crested tern, great frigatebird, and brown booby). BIAs for seabirds and shorebirds are primarily restricted to within tens of kilometres of emergent features where nesting may occur. Hence there is the potential to impact on nesting populations, which has the potential to affect species recruitment at a local population level.

Four bird species which have been identified as occurring within the Project Area have specific conservation advice which identifies key threats to the species that are relevant to hydrocarbon spills (i.e. habitat degradation, loss or modification). These species are the Australian lesser noddly, Abbott's booby, ruddy turnstone and common sandpiper.

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact bird species, including protected species, within the Project Area and EMBA. Although potential impacts could include mortality or sub-lethal injury/illness of birds, this would be expected to comprise a small proportion of the resident and transitory population. Impacts may be more significant if hydrocarbons,

particularly floating and shoreline hydrocarbons, reach key aggregation and breeding areas listed above.

Injury or mortality to fauna - marine mammals

Habitat loss or degradation is highlighted in the conservation advices for humpback whales, sei whales and fin whales. Marine mammals have the potential to be impacted by exposure to hydrocarbons through contact at the water surface (feeding, surfacing, breaching, travelling, socialising, resting), hydrocarbon adherence following coating (although this is considered minor due to their mainly smooth skin and minor area of both hair (pelage) and rough-skinned areas), ingestion and vapour inhalation, and ingestion from contaminated prey. Hydrocarbon impacts may result in sublethal and lethal effects from irritation and injury to eyes, skin and mouth cavity; damage to internal organs; and (if high vapour concentrations are present) narcosis and drowning. Fresh hydrocarbons (i.e. typically in the vicinity of the release location) are likely to have a higher potential to result in toxic effects, while weathered hydrocarbons are considered to be less likely to result in toxic effects.

Cetaceans that have direct physical contact with entrained or dissolved aromatic hydrocarbons may suffer ingestion of hydrocarbons (from prey, water and sediments), aspiration of contaminated water or droplets and inhalation of toxic vapours (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system, neurological damage (Helm et al., 2015), reproductive failure, adverse health effects (e.g. lung disease, poor body condition) and potentially mortality (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). A review of cetacean observations in relation to large scale hydrocarbon spills was undertaken for the Deepwater Horizon spill. It is worth noting that the Deepwater Horizon hydrocarbon release was crude oil, which is much more persistent in the environment than the condensate that may be released during the proposed Browse to NWS Project and also more amenable to the formation of surface slicks, which cetaceans may be exposed to when breathing. The review concluded that exposure to oil from the Deepwater Horizon resulted in increased mortality to cetaceans in the Gulf of Mexico (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). Given the relatively non-persistent nature of the hydrocarbons that have the potential to be released during the proposed Browse to NWS Project, and the possible floating hydrocarbon spill extents (between 67 km and 143 km; [Table 6-157](#)), the area where potential impacts from inhalation could occur would be localised around the release location.

Cetacean populations that are resident within the EMBA (e.g. Indo-Pacific humpback dolphin) may be more susceptible to impacts from spilled hydrocarbons given they may be less likely to avoid an area of a spill and, therefore, could have increased exposure durations. However, resident species are more likely to occupy coastal waters where probabilities for hydrocarbon contact are very low (e.g. 1% probability to contact Kimberley coast; [Table 6-158](#)). In the unlikely event that hydrocarbons reached the coastline, they would be significantly weathered and likely to be less toxic than in areas closer to potential release locations. Suitable habitat for these species is also broadly distributed throughout the region and, as such, impacts are unlikely to affect an entire population.

Resident spinner dolphins, which are known to occur at offshore islands including at Scott Reef, are an exception to this. Resident spinner dolphins at Scott Reef have a higher probability of being impacted than coastal resident mammal populations, with a potential for a significant portion of this local population to be impacted in the event of a worst-case hydrocarbon spill.

Migratory cetaceans which have transient interactions with the EMBA (e.g. pygmy blue whales and humpback whales) have the potential to be impacted if a spill occurs during their annual migration periods, or if a spill is severe enough to result in significant long-term impacts to prey species' populations. Physical contact with hydrocarbons is likely to have biological consequences for individuals present in the area. However, it is unlikely to affect an entire population or impact overall population viability as migration periods are spatially and temporally varied, meaning only a small portion of the population is likely to be present within the spill extent.

Pygmy blue whales are known to migrate seasonally through the Project Area and EMBA. The Project Area overlaps a migration BIA and a possible foraging area for pygmy blue whales. Studies have shown small numbers of pygmy blue whales pass through the wider region of Scott Reef up to twice a year during their annual migrations (Gavrilov et al., 2018; McCauley, 2011). Occurrences have been recorded between October and January (southbound migration), with a peak in November, and April to August (northbound migration) (Blue Planet Marine, 2019; Commonwealth of Australia, 2015b). Individuals typically transited to the west of Scott Reef, however, have also been recorded transiting through the channel between north and south Scott Reef and in deep waters adjacent to the rim of Scott Reef (Jenner and Jenner, 2009). While there have been no direct observations of pygmy blue whales feeding at Scott Reef, the species has been recorded at Scott Reef during periods of elevated plankton biomass (Blue Planet Marine, 2019).

Humpback whales also migrate seasonally through the Project Area and EMBA. Humpback whales are not likely to occur in high numbers within the Development Area, however, will occur seasonally in high numbers within the EMBA (from June to October with a peak between late July and mid-August) (RPS, 2012). A migration BIA along the Pilbara and Kimberly coast overlaps the EMBA; spill modelling predicted entrained and dissolved hydrocarbons to contact the area (Kimberley AMP) at probabilities of between 2% and 31% for Scenarios 1 and 2 only. Based on historical observations (Jenner et al., 2001) and studies by RPS (2010b) and McCauley (2011), it is likely that there may be low numbers of transient individuals occurring within the Browse Development Area and, in particular, within the vicinity of Scott Reef.

Pygmy blue and humpback whales are baleen whales and the most likely to be significantly impacted by toxic effects when feeding. However, feeding during migrations is low level and opportunistic, with most feeding for both species occurring in the Southern Ocean prior to migration. As such, the risk of ingestion of hydrocarbons is low. Migrations of both pygmy blue whales and humpback whales are protracted through time and space (i.e. the whole population would not be within the EMBA at one time), and as such, a hydrocarbon spill is unlikely to affect an entire population.

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact marine mammal species, including protected species, within the Project Area and EMBA. In particular, impacts may occur to a small percentage of the migratory populations of pygmy blue whales and humpback whales if a spill occurs during their annual migrations. Given the mobile migratory nature of most marine mammal species and the relatively localised extent of floating hydrocarbons, impacts are not expected to have a substantial adverse effect on an ecologically significant proportion of any migratory marine mammal species populations. In addition, the occurrence of hydrocarbon spills is considered highly unlikely and the extent of impacts would depend on exposure concentration, duration and degree of weathering of the hydrocarbons.

Injury or mortality to fauna - Marine reptiles

Marine turtles are vulnerable to the effects of hydrocarbons at all life stages (eggs, hatchlings, juveniles and adults) (NOAA, 2010). Marine turtles are in frequent contact with the sea surface and they may also feed at or below the water surface or rest at the surface. This frequent contact with the sea surface and a lack of avoidance behaviour makes turtles susceptible to exposure to surface hydrocarbons and associated vapours. On contact with surface hydrocarbons, turtles may experience irritation and injury to airways or lungs,

eyes and mucous membranes of the mouth and nasal or other cavities. Exposure can also irritate and injure skin, which is most evident on particularly pliable areas such as the neck and flippers. Ingestion of hydrocarbons through contaminated food or tar balls may also injure the salt-gland, digestive tract or other organs with potentially lethal effects. When crossing beaches contacted with hydrocarbons, gravid adult females and hatchlings are likely to be in turn exposed to hydrocarbons.

Although buried eggs are unlikely to be directly impacted by hydrocarbon accumulated at the shoreline, they may become directly exposed to hydrocarbons as a result of the gravid female turtles becoming oiled as they cross the shore. This may result in the transfer of hydrocarbons onto eggs during nest laying, which may cause impaired embryo development or embryo mortality. Weathered hydrocarbons have been shown to have little impact on egg survival, while fresh hydrocarbons significantly reduced egg survival (Milton and Lutz, 2003).

Locations predicted to be contacted are Scott Reef and Seringapatam Reef, Ashmore Reef and Cartier Island, and the Kimberley AMP and Argo-Rowley Terrace AMP (Table 6-157).

Several important habitats for marine turtle species, including key breeding/nesting areas, internesting and foraging areas, occur in the Project Area and EMBA, in particular Scott Reef, Ashmore Reef, Cartier Island, ArgoRowley Terrace and Kimberley AMPs. Scott Reef has the highest probabilities for hydrocarbon contact above thresholds and, therefore, is the most vulnerable area. Sandy Islet, a part of South Scott Reef, supports nesting green turtles and hawksbill turtles. The breeding population of these species, particularly green turtles, also interest in the surrounding lagoonal waters of South Scott Reef adjacent to Sandy Islet (between 4-15 m water depth) and, as such, marine turtles present during the nesting season (November to February) are highly vulnerable in the event of a hydrocarbon spill. Short-term impacts include significant mortality amongst adults and hatchlings and reduced egg survival. Sublethal stress to individuals may also reduce breeding and nesting success. Such impacts would have the potential for longer-term effects on the Scott Reef – Browse Island genetic stock of green turtles. As the breeding population at Scott Reef forms part of a limited genetic stock that is geographically isolated, this could have implications for recovery time of the population depending on the extent of impacts. However, female turtles are reported to return to Sandy Islet every two to eight years and the turtles present at Scott Reef in any one breeding season, therefore, represent only a portion of the population (Guinea, 2010).

In addition, in any given breeding season different turtles may only be present for part of the season due to different arrival times. In this way, the potential for mortality among breeding turtles and hatchlings would affect a portion of and not the entire breeding green turtle population nesting at Sandy Islet. Acute and chronic chemical discharges are highlighted within the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) as a key risk to green turtles within the Scott Reef and Browse Island area. The Recovery Plan identifies ensuring spill risk strategies and response programs include management for turtles and their habitats.

The Project Area and EMBA overlap BIAs and habitat critical to the survival of a species for four marine turtle species, including the green turtle, olive ridley turtle, flatback turtle and hawksbill turtle. Given this, there is the potential to impact on breeding populations, which has the potential to affect species recruitment at a local population level.

PMST searches identified 17 sea snakes as potentially occurring within the Project Area, including threatened and migratory species. Conservation Advice for the short-nosed sea snake (DSEWPac, 2011) includes ensuring there is no anthropogenic disturbance in areas where the species occurs, excluding necessary actions to manage the conservation of the species. Sea snakes are expected to occur predominately in shallow regions of the EMBA, such as Scott Reef, Ashmore and Cartier, Rowley Shoals and other small offshore shoals and reefs. Given this, there is potential to impact on local populations of sea snakes.

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact marine reptile species, including protected species, within the Project Area and EMBA. However, the occurrence of hydrocarbon spills is considered highly unlikely and the extent of impacts would depend on exposure concentration, duration and degree of weathering of the hydrocarbons.

Injury or mortality to fauna - fish

Fish, including sharks and rays, have the potential to be impacted by exposure to hydrocarbons through exposure to dissolved and entrained hydrocarbons, ingestion of entrained hydrocarbons, and contact with surface slick (if travelling/skim feeding at the surface e.g. whale shark). This could result in sublethal and lethal effects from toxicity effects or damage to internal organs. Any surface and subsea hydrocarbon release could impact fish, as they are widely dispersed throughout the water column.

Hydrocarbons may contaminate fish tissues and internal organs, either through direct contact or via the food chain (consumption of prey). As gill breathing organisms, bony fishes and elasmobranchs (sharks and rays) may be vulnerable to toxic effects of dissolved hydrocarbons (entering the body via the gills) and entrained hydrocarbons (coating of the gills inhibiting gas exchange).

Fish mortalities are rarely observed as a result of hydrocarbon spills (ITOPF, 2011). This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Laboratory studies have shown that adult fish can detect hydrocarbons in water at very low concentrations, and large numbers of dead fish have rarely been reported after hydrocarbon spills (Hjermann et al., 2007). Where fish mortalities have been recorded, the spills (resulting from the groundings of the tankers Amoco Cadiz in 1978 and the Florida in 1969) occurred in sheltered bays.

Fish that have been exposed to dissolved aromatic hydrocarbons are capable of eliminating the toxicants once placed in clean water; hence, individuals exposed to a spill are likely to recover (King et al., 1996). The effects of exposure to hydrocarbons on the metabolism of fish appear to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Hydrocarbon reduces the aerobic capacity of fish exposed to aromatics in the water, and to a lesser extent affects fish consuming contaminated food (Cohen et al., 2005). The liver, a major detoxification organ, appears to be where anaerobic activity is most impacted, probably increasing anaerobic activity to help eliminate ingested hydrocarbons from the fish (Cohen et al., 2005).

Fish are most susceptible to the effects of hydrocarbons in their early life stages, particularly during egg and planktonic larval stages (see assessment above regarding plankton), which can become entrained in spilled hydrocarbons. Contact with droplets can mechanically damage feeding and breathing apparatus of embryos and larvae (Fodrie and Heck, 2011). The toxic hydrocarbons in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie and Heck, 2011). More subtle, chronic effects on the life history of fish from hydrocarbon exposure in early life stages include disruption to complex behaviour such as predator avoidance, reproductive and social behaviour (Hjermann et al., 2007). Prolonged exposure of eggs and larvae to weathered concentrations of hydrocarbons in water has also been shown to cause immunosuppression and allows expression of viral diseases (Hjermann et al., 2007).

The NWMR is known for its demersal slope fish assemblages; it is the second richest area for demersal fish species across the entire Australian continental slope. Additionally, a number of threatened and migratory fish species are found within the Project Area and EMBA, such as the whale shark, shortfin and longfin mako sharks, and the green and largetooth sawfish. A foraging BIA for whale sharks overlaps the Project Area. Shortfin and longfin mako sharks are pelagic species and likely to occur in small numbers throughout the year. Sawfish are generally resident to coastal and estuarine areas, occurring throughout the Kimberley and north WA coast.

The Whale Shark Recovery Plan, although no longer in effect, identified habitat degradation/modification as a key threat to the species (DEH, 2005). Whale sharks migrate along the northern WA coastline, broadly following the 200 m isobath, between July and November (DEWHA, 2015). The extents predicted from hydrocarbon spill modelling suggested that hydrocarbons above thresholds could extend into the northern edge of the whale shark BIA. It is predicted that only low numbers of whale sharks will occur seasonally within the Project Area and EMBA. Given this, and that whale sharks occur globally in tropical and warm temperate waters and are thought to form one single genetic population (Yender et al., 2002; DEWHA, 2015), impacts to this species would be restricted to a small number of whale sharks if a spill occurred during their annual migration or if prey populations were impacted.

Although fish populations occur throughout the EMBA and Project Area, areas of particularly high fish diversity or abundances that are predicted to be contacted above thresholds include Scott Reef and Seringapatam Reef, Browse Island, Ashmore Reef and Cartier Island, Rowley Shoals, the Kimberley AMP and the Argo-Rowley Terrace AMP (probabilities of contact in relation to specific hydrocarbon fate are provided in [Table 6-158](#)).

Fish assemblages in these areas are likely to include various species of site-attached reef fish assemblages and also species of pipefish and seahorses that are protected under the EPBC Act. Submerged banks and shoals that have low probability of contact above entrained and/or dissolved thresholds are also expected to support higher fish abundances than surrounding featureless, deepwater habitat, these being Barracouta Shoal, Eugene McDermott Shoal, Heywood Shoal, Hibernia Reef, Vulcan and Goeree Shoals and Fantome Bank. Coral reef fish generally have small home ranges and as reef residents they are at higher risk from hydrocarbon exposure than non-resident, more wide-ranging fish species. The exact direct impact on resident fish populations would be entirely dependent on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. In addition,

the could be indirect consequences to site-attached fish assemblages due to the loss of coral habitat and subsequent recovery of the reef system. It is also noted that the early life stages (larval and fingerling) of resident fish populations are particularly sensitive to hydrocarbon exposure.

A number of KEFs also overlap the EMBA, with many of these associated with high fish abundances and diversity. Impacts to KEFs and AMPs are discussed below.

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to significantly impact fish species, including protected species, within the Project Area and EMBA. Although such potential impacts could include mortality or sub-lethal injury/

illness of fish, for most mobile species this would be expected to comprise a small proportion of the transitory populations (i.e. whale sharks, shortfin and long fin mako sharks). For species which are considered site-attached, such as reef fish and pipefish and seahorses, a hydrocarbon spill could potentially have higher level impacts (e.g. site-attached coral fish assemblages of Scott Reef).

Assessment against EPBC Act recovery and conservation plans and advices

Table 6-159 summarises how the risk of an unplanned hydrocarbon release associated with the proposed Browse to NWS Project is not inconsistent with the objectives and actions of the relevant EPBC Act recovery and conservation plans and advice for protected fauna.

Table 6-159 Alignment with EPBC Act recovery and conservation plans and advices for protected fauna – unplanned hydrocarbon release

Fauna	Relevant plan(s)/ Conservation Advice	Plan/advice objectives and actions	Assessment
Migratory shorebirds	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)	Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated.	With the implementation of controls, it is considered highly unlikely that impacts will occur to migratory shorebirds as a result of unplanned hydrocarbon release. Therefore, it is considered that the proposed activities are not inconsistent with the Wildlife Conservation Plan for Migratory Shorebirds.
Whale shark	Conservation advice <i>Rhincodon typus</i> whale shark (Threatened Species Scientific Committee, 2015a)	Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	No specific reference to hydrocarbon pollution is provided in the conservation advice. Given the low number and infrequent nature of whale shark presence in the Project Area, and the implementation of controls, it is considered highly unlikely impacts to whale sharks will occur as a result of an unplanned hydrocarbon release. Therefore, it is considered that the proposed activities are not inconsistent with the conservation advice.

Fauna	Relevant plan(s)/ Conservation Advice	Plan/advice objectives and actions	Assessment
Green turtle Hawksbill turtle	The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017)	Management actions: + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival. + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue. + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival.	Risk to marine turtles have been assessed and will be managed in accordance with the Recovery Plan for Marine Turtles in Australia which includes the minimisation of chemical discharge as an overarching action area (Commonwealth of Australia, 2017a). In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action to manage anthropogenic activities to ensure marine turtle are not displaced from identified habitat critical to their survival is predicted to be met as the likelihood of an unplanned hydrocarbon release impacting marine turtles has been assessed as highly unlikely. Therefore, it is considered that the proposed activities are not inconsistent with the Recovery Plan for Marine Turtles.
Pygmy blue whale	Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c)	Acute chemical discharge (oil or condensate spill) is identified as a moderate risk to pygmy blue whales, however, there are no specific actions identified.	With the implementation of controls, it is considered highly unlikely that impacts will occur to cetaceans as a result of unplanned hydrocarbon release. Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale or the conservation advices listed.
Humpback whale	Conservation advice <i>Megaptera novaeangliae</i> , Humpback Whale	Marine discharges have not been identified as a direct threat to these whale species; however, habitat degradation has been identified as a threat and unmanaged discharges may contribute to this threat. The conservation advice relevant for this threat – identifies modification to the coastal region in areas of importance to listed whales may result in reduced occupancy, compromised reproductive success and even mortality.	
Sei whale	Conservation advice <i>Balaenoptera borealis</i> , Sei Whale		
Fin whale	Conservation advice <i>Balaenoptera physalus</i> , Fin Whale		

Key Ecological Features

Change in sediment quality, change in water quality, injury or mortality to fauna

KEFs have the potential to be impacted through exposure to hydrocarbons in the event of an unplanned hydrocarbon release. Based on the outcomes of quantitative spill modelling for Scenarios 1 to 4, the following KEFs have the potential to be impacted at varying probabilities of exposure above threshold concentrations for floating, dissolved and entrained hydrocarbons (see [Table 6-158](#)):

- + Continental slope demersal fish communities

- + Seringapatam Reef and Commonwealth waters in the Scott Reef complex
- + Ancient coastline at 125 m depth contour
- + Mermaid Reef and Commonwealth waters surrounding Rowley Shoals
- + Ashmore Reef and Cartier Island and surrounding Commonwealth waters

Although these KEFs are primarily defined by seabed geomorphological features, they are described to identify the potential for increased biological productivity and, therefore, ecological significance. The

values and sensitivities of these KEFs primarily relate to seafloor features and demersal fish species (i.e. that live close to the seafloor). Therefore, water depth can determine whether any hydrocarbons (i.e. dissolved and entrained) can potentially interact with these values and sensitivities. Some KEFs, such as those defined around Scott Reef, Ashmore Reef and Cartier Island, and Rowley Shoals, also have shallow and emergent features and are, therefore, more vulnerable to the impacts of hydrocarbon spills. These KEFs have added protection of being Commonwealth and State protected marine parks. Potential impacts to KEFs include the contamination

of sediments, impacts to benthic fauna/habitats and associated impacts to demersal fish populations and reduced biodiversity. Most of the KEFs within the EMBA have relatively broad-scale distributions and are unlikely to be significantly impacted.

Summary

Table 6-160 provides an assessment of the risk of unplanned hydrocarbon discharge in relation to the pressures on KEFs identified in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).

Table 6-160 Alignment with protection of conservation values of KEFs – unplanned hydrocarbon release

Key Ecological Feature	Relevant plan(s)	Relevant pressures	Assessment
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012).	Oil pollution currently identified as “of potential concern”	With the implementation of controls, it is considered highly unlikely that impacts will occur to KEFs as a result of unplanned hydrocarbon release. Therefore, there is a high level of confidence that there will not be an adverse impact to marine ecosystem function or integrity with in the KEFs; or any reduction to the conservation values of the KEFs will occur.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex			
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals			
Ancient coastline at 125 m depth contour		Oil pollution currently identified as “of less concern”	
Continental slope demersal fish communities		Oil pollution currently identified as “no of concern”	

Australian marine parks

Change in sediment quality, change in water quality, injury or mortality to fauna

AMPs have the potential to be impacted through exposure to hydrocarbons in the highly unlikely event of an unplanned hydrocarbon release. Based on the outcomes of quantitative spill modelling for Scenarios 1 through 4, the following AMPs have the potential to be impacted at varying probabilities (**Table 6-158**):

- + Kimberley Marine Park (highest probability is 31% probability for entrained hydrocarbons)
- + Argo-Rowley Terrace Marine Park (highest probability is 100% probability for surface hydrocarbons)
- + Rowley Shoals Marine Park (highest probability is 34% for entrained hydrocarbons)
- + Ashmore Reef Marine Park (highest probability is 18% probability for accumulated hydrocarbons)
- + Cartier Island Marine Park (highest probability is 22% for accumulated hydrocarbons)
- + Mermaid Reef Marine Park (highest probability is 34% for entrained hydrocarbons).

In the highly unlikely event of a worst-case scenario release, the open water environment protected within the AMPs may be affected by floating, dissolved, entrained, and/or shoreline hydrocarbons above thresholds. If hydrocarbons contact key receptor locations within these protected areas, such as islands and mainland coastlines or defined BIAs, significant impacts may occur, including the contamination of sediments and water, impacts to benthic fauna/habitats, impacts to protected and other marine fauna, and a potential to result in ecosystem level impacts (including a reduction in biodiversity).

Conservation values of these areas are described in **Section 5.3.3**. Potential impact on the values of these AMPs is discussed in the relevant sections above for ecological and physical (water quality) values and below for social (socio-economic) values.

Table 6-161 provides an assessment of the proposed seabed disturbance in consideration of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Table 6-161 Alignment with the North-west Marine Parks Network Management Plan – Risk of unplanned release of hydrocarbons

Australian Marine Park	Relevant plan(s)	Australian Marine Park objectives	Assessment
Argo-Rowley Terrace Marine Park	North-west Marine Parks Network Management Plan (Director of National Parks, 2018)	<u>Sanctuary Zone (1a)</u> The objective of the Sanctuary Zone (1a) is to conserve ecosystems, habitats and native species in as natural and undisturbed a state as possible	If a large hydrocarbon spill occurred as a result of the proposed Browse to NWS Project, AMPs could potentially be impacts (depending in the nature and location of the spill). However, as described above, it is considered highly unlikely that such a spill will occur. Therefore, it is considered that the risk of unplanned release of hydrocarbons as a result of the proposed activities is not inconsistent with the North-west Marine Parks Network Management Plan.
Kimberley Marine Park		<u>National Park Zone (II)</u> The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	
Mermaid Reef Marine Park		<u>Habitat Protection Zone (IV)</u> The objective to the Habitat Protection Zone (IV) is to allow activities that do not harm or cause destruction to seafloor habitats, while conserving ecosystems, habitats and native species in as natural a state as possible.	
Cartier Island Marine Park		<u>Multiple Use Zone (VI)</u> The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.	
Ashmore Reef Marine Park			

State marine parks and nature reserves**Change in sediment quality, change in water quality, injury or mortality to fauna**

Based on the outcomes of quantitative spill modelling for Scenarios 1 through 4, the following State marine parks and nature reserves have the potential to be impacted at varying probabilities ([Table 6-158](#)):

- + Scott Reef Nature Reserve
- + Rowley Shoals Marine Park
- + Lalang-garram/Camden Sound Marine Park (however, modelling only predicted the area to be contacted by localised shoreline accumulation above thresholds, i.e. not dissolved, entrained or floating hydrocarbons, at a probability of 1%).

In the highly unlikely event of a worst-case scenario release, these State marine parks and nature reserves may be affected by floating, dissolved, entrained, and/or shoreline hydrocarbons above thresholds. If hydrocarbons contact key receptor locations within these protected areas, significant impacts may occur including the contamination of sediments and water, impacts to benthic fauna/habitats, impacts to protected and other marine fauna, and a potential to result in ecosystem level impacts including a reduction in biodiversity.

Conservation values of these areas are described in [Section 5.3.3](#). Potential impact on the values of these State marine park and nature reserves is discussed in the relevant sections above for ecological and physical (water quality) values and below for social (socio-economic) values.

Other protected places**Change in sediment quality, change in water quality, injury or mortality to fauna**

In the event of an unplanned hydrocarbon release, the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places may be affected by floating, dissolved, entrained and/or shoreline hydrocarbons above thresholds. If hydrocarbons contact key receptor locations within these protected areas, significant impacts may occur, including the contamination of sediments and water, impacts to benthic fauna/habitats, impacts to protected and other marine fauna, and a potential to result in ecosystem level impacts (including a reduction in biodiversity).

Conservation values of these areas are described in [Section 5.4.3](#). Impact on the values of these protected areas is discussed in the relevant sections above for ecological and physical (water quality) values.

Other users

Changes to the functions, interests or activities of other users - Commonwealth and State managed fisheries

Four Commonwealth and 11 WA State fisheries overlap the Project Area, in particular the BTL ([Section 5.4.2.2](#)). Of these, six have been assessed as having the potential to actively operate within the Project Area (Development Area and BTL) and, therefore, be most likely to be impacted in the event of a hydrocarbon spill given their proximity to potential release locations.

In general, fisheries have the potential to be impacted by an unplanned hydrocarbon release through direct impacts to target populations or prey species and fishing gear and from the exclusion of users from a fishing area, potentially resulting in lost revenue.

Fish exposure to hydrocarbons can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Tainting is reversible over time through the process of depuration which removes hydrocarbons from tissues by metabolic processes, although it depends on the magnitude of the contamination. Fish have a high capacity to metabolise these hydrocarbons while crustaceans (such as prawns) have a reduced ability (Yender et al., 2002).

Seafood safety is a major concern associated with spill incidents. Actual or potential contamination of seafood can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender et al., 2002). A major spill could result in the establishment of an exclusion zone around the spill-affected area, leading to temporary prohibition on fishing activities and subsequent potential economic impacts to affected commercial fishing operators. Additionally, hydrocarbons can foul fishing equipment such as traps and trawl nets, requiring cleaning or replacement. Depending on the release scenario and its severity, an exclusion zone could be a temporary localised area around the immediate vicinity of the release point or could cover a large portion of fishery or management zones and extend over a number of fishing seasons.

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project would have the potential to impact commercial fisheries, with potential impacts including mortality or sub-lethal injury/illness of fish, with subsequent impacts to fishers as a result of reduction in catch.

Changes to the functions, interests or activities of other users - tourism and recreation, scientific studies

Tourism, recreation and scientific users have the potential to be impacted by an unplanned hydrocarbon release due to exclusion from an area or indirectly from a change in marine fauna behaviour, injury or mortality to marine fauna. Hydrocarbons can also accumulate

on recreation areas predicted to be contacted and impact access to such areas due to any clean-up or decontamination activities. Tourists and recreational users may also avoid areas due to perceived impacts, including after the hydrocarbon spill has dispersed. Any impact to receptors that provide nature-based tourism opportunities may cause a subsequent negative impact to recreation and tourism activities.

Charter fishing, diving, snorkelling, whale, marine turtle and dolphin watching and cruising are the main commercial tourism activities in and adjacent to the North-west Marine Region. With the exception of offshore charter fishing, most marine tourism activities occur in State waters (DEWHA, 2008a). Recreational fishing tends to be concentrated in State waters adjacent to population centres (e.g. Broome) (DEWHA, 2008a). Engagement with regional tourism groups and Recfishwest indicate that only one to two recreational fishing charter operators run trips to Scott Reef approximately four to five times per year. Scott Reef has the potential to provide significant opportunities increased tourism; however, given the distance from closest landfall and costs, only a limited number of charter operators are prepared to take recreational fishers out to Scott Reef.

Similar activities occur or have the potential to occur at other key locations within the EMBA such as the Kimberley AMP, Seringapatam Reef, Ashmore Reef, Cartier Island and Rowley Shoals. However, the offshore waters of the Project Area and EMBA are not expected to support significant tourism or recreational activities. Should shoreline contact occur in the event of a spill, restricted access to beaches for a period of days to weeks may occur until natural weathering or tides and currents remove the hydrocarbons. Modelling results found localised areas of the Kimberley coast, as well as Timor Leste and Indonesia, have the potential to be contacted by shoreline hydrocarbons, however, as discussed in impacts to shoreline habitat, these areas are not expected to be significantly impacted. Hydrocarbons are not expected to reach any major inhabited areas.

Based on the outcomes of quantitative spill modelling, hydrocarbon spills resulting from the proposed Browse to NWS Project have the potential to impact tourism, recreational, scientific and traditional fishing activities in localised offshore areas such as Scott Reef and Rowley Shoals. However, even in the highly unlikely event of a large spill, potential impacts are likely to be restricted to short-term exclusion to an area with a potential for long term impacts to a small number of operators and users that visit these areas.

Changes to the functions, interests or activities of other users - shipping

Shipping has the potential to be impacted from an unplanned hydrocarbon release through exclusion to an area resulting in altered shipping routes and from

increased operating costs (e.g. fuel consumption). Shipping activity is widespread across the NWS region. Shipping is sparse near the Browse Development Area, with the nearest main shipping channels approximately 50 to 100 km west of Scott Reef. However, a number of shipping channels do overlap or come in proximity to the BTL corridor.

In the highly unlikely event of a large spill, an exclusion zone may be established around the spill-affected area. This could result in exclusion of other users such as shipping vessels or vessels used by the mining and petroleum industries. Any exclusion zone established would probably be limited to the projected extent of floating hydrocarbons, estimated from spill modelling to be a maximum of between 67 and 143 km for Scenarios 1 through 4. The exclusion zone would probably be temporary, given the significant weathering predicted to take place within a few days of a worst-case scenario spill, therefore, physical displacement of vessels is unlikely to be a significant impact. Modelling did not predict surface hydrocarbons to reach any active port, therefore, there will be no impacts to these areas.

Changes to the functions, interests or activities of other users – industry

Industry, including other oil and gas operators, has the potential to be impacted from an unplanned hydrocarbon release through exclusion to an area or from a change to the functions, interests or activities of other users. The NWMR supports a number of industries including petroleum exploration and production, as well as minerals extraction.

In the highly unlikely event of a large spill, an exclusion zone may be established around the spill-affected area. The exclusion zone would extend from the spill source to encompass the projected limit of floating hydrocarbons (67 to 143 km for Scenarios 1 to 4). This could result in exclusion of other users such as vessels used by the mining and petroleum industries. The exclusion zone would probably be temporary, as significant weathering is predicted to occur within a few days of a worst-case scenario spill, therefore, physical displacement of vessels or impacts to other oil and gas operators is unlikely to be a significant impact. Modelling did not predict that surface hydrocarbons would reach any shoreline where significant industry occurs, therefore, there will be no impacts to these areas (e.g. Broome, Karratha, Dampier).

Changes to the functions, interests or activities of other users – aboriginal and indigenous heritage

Aboriginal heritage has the potential to be impacted from an unplanned hydrocarbon release through direct contact with heritage sites and impacts to Indigenous fishing activities. Although no known sites of significant Aboriginal heritage have been identified within the Project Area or EMBA, modelling indicated that localised shoreline contact above thresholds could

occur at the Bardi Jawi, Uunguu and Dambimangari Indigenous Protected Areas on the Kimberley Coast at probabilities of 1-2% (Scenario 1 only). As discussed in impacts to shoreline habitats, no dissolved, entrained or floating hydrocarbons were predicted to reach these areas and contact was highly localised with maximum accumulated volumes of between 8 and 14 m³. Furthermore, the minimum time to contact was 98 days, meaning hydrocarbons would be significantly weathered and unlikely to reach the receptor at the modelled volumes. Given this and the initial low likelihood of a spill occurring, no significant impacts are predicted to these protected areas.

Although no designated traditional fisheries have been identified, it is recognised that Indigenous communities' fish in shallow coastal and nearshore waters of the Kimberley coastline and, therefore, may be potentially impacted in the highly unlikely event that a hydrocarbon spill was to reach the coastline in significant quantities. Given no contact is predicted by floating, entrained and dissolved hydrocarbons and only minimal volumes of shoreline accumulation are predicted, no significant impacts to indigenous fishing are expected.

In addition, traditional Indonesia fishermen visiting Scott Reef and Seringapatam Reef as part of the MOU 74 provisions may be impacted in the highly unlikely event of a spill within the Browse Development Area, potentially contaminating and restricting access to their traditional fishing grounds. However, the extent of impacts will depend on exposure concentration, duration and degree of weathering of the hydrocarbons.

Marine archaeology and other cultural heritage

Change in heritage values

Marine archaeology sites such as historic shipwrecks have the potential to be impacted from an unplanned hydrocarbon release through direct contact with hydrocarbons resulting in toxicity impacts to marine life that shelter in and around these wrecks. The consequences of such hydrocarbon exposure may include all or some of the following: large fish species moving away and/or resident fish species and sessile benthos (such as hard corals) exhibiting sub-lethal and lethal impacts (which may range from physiological issues to mortality).

Within the EMBA a number of places are designated National and Commonwealth heritage places. These places are also covered by other designations such as marine parks, and listed shipwrecks. Potential impacts have, therefore been discussed in the sections above.

6.3.21.6 Cumulative Impacts

The risk of cumulative impact of hydrocarbons spills from other development activities within the Browse Basin is low, as large scale events, although they could

occur, are extremely rare. Titleholders undertaking petroleum activities are required to have in place an approved OPEP detailing its oil spill response. These OPEPs are backed up by State and national response plans.

6.3.21.7 Prevention and response

In order to prevent a potential unplanned release of hydrocarbons, the following management measures will be put in place:

Drilling and completion activities

- + During drilling, proven systems and procedures will be employed. These will be applied and supervised by highly competent and experienced personnel. The industry is also highly regulated.
- + Drilling and completion activities will only be undertaken when metocean conditions are deemed suitable for safe operations.
- + Reservoirs will be isolated from the surface by a minimum of two independent and verifiable barriers. The configuration of isolation barriers during the drilling phase typically includes:
 - + Overbalanced hydrostatic pressure maintained on the reservoir via the drilling fluids.
 - + Seabed BOPs which can be activated to “shut in” the well in the event that well control via overbalanced drilling fluids is lost.
- + A 500 m petroleum safety zone will be implemented around the MODU.
- + Relief well planning will be outlined in the OPEP.
- + Accepted Safety Case for MODU.

Commissioning, operational and IMR activities

- + Testing will be undertaken prior to commissioning to confirm integrity of SURF and BTL system.
- + IMR activities to manage integrity of subsea systems will occur throughout operations.
- + The configuration of reservoir isolation barriers during the operations phase typically includes:
 - + production tubing from the reservoir to valving on the subsea tree
 - + cemented casing and associated valving on the subsea tree, plus a production packer to isolate the annulus between the casing and production tubing from the reservoir
 - + a Surface Controlled Subsurface Safety Valve (SCSSV) fitted on all production wells.
- + the wells, subsea system and FPSO facilities will use corrosion resistant materials, where applicable and be designed to protect against integrity threats

(e.g. corrosion, impact, erosion, low temperature embrittlement).

- + Wellhead valve design and configuration will allow safe operation and control of the well.
- + FPSO facilities will be designed to include compartmentalised condensate storage.
- + FPSO facilities are assessed against one in 10,000-year return period weather conditions to mitigate risk of extreme weather conditions.
- + FPSO facilities will include double sided hull design to minimise risk of hydrocarbon release in the event of a collision.
- + 500 m petroleum safety zones will be maintained at the FPSO facilities.
- + Design codes and material specifications for all risers and flowlines will be compliant with the relevant Australian and international standards.
- + SURF and BTL monitoring will be undertaken including:
 - + monitoring of corrosion protection system
 - + periodic integrity inspections in line with risk-based inspection outcomes.
- + Export trunkline volumes will be able to be isolated to prevent an ongoing fire impacting the FPSO
- + accepted Safety Case for FPSOs.

Offloading and refuelling activities during drilling and operations

- + Condensate offtake hoses will be fitted with ‘dry break’ or ‘breakaway’ couplings.
- + Scuppers and save-alls (receptacles or enclosures to contain minor leakages around machinery), including those around tank vents, will be in place before commencement of refuelling activities.
- + The diesel refuelling hose inventory will be drained before disconnection.
- + The diesel refuelling station will be isolated and equipment stowed when not in use.
- + Offloading and refuelling hoses will be certified as suitable for a safe operating pressure range. The hoses and fittings will also be compatible with support vessel/condensate tanker pump pressures.
- + Support vessel/condensate tanker pumps will be fitted with relief valves to allow diverting back of fluids to source in the event of excessive pressure build up in the transfer hose.
- + Where practicable, refuelling of support vessels will be conducted in port.
- + Diesel storage tank levels will be continuously

monitored to prevent overflow, and tank level indication and level alarms will be provided for diesel storage tanks.

- + Vessels (as appropriate to vessel class) will be required to have in place a Shipboard Oil Pollution Emergency Plan (SOPEP)/ Shipboard Marine Pollution Emergency Plan (SMPEP), as required by Marine Order 91 (Marine Pollution Prevention) 2014. Offloading and refuelling will only be undertaken when metocean conditions are deemed suitable for safe operations.
- + Condensate tankers will be piloted during berthing and offloading operations.
- + Offloading and refuelling will be undertaken by trained personnel using defined procedures.
- + Responsibilities and accountabilities will be defined for hydrocarbon spill response and notifications to Woodside and relevant authorities.
- + A loading plan (volume to be transferred) will be agreed between the supply point (vessel) and the delivery point, and a pre-load checklist completed.
- + Transfer equipment and emergency shutdown functions will be checked immediately prior to commencement of offtake.
- + The diesel transfer pumps emergency shutdown system onboard condensate tankers will be tested at the commencement of transfer.
- + Communication (visual and/or radio) between the support vessel/condensate tanker will be maintained throughout refuelling and offloading operations.

Spill response techniques

In the event of a spill, Woodside will respond in accordance with the Environment Plans and OPEPs specifically developed for the proposed Browse to NWS Project, which will be not inconsistent with the *National Plan for Maritime Environmental Emergencies 2019*. The Environment Plans and OPEPs will detail the spill response and mitigation measures adopted by Woodside following the rigorous risk assessment of a range of spill response strategies available. These will include strategies to limit the volume of hydrocarbons being released to the marine environment and strategies to reduce the volume of hydrocarbons reaching sensitive receptors.

A comprehensive Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) will be undertaken to evaluate and determine which techniques may be incorporated into a Browse to NWS Project spill response. This OSPRMA will use the detailed environmental assessment in the EP, including the identified environmental values and sensitivities, to conduct a Net Environmental Benefit Analysis (NEBA).

The NEBA is a systematic process undertaken during both planning and response that supports the

assessment and selection of response techniques to manage and reduce the overall impact of an incident. The IPIECA/IOGP good practice Spill Impact Mitigation Assessment (SIMA) methodology is adopted to undertake the NEBA. The NEBA considers the potential feasibility and effectiveness of various techniques in monitoring, treating and/or removing spilled materials. It also assists in identifying and evaluating any subsequent impacts that may be generated from the adopted response actions and which require further measures.

A NEBA is undertaken as part of the development of the OSRPRMA, using simulated oil spill modelling scenarios. Feasibility and effectiveness of the following response techniques, together with the potential exposure of environmental receptors, are considered by assessing this modelling scenario data:

- + **Monitoring and evaluation of a hydrocarbon spill** includes Operational Monitoring methods that may be activated:
 - + satellite tracking drifter buoy(s)
 - + aerial monitoring including use of UAVs where feasible
 - + satellite radar imagery
 - + water quality monitoring
 - + shoreline assessment: pre-emptive assessment as well as clean-up assessment
 - + modelling:
 - + ADIOS 2 – a hydrocarbon model that estimates the expected characteristics and behaviour of hydrocarbons spilled into the marine environment.
 - + trajectory modelling – Woodside has access to both an in-house rapid modelling tool and 24/7 scenario-specific modelling capabilities.
- + **Activation of a Subsea First Response Toolkit (SFRT)**, maintained by AMOSC in a constant state of readiness. The SFRT provides the following capability:
 - + pressure injection to close the BOPs
 - + preparing a subsea wellhead for a capping stack including removal of damaged/obstructing equipment
 - + injecting dispersant subsea (including a supporting stockpile of dispersant).
- + **Deployment of a well capping stack**, to be installed on the subsea well where feasible and safe to do so.
- + **Drilling of a relief well** to kill the well.
- + **Application of dispersants:** Dispersion of hydrocarbons into the water column reduces the volume on the ocean surface, which then reduces the potential for direct impact on emergent receptors. Dispersants break hydrocarbons down into smaller droplets which are rapidly diluted into

the water column, aiding the process of natural dispersion and accelerating biodegradation. It can also reduce surface volatile or organic compounds when dispersants are applied subsea.

Many light hydrocarbons, including Torosa condensate, may not be amenable to dispersants, as the droplet sizes are already below the point that can be achieved with dispersants. In Australia, AMSA maintains a list of approved Oil Spill Control Agents (OSCA) that includes dispersants. In the highly unlikely event of an unplanned hydrocarbon spill from the Browse to NWS Project, dispersant use would only be considered for use in areas that are within the dispersant 'Zone of Application' (ZoA) defined in the Browse Environment Plans and OPEPs. In defining the ZoA for dispersant use, Woodside would expressly prohibit the use of dispersants within areas such as Scott Reef.

The decision to apply dispersants during a spill would still be subject to a rigorous risk assessment, including revalidation of the NEBA undertaken in the OSPRMA using modelling and monitoring of actual data from the spill. If dispersant is assessed to be an appropriate technique, only OSCA dispersants approved by the regulator will be utilised. They will only be applied to surface hydrocarbons where appropriate concentration thresholds are present, and continuous monitoring of the dispersed oil plume will be undertaken to ensure ongoing effectiveness. Dispersant application will cease when operational monitoring shows that its use is no longer effective.

- + **Containment and recovery:** Physical containment and removal of hydrocarbons from the marine environment minimises damage to sensitive resources. This technique may be triggered when monitoring indicates that a floating hydrocarbon threshold has been reached, making it a potentially effective technique. Some limitations also include current and wind conditions, which may inhibit effectiveness.
- + **Protection and deflection:** Use of booms to create physical barriers to separate hydrocarbons from sensitive resources. This technique can be effective on some hydrocarbons where surface accumulation exceeds thresholds required. Browse hydrocarbons will be assessed against viability for using protection and deflection.
- + **Shoreline clean-up:** Recovery of hydrocarbons accumulated on shorelines to minimise environmental damage. Typical techniques that may be used for shoreline clean-up include:
 - + nearshore booming and skimming
 - + use of sorbents
 - + manual clean-up
 - + waste collection facilities – temporary storage or vessels with waste tanks.

- + **In-situ burning:** A NEBA will consider in-situ burning to determine its suitability as a response technique for Browse and to support identifying any restrictions that may apply to its use, if it is identified as a suitable response technique. However, potential long-term damage to the subsea ecology due to particulates as a result of in-situ burning is not well understood scientifically and its benefits versus risks have not been proven. Although this remains a potential technique, it is unlikely to be used for the Browse to NWS Project.
- + **Oiled wildlife response:** Undertaken to minimise impacts on at-risk wildlife populations, oiled wildlife response activities would be carried out in accordance with the Western Australian Oiled Wildlife Response Plan (WA OWRP), to ensure it is conducted in accordance with legislative requirements, and additionally following Woodside's Oiled Wildlife Response Operational Plan. Woodside has access to oiled wildlife response kits from AMOSC and OSRL and trained personnel via AMOSC, OSRL, Woodside and Sea Alarm.
- + **Scientific monitoring:** Undertaken to quantify and monitor impacts and recovery to a range of environmental receptors, such as (but not limited to) water quality, sediment quality, benthic primary producers and fauna. Scientific monitoring will also be used to inform response techniques and longer term recovery programs. The types of scientific monitoring needed would be assessed as part of the OSPRMA. Scientific monitoring would be carried in accordance with Woodside's Scientific Monitoring Program. Woodside has access to a range of equipment and trained personnel via standby contract with selected environmental consultancies. Each EP and OPEP will include an assessment of any additional risks and impacts that may be generated from the adopted response techniques, including further reduction and mitigation measures. From previous assessments, Woodside has identified a series of treatment measures to mitigate further potential impacts and risks generated from implementing response techniques. An indicative list of these measures are described below.

Vessel operations and access in the nearshore environment

- + Booms will be monitored and maintained to ensure trapped fauna are released as early as possible, with containment and recovery activities only occurring in daylight hours.
- + If vessels are required for accessing areas, anchoring locations will be selected to minimise disturbance to benthic primary producer habitats.
- + Shallow draft vessels will be used to access remote shorelines to minimise the impacts associated with seabed disturbance.

Dispersant

- + Surface dispersant will only be applied within the approved zone and to hydrocarbons at the appropriate concentration thresholds.
- + Continuous monitoring of dispersed oil plume will be undertaken to monitor effectiveness.
- + Regulator-approved dispersants will be prioritised for surface and subsea use.

Presence of personnel on the shoreline

- + Oversight will be provided by trained personnel who are aware of the risks.
- + Trained unit leaders will brief personnel of the risks prior to operations.
- + Shoreline access routes (foot, car, vessel and helicopter) with the least environmental impact will be selected by trained specialists.
- + Vehicular access will be restricted on dunes, turtle nesting beaches and in mangroves.

Waste generation

- + All shorelines will be zoned and marked before clean-up operations commence to prevent secondary contamination and minimise the mixing of clean and oiled materials.
- + Removal of vegetation will be limited to moderately or heavily oiled vegetation.

Additional stress or injury caused to wildlife

- + Operations will be conducted with advice from the Department of Biodiversity, Conservation and Attractions (DBCA) Oiled Wildlife Advisor and in accordance with the WA OWRP.

Review of major incidents

Woodside periodically reviews major incidents and updates (as appropriate) practices, emergency response and oil spill contingency plans to ensure that the systems in place are comprehensive and appropriate to design for, maintain and manage primary and secondary well control. Woodside also evaluates and improves the adequacy of procedural controls such as management of change, engineering assurance and competency assessments of personnel to ensure that the mechanisms outlined above are correctly and consistently applied.

6.3.21.8 Impact and Risk Assessment Summary and Acceptability Assessment

A summary of the risk assessments for the highly unlikely event of an unplanned release of hydrocarbons is provided in [Table 6-162](#). Assessment has been given for the worst-case predicted consequences from any unplanned hydrocarbon release, including modelled Scenarios 1 through 4.

These tables provide the environmental objectives relevant to each potentially impacted receptor, as well as the risk rating for unplanned events and incidents.

For unplanned incidents and events, the environment objective is predicted to be achieved and the risk deemed acceptable where the risk rating has been assessed as Low, or where the risk rating has been assessed as Moderate or High, with the risk likelihood of the event occurring assessed as remote or highly unlikely.

The final acceptability assessment is provided in [Table 6-163](#).

Table 6-162 Risk assessment summary and adopted controls – Unplanned Hydrocarbon Releases (Modelled Scenarios 1 to 4) (Hold: added scenario 4)

Receptor	Risk Event	Environmental objective	Adopted controls	Scenario	Consequence	Likelihood	Risk Rating
Marine sediments (medium value (open waters))	Unplanned hydrocarbon release leading to: + Change in sediment quality + Change in water quality + Injury or mortality to fauna + changes to the functions, interests or activities of other users + change in heritage values.	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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. Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	Refer to Section 6.3.21.7 for details of the planned preventive measures and approach to hydrocarbon spill response.	Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)
				Scenario 2: Cargo tank rupture	Major		Moderate (B1)
				Scenario 3: Vessel offtake system failure	Minor		Moderate (D1)
				Scenario 4: Vessel fuel tank rupture	Moderate		Moderate (C1)
Water quality (medium value (open waters))				Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)
				Scenario 2: Cargo tank rupture	Major		Moderate (B1)
				Scenario 3: Vessel offtake system failure	Minor		Moderate (D1)
				Scenario 4: Vessel fuel tank rupture	Moderate		Moderate (C1)
Plankton communities (medium value (open water))		Objective 7: To not have a substantial adverse effect on a population of plankton including its lifecycle and spatial distribution.		Scenario 1: Well loss of containment	Moderate	Highly unlikely	Moderate (C1)
				Scenario 2: Cargo tank rupture	Moderate		Moderate (C1)
				Scenario 3: Vessel offtake system failure	Minor		Moderate (D1)
				Scenario 4: Vessel fuel tank rupture	Minor		Moderate (D1)
Shallow water benthic communities and habitats (<75 m depth)		Objective 10: To avoid changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic habitat (<75 m water depth).		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)
				Scenario 2: Cargo tank rupture	Catastrophic		High (A1)
				Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)
				Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)
Deep water benthic communities and habitats (>75 m depth) – (medium value)		Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)
				Scenario 2: Cargo tank rupture	Major		Moderate (B1)
				Scenario 3: Vessel offtake system failure	Minor		Moderate (D1)
				Scenario 4: Vessel fuel tank rupture	Moderate		Moderate (C1)

Receptor	Risk Event	Environmental objective	Adopted controls	Scenario	Consequence	Likelihood	Risk Rating
Seabirds and migratory shorebirds (high value species)	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population. Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.	Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)		
			Scenario 2: Cargo tank rupture	Catastrophic		High (A1)	
			Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)	
			Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)	
Fish (high value species)		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)		
			Scenario 2: Cargo tank rupture	Catastrophic		High (A1)	
			Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)	
			Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)	
Marine mammals (high value species)		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)		
			Scenario 2: Cargo tank rupture	Catastrophic		High (A1)	
			Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)	
			Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)	
Marine reptiles (high value species)		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)		
			Scenario 2: Cargo tank rupture	Catastrophic		High (A1)	
			Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)	
			Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)	
KEFs (medium value)	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.	Scenario 1: Well loss of containment	Moderate	Highly unlikely	Moderate (C1)		
			Scenario 2: Cargo tank rupture	Minor		Moderate (D1)	
			Scenario 3: Vessel offtake system failure	No lasting effect		Low (F1)	
			Scenario 4: Vessel fuel tank rupture	Slight		Low (E1)	
Australian marine parks (medium value (multiple use zones))		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)		
			Scenario 2: Cargo tank rupture	Catastrophic		High (A1)	
			Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)	
			Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)	
State marine parks and nature reserves and other protected places (high value)		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)		
			Scenario 2: Cargo tank rupture	Catastrophic		High (A1)	
			Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)	
			Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)	

Receptor	Risk Event	Environmental objective	Adopted controls	Scenario	Consequence	Likelihood	Risk Rating
State and Commonwealth managed fisheries (high value marine users)		Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Scenario 1: Well loss of containment	Catastrophic	Highly unlikely	High (A1)
				Scenario 2: Cargo tank rupture	Catastrophic		High (A1)
				Scenario 3: Vessel offtake system failure	Moderate		Moderate (C1)
				Scenario 4: Vessel fuel tank rupture	Major		Moderate (B1)
Other users including tourism and recreation and scientific studies (high value users)		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Scenario 1: Well loss of containment	Major	Highly unlikely	Moderate (B1)
				Scenario 2: Cargo tank rupture	Moderate		Moderate (C1)
				Scenario 3: Vessel offtake system failure	Slight		Low (E1)
				Scenario 4: Vessel fuel tank rupture	Minor		Moderate (D1)
Shipping (Medium/high value users)		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Scenario 1: Well loss of containment	Major	Highly unlikely	Moderate (B1)
				Scenario 2: Cargo tank rupture	Moderate		Moderate (C1)
				Scenario 3: Vessel offtake system failure	Slight		Low (E1)
				Scenario 4: Vessel fuel tank rupture	Minor		Moderate (D1)
Industry (low value)		Objective 21: To not interfere with other marine users to a greater extent than is described in the EIS/ERD.		Scenario 1: Well loss of containment	Slight	Highly unlikely	Low (E1)
				Scenario 2: Cargo tank rupture	No lasting effect		Low (F1)
				Scenario 3: Vessel offtake system failure	No lasting effect		Low (F1)
				Scenario 4: Vessel fuel tank rupture	No lasting effect		Low (F1)
Aboriginal and indigenous heritage (high value)		Objective 19: To not have a substantial adverse impact on heritage value.		Scenario 1: Well loss of containment	Minor	Highly unlikely	Moderate (D1)
				Scenario 2: Cargo tank rupture	Slight		Low (E1)
				Scenario 3: Vessel offtake system failure	Slight		Low (E1)
				Scenario 4: Vessel fuel tank rupture	Slight		Low (E1)
Marine archaeology (high value)		Objective 19: To not have a substantial adverse impact on heritage value.		Scenario 1: Well loss of containment	Minor	Highly unlikely	Moderate (D1)
				Scenario 2: Cargo tank rupture	Slight		Low (E1)
				Scenario 3: Vessel offtake system failure	Slight		Low (E1)
				Scenario 4: Vessel fuel tank rupture	Slight		Low (E1)

Table 6-163 Acceptability assessment – unplanned hydrocarbon releases

Acceptability Assessment
Confidence in assessment Woodside has a high level of certainty with respect to the risks and consequences of an unplanned hydrocarbon release as: + Quantitative hydrocarbon spill modelling utilising established methods has been undertaken of the worst-case credible spill scenarios. + The worst-case impact magnitudes to receptors, although significant, are based on worst-case scenarios which are highly unlikely to occur given the controls implemented and, therefore, within the applicable standards. + As an experienced and reputable operator, Woodside has a proven track record with respect to spill prevention and response preparedness. + In the event of a spill, Woodside will respond in accordance with the Environment Plans and OPEPs specifically developed for the proposed Browse to NWS Project, which will be not inconsistent with the <i>National Plan for Maritime Environmental Emergencies 2019</i>. The Environment Plans and OPEPs will detail the spill response and mitigation measures adopted by Woodside following the rigorous risk assessment of a range of spill response strategies available.
Principles of ESD There are no planned release of hydrocarbons to the environment. The likelihood of an unplanned hydrocarbon release is considered highly unlikely, particularly given the stringent controls in place. With the application of the proposed controls it is predicted that the nominated environmental objective for each potentially impacted receptor will be achieved. As such, it is considered that the principles of ESD will be met. Conclusion: Acceptable
Significant impacts as defined by the MNES Significant Impact Guidelines <u>Listed threatened species and ecological communities/listed migratory species</u> As described in Table 6-162, the risk of an unplanned hydrocarbon release presents a Moderate to High risk to all listed threatened and migratory species (depending on the scenario). These risk ratings are driven by the potential Moderate to Catastrophic consequence (depending on the scenario) where regional impacts affecting species at a population level could occur. It should be noted, however, that with the implementation of the proposed controls it is highly unlikely that such an event would occur. As such, no significant impacts to listed threatened or migratory species (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>Commonwealth marine environment</u> As described in Table 6-162, the risk of an unplanned hydrocarbon release presents a Moderate to High risk to all ecological receptors (depending on the scenario) and a Low to High risk to other marine users (depending on the user and the scenario). As above, these risk ratings are driven by the potential Moderate to Catastrophic consequence (depending on the scenario) where regional impacts affecting the marine environment could occur. As above, with the implementation of the proposed controls, it is highly unlikely that such an event would occur. As such, no significant impacts to the Commonwealth marine environment (as defined by the Significant Impact Guidelines (Table 6-5)) are predicted. <u>National Heritage Places</u> Even the highly unlikely event of an unplanned hydrocarbon release, no impact to National Heritage Places would be expected. Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

An assessment of the risk presented in relation to unplanned hydrocarbon release against the WA EPA Objectives is presented in the State Proposal ERD ([Chapter 10, Appendix B](#)).

Marine environmental quality

As described in [Table 6-162](#), the risk of an unplanned hydrocarbon release presents a Moderate to High risk to sediment quality and water quality and a Moderate risk to plankton (depending on the scenario). As above, these risk ratings are driven by the potential Moderate to Catastrophic consequence (depending on the scenario) where regional impacts affecting the marine environmental quality both within the State Proposal Area and other State waters including adjacent to the mainland could occur. As above, with the implementation of the proposed controls, it is highly unlikely that such an event would occur. Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors will be achieved, and the WA EPA environmental objective “*To maintain the quality of water, sediment and biota so that environmental values are protected*” will be achieved for the State Proposal.

Benthic communities and habitats

As described in [Table 6-162](#), the risk of an unplanned hydrocarbon release presents a Moderate to High risk to benthic habitats including regional shallow water benthic habitats. As above, these risk ratings are driven by the potential Minor to Catastrophic consequence (depending on the scenario) where regional impacts affecting benthic communities and habitats both within the State Proposal Area and other State waters including adjacent to the mainland could occur. As above, with the implementation of the proposed controls, it is highly unlikely that such an event would occur. Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors will be achieved, and the WA EPA environmental objective “*To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*” will be achieved for the State Proposal.

Marine fauna

As described in [Table 6-162](#), the risk of an unplanned hydrocarbon release presents a Moderate to High risk to marine fauna. As above, these risk ratings are driven by the potential Moderate to Catastrophic consequence (depending on the scenario) where regional impacts affecting the marine fauna within the State Proposal Area and other State waters including adjacent to the mainland could occur. As above, with the implementation of the proposed controls, it is highly unlikely that such an event would occur. Given this, it is considered that with the application of the proposed controls, the nominated environmental objectives for these receptors will be achieved, and the WA EPA environmental objective “*To protect marine fauna so that biological diversity and ecological integrity are maintained*” will be achieved for the State Proposal.

Conclusion: Acceptable

External context

To date, there have been no specific matters raised by stakeholders regarding hydrocarbon spills in relation to the proposed Browse to NWS Project.

Conclusion: Acceptable

Internal context

Hydrocarbon spill prevention and response will be managed in accordance with regulatory requirements, including Safety Cases, EPs, OPEPs and a Well Operations Management Plan to manage credible spill risks, capability and response, which require acceptance by NOPSEMA. In addition, vessels will have a valid and appropriate SOPEP and/or SMPEP.

Conclusion: Acceptable

Acceptability Assessment

Other requirements

EPBC Act recovery and conservation plans and advices

As detailed in [Table 6-159](#), the proposed activities are considered to be not inconsistent with the objectives and actions of:

- + Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a)
- + Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015a)
- + Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017a)
- + Conservation Management plan for the Blue Whale (Commonwealth of Australia, 2015c)
- + Conservation advice *Megaptera novaeangliae*, Humpback Whale (Threatened Species Scientific Committee, 2015b)
- + Conservation advice *Balaenoptera borealis*, Sei Whale (Threatened Species Scientific Committee, 2015c)
- + Conservation advice *Balaenoptera physalus*, Fin Whale (Threatened Species Scientific Committee, 2015d)

KEFs

As detailed in [Table 6-160](#), the proposed activities are not predicted to materially increase existing relevant pressures on the conservation values of KEFs.

AMPs

As detailed in [Table 6-161](#), proposed activities are considered to be within the objectives of AMPs.

Other protected places

No impacts are expected to occur to the values of the Scott Reef and Surrounds or the Mermaid Reef – Rowley Shoals Commonwealth Heritage Places.

Conclusion: Acceptable

6.4 Social and Economic Considerations

Introduction

Assessment under the EPBC Act and EP Act requires consideration of the social, economic, aesthetic and cultural aspects of the physical and biological environment. Under the EPBC Act, the Minister must also consider economic and social matters in deciding whether to approve an action and what conditions to impose.

6.4.1 Social Impact Assessment

To inform the assessment of social matters and potentially to identify any social aspects relevant to stakeholders in relation to the physical environment, in 2018, Woodside commissioned a SIA for the proposed Browse to NWS Project to identify potential impacts and opportunities and provide recommendations for management and mitigation while also ensuring the opportunities presented are maximised.

The Browse to NWS Project SIA study area incorporated the community of Broome, the Dampier Peninsula, the wider Kimberley region and the State of Western Australia (Advisian, 2019).

Broome and the Dampier Peninsula are considered most likely to be affected by the potential social benefits and impacts due to Broome being considered the potential primary supply chain and logistic locations for the proposed Browse to NWS Project. The SIA addressed socio-economic impacts and risks related directly to offshore activities associated with the proposed Browse to NWS Project. These impacts and risks are addressed for each relevant aspect in [Section 6.3](#).

This section summaries the results of the SIA to assess the potential social impacts and opportunities which may arise from the proposed Browse to NWS Project, including potential changes resulting from the construction and operation phases.

6.4.2 Method

Potential social impacts and opportunities on Broome and the Dampier Peninsula communities arising from the proposed Browse to NWS Project were assessed in terms of how potential Browse to NWS Project activities may interact with communities and stakeholders that are likely to be affected.

At the direction of Woodside, the SIA methodology included targeted stakeholder engagement. Key stakeholders were consulted and provided input into the identification and assessment of impacts as well as the understanding of local and regional dynamics. Refer to [Chapter 4](#) for further detail on stakeholders.

Identified impacts and opportunities were rated with a significance and ranked. This process facilitated an understanding of the overall magnitude and significance of each issue.

Following this process, mitigation and management measures to enhance opportunities and minimise potential impacts for the local communities were developed. The process sought to align measures with regional planning initiatives to maximise outcomes for communities rather than duplicate existing services or programs. They were also aligned with, or serve to enhance, Woodside's current activities in the region (Advisian, 2019).

6.4.3 Key Findings

6.4.3.1 Economic Development, Local Business and Employment Opportunities

The economic development, business and employment opportunities were the primary opportunities for local communities, particularly within Broome.

The findings of the ACIL Allen Economic Impact Assessment (further detailed in [Chapter 3](#)) suggests that the proposed Browse to NWS Project is projected to provide direct economic benefit into the Western Australian economy, as well as indirect benefits through utilisation of service and support industries. With a 44-year project lifecycle, this represents a significant opportunity to contribute to the economic development of Broome and the Kimberley more broadly.

Woodside's commitment to using Broome as the supply chain and logistics hub offers increased potential to contribute to the economy of Broome and has generated a level of excitement within the town for the potential this offers in terms of economic development, employment and skills development.

The proposed Browse to NWS Project presents Woodside with an opportunity to utilise an increased regional approach building employment opportunities and a skilled labour force. It was acknowledged that the opportunity would be incremental, and expectations should be managed through transparent engagement with communities.

The long potential project lifecycle of the proposed Browse to NWS Project presents an opportunity for Woodside to identify social investment options designed to support local capability development for a number of communities within the project impact areas, specifically Indigenous communities.

6.4.3.2 Community Amenity and Cohesion

Community amenity concerns were identified, for example, these included helicopter noise in Broome and the 'visibility' and behaviour of the workforce. Amenity related impacts will be more concentrated during construction.

As a workforce transit point for offshore and onshore developments, workforce behaviour was identified as an issue by some stakeholders.

Stakeholders emphasised that while the oil and gas industry and the tourism industry can co-exist, the 'visibility' of the oil and gas industry through poor workforce behaviour and a lot of 'high-vis' can detract from the overall amenity and lifestyle in the town. While these impacts can be significant, they are also readily mitigated.

A further attraction contributing to amenity and lifestyle in Broome is its location. However, it is this location, primarily the distance and sometimes excessive costs to travel in and out of Broome. Airfare costs also impact on residents and local businesses, particularly the tourism industry. With the exception of some seasonal direct flights from the east coast of Australia to Broome, almost all flights transit via Perth. SIA consultations revealed a concern that once construction of the proposed Browse to NWS Project begins, flights in and out of Broome, specifically to Perth, will again become excessively expensive. It should be noted expensive airfares are the result of a number of factors, and while the proposed Browse to NWS project may contribute to price increases, clear attribution for this will be difficult to quantify. Consultations did reveal that measures have been made by airlines to manage excessive flight costs for Broome residents.

6.4.3.3 Housing and Accommodation

The proposed Browse to NWS Project is likely to have minimal negative or positive impacts on the housing and accommodation market in Broome. The offshore nature of the proposed Browse to NWS Project and the small operations workforce will not see a significant increase in demand for housing and accommodation.

6.4.3.4 Population Growth

The SIA identified a desire among the Broome community for the population to grow, but in a sustained way that contributes to a vibrant community with a strong economy. Population growth could translate into economic growth and stability if this growth is sustained in the long-term. SIA findings indicate that Broome can accommodate an increase in population and there will be limited to no impact on existing service providers such as health providers, who all indicated capacity to meet increased demands.

6.4.3.5 Cultural Heritage

The impact of the proposed Browse to NWS Project on sites of cultural significance was considered in the context of the offshore nature of the project.

SIA consultations with Dampier Peninsula communities highlighted the strong linkage that exists between Aboriginal stakeholders and the sea, as an important food source, but also as an important cultural resource.

6.4.4 Proposed Approach to Mitigation and Management

Mitigation and management measures proposed in this assessment will be implemented through social impact management plans prepared in the usual course as part of the implementation of Woodside Management System.

CHAPTER 7

GREENHOUSE GAS EMISSIONS

7. GREENHOUSE GAS EMISSIONS

7.1 Overview

This chapter details the assessment of greenhouse gas (GHG) emissions, including the potential impact on sensitive receptors within Australian jurisdictions and the contribution of GHG emissions from the proposed Browse to NWS Project.

GHG emissions are those that absorb infrared radiation in the atmosphere and release this energy as heat, consequently increasing global temperatures. This increase in temperature is predicted to have an adverse effect on natural ecosystems as a result of reductions in the bioclimatic range within which a given species or ecological community exists.

The main categories of human-induced activities that emit GHGs are:

- + energy
- + industrial processes including use of synthetic gases
- + waste emissions
- + agriculture
- + land use, land use change and forestry.

Ecosystems which are particularly susceptible to adverse effects of climate change include alpine habitats, coral reefs, wetlands and coastal ecosystems, polar communities, tropical forests, temperate forests and arid and semi-arid environments (Department of the Environment and Energy, 2019). In Australia, the most affected ecosystems include coral reefs, alpine regions, rainforests, arid and semi-arid environments, mangroves, grasslands, temperate forests and sclerophyll forests. Future climate change (increased temperature and decreased rainfall) has the potential to have a range of impacts on ecological factors and threaten biodiversity in the Australian Mediterranean ecosystem (CSIRO, 2017).

7.2 Environment Objective

The key environmental objectives of the proposed Browse to NWS Project in relation to GHG emissions are:

- + To not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.
- + To optimise efficiencies in air emissions and reduce greenhouse emissions to acceptable levels.

7.3 Policy and Guidance

7.3.1 International Policy

The United Nations Framework Convention on Climate Change (UNFCCC) came into force in 1994 and has been ratified by 197 countries. The UNFCCC established a goal of preventing dangerous anthropogenic interference with the climate system. Subordinate treaties and agreements have been ratified by parties to the UNFCCC, including the Paris Agreement in 2015. The Paris Agreement establishes a series of targets including:

- + Keeping “global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit temperature increase to 1.5°C” (Article 2.1(a)).
- + Reaching “global peaking of GHG emissions as soon as possible...achieve a balance between anthropogenic emissions by sources and removals by sinks in the second half of this century” (Article 4.1).

The ratification of the Paris Agreement under decision 1/CP.21 (UNFCCC, 2016) acknowledged that the Nationally Determined Contributions (NDCs) made by countries as commitments under the Paris Agreement were insufficient to meet the goals of the Paris Agreement. To manage this, the Paris Agreement includes a process to update, or ‘ratchet-up’ NDCs every 5 years.

Australia’s NDC is for an absolute economy-wide emissions reduction by 2030, to be developed into an emissions budget covering the period 2021-2030 (Australia, 2015). Australia is expected to restate its NDC in 2020 and update it in 2025.

7.3.2 Commonwealth Legislation and Policy

The following key legislation relating to GHG is administered by the Clean Energy Regulator:

- + *National Greenhouse & Energy Reporting Act 2007* (Cth) (NGERS) established the NGER scheme which require companies such as Woodside to report on GHG emissions, energy production and energy consumption.
- + *National Greenhouse and Energy Reporting Regulations 2008* (Cth) sets out the details that establish compliance rules and procedures for administering the NGERS.

- + *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Cth) sets the methods, criteria and measurement standards for calculating greenhouse gas emissions and energy data.
- + *The National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (Cth) (SGM) sets out the details that establish compliance rules and procedures for administering the safeguard mechanism.

The Safeguard Mechanism (see 7.3.2 below) is one of a number of mechanisms by which Australia intends to meet its NDC. It was developed to ensure that emission reductions implemented through the Emissions Reduction Fund (ERF) are not offset or exceeded by significant GHG emissions (above 'business-as-usual levels') emanating from other industrial or economic sectors. The SGM currently applies to facilities which emit greater than 0.1 MtCO₂-e per annum, requiring annual covered emissions to be reported against a designated emissions 'baseline'.

In March 2019, modifications to the SGM were introduced to transition facilities from current 'reported' baselines (an absolute value based on the historical high-point of emissions) to a 'calculated' baseline (set based on production forecasts and emissions intensity). There is now an expectation that existing facilities will transition to calculated baselines within the next two years.

This change to the SGM also provides direction for future transition from calculated baselines, which are valid for a fixed period, to 'production adjusted' baselines which are annually updated in line with production.

New facilities after 1 July 2020 will be subject to a 'benchmark baseline', which is expected to be defined by the DoEE and be based on leading-practice emissions intensities (top 10% of comparable facilities).

At the time of writing, three schedules within the SGM remain unpublished. These will include the benchmark parameters, production adjusted production variables and emissions intensities and fixed production variables and emissions intensities (Schedules 1, 2 and 3 respectively). The publication of this data is intrinsic to determining a baseline emissions figure under the SGM amendments.

The Federal Government climate change policy is the Climate Solutions Package (CSP), "a \$3.5 billion investment to deliver on Australia's 2030 Paris climate commitments" (DOEE, 2019). In addition to the SGM, the CSP includes a range of programs to reduce emissions, including a \$A2 billion 'Climate Solutions Fund' to provide additional budget for the operational Emissions Reduction Fund, support for energy efficiency and electric vehicles, two large projects to manage additional intermittent renewables and an education campaign to encourage households and business to regularly maintain air conditioning equipment (COA, 2019).

The compliance of Browse with the SGM is discussed in [Section 7.7.2](#).

As described in Chapter 2, the controlling provisions under the EPBC Act for the proposed Browse to NWS Project include "the Commonwealth marine area, the protected matter being the environment generally". Under the EPBC Act, the 'environment' includes consideration of:

- + ecosystems and their constituent parts including people and communities
- + natural and physical resources
- + qualities and characteristics of locations, place and areas
- + heritage values of places
- + social, economic and cultural components of the environment.

These receptors and sensitivities with respect to global GHG emissions are further discussed in [Section 7.5](#).

7.3.3 State Legislation and Policy

The Western Australian Government released a GHG Emissions Policy for Major Projects on 28 August 2019. The Policy included an aspirational target of net zero greenhouse gas emissions by 2050. The Minister for Environment will consider how the Policy relates to major proposals assessed under Part IV of the EP Act (Government of Western Australia, 2019).

Public consultation on the WA EPA's draft Environmental Factor Guideline and Technical Guidance relating specifically to GHG emissions closed on 2 September 2019.

Woodside is continuing to work to reduce (net) emissions intensity through improvements in energy efficiency, investments in biosequestration projects and innovation in our production processes. Woodside has a Climate Change Policy described on the website <https://www.woodside.com.au/sustainability/climate-change>.

7.4 Source Activity

7.4.1 Origin of GHG Emissions

The EIS Guidelines/Environmental Scoping Document for the proposed Browse to NWS Project requires quantification and impact assessment for GHG emissions associated with both the proposed Browse Joint Venture infrastructure and proposed processing of Browse feed gas through North West Shelf Project Extension third party tolling facility infrastructure (EPA 2186, EPBC 2018/8335).

GHG emissions associated with gas extraction and LNG processing activities are typically from two key sources; the combustion of the hydrocarbon-based fuel (Coulson et al., 2010) and pre-existing CO₂ in the hydrocarbon reservoir. Combustion of hydrocarbon-based fuel is used to power export compression and associated processing and utilities. CO₂ content in the hydrocarbon reservoir is a naturally occurring geological phenomenon that must be treated as a waste product during LNG liquefaction. It is not influenced by the design of the processing facilities.

Contemporary large operating and proposed developments off the west coast of Australia include a number of developments where the levels of CO₂ in the reservoir are comparatively high (at an average of *circa* 10 - 20 mol%) compared to historical development on the NWS. The relative proportion of CO₂ emissions associated with reservoir and fuel combustion components are modified accordingly. For example:

- + Barossa Development (proposed): *circa* 16–20 mol%
- + Gorgon LNG Development (operating): *circa* <1-14 mol%
- + Ichthys Project (operating): *circa* 8-17 mol%
- + Prelude FLNG: *circa* 9 mol%
- + Proposed Browse to NWS Project: *circa* 7-12 mol%.

In terms of the feed gas, the removal of reservoir CO₂ is essentially a purification process, but is also a critical pre-cursor to liquefaction, preventing the formation of solids during that process and the associated plugging of system elements (particularly the heat exchanger) (Li et al., 2011). A variety of methodologies and technologies have been employed to achieve the effective separation and removal of CO₂ from the LNG stream.

In the upstream environment, the separation of reservoir CO₂ from hydrocarbon gas takes place principally within the Acid Gas Removal Unit (AGRU). The CO₂ removed at this point is vented to the atmosphere and this represents one of the principal sources of carbon emissions for the proposed Browse to NWS Project.

Not all the reservoir CO₂ is removed by upstream processing. Further removal may take place in the downstream environment, allowing for installation of a smaller offshore AGRU. This both improves the overall safety profile of the offshore facilities and also results in a slight reduction in overall emissions (due to reduced overall fuel consumption). Under current plans, between 1 mol% and 2.8 mol% CO₂ will be exported via the BTL from the FPSO facilities along with the hydrocarbon gas, with an expected target of 2.5 mol% CO₂. In the downstream environment, a second phase of acid gas removal at KGP will remove the remaining proportion of the reservoir CO₂ and it is expected to be described in the proposed NWSJV's 'North West Shelf Project Extension ERD' (EPA 2186, EPBC 2018/8335). The proportion of reservoir CO₂ that will be emitted at the NWS infrastructure is anticipated

to be broadly consistent with the historical reservoir emissions associated with NWS feed gas, subject to the outcome of commercial arrangements. At each AGRU it is possible that hydrocarbons, in particular methane, may be entrained in the reservoir CO₂. Typically, these hydrocarbons are converted to CO₂ by a thermal oxidiser on the vent stream which processes the vent stream of the AGRU. When the thermal oxidiser is not online, the hydrocarbons are vented to atmosphere. These emissions form a small part of the overall CO₂-e vented from the AGRU. Estimates of vented reservoir emissions are inclusive of vented hydrocarbons.

As the separation of reservoir CO₂ from the gas stream occurs prior to liquefaction, the total (i.e. upstream and downstream) reservoir CO₂ emissions are a function of the CO₂ content of the reservoir.

A further source of CO₂ emissions is flaring and fugitive emissions. Flaring refers to the combustion of hydrocarbons that are not able to be processed. The flare is a safety feature to prevent the risk of creating explosive atmosphere in case of a process blowdown. Flaring from the FPSO facilities is expected to be minimal relative to other processing emissions and reservoir emissions. Further information on flaring is provided in [Chapter 3](#). Fugitive emissions refer to minor leaks of hydrocarbon gases that occur from the process, or uncombusted hydrocarbons that pass through the flare or gas turbines. Fugitive emissions are expected to be minimal relative to flaring, other processing emissions and reservoir emissions.

Finally, some combustion of fuel and flaring will be associated with downstream processing at KGP. It is noted that the emissions for downstream processing at KGP are expected to be assessed under the NWSJV's 'North West Shelf Project Extension ERD' (EPA 2186, EPBC 2018/8335).

7.4.2 GHG Accounting Principles

GHG emissions are typically characterised by reference to the GHG Protocol Corporate Standard. Originally published in 2001, the GHG Protocol represents a collaboration between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), with the objective of developing an international standard for corporate GHG accounting and reporting. One of the most important outcomes of developing the Protocol has been the widespread recognition of a high-level emissions classification scheme that allows organisations and industries to better define key focus areas for abatement activities. This scheme has been adapted and deployed by national and local regulators and represents a globally accepted subdivision of GHG emissions for evaluation and reporting purposes.

Direct emissions are most commonly associated with the generation of energy, manufacturing processes, transportation and intentional or unintentional GHG ('fugitive') emissions. Indirect emissions are most commonly associated with the consumption of electricity, although numerous other sources exist.

In this context, the GHG Protocol emissions classification scheme is defined in terms of Scope as shown in [Figure 7-1](#).

The GHG Protocol is aligned to the definitions for Scope 1 and Scope 2 emissions as defined by the *National Greenhouse and Energy Reporting Regulations 2008 (Cth)*.

<i>Emissions type</i>	<i>Scope</i>	<i>Definition</i>	<i>Examples</i>
Direct emissions	Scope 1	Emissions from operations that are owned or controlled by the reporting company	Emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment
	Scope 2	Emissions from the generation of purchased or acquired electricity, steam, heating, or cooling consumed by the reporting company	Use of purchased electricity, steam, heating, or cooling
Indirect emissions	Scope 3	All indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions	Production of purchased products, transportation of purchased products, or use of sold products

Figure 7-1 GHG Protocol Emissions Classification Scheme

7.4.3 Emissions Classification

On the basis of the definitions that support the GHG Protocol's emissions classification scheme, the nature and origin of the main sources of GHG emissions from the proposed Browse to NWS Project are shown in [Table 7-1](#).

Table 7-1 Classification of GHG emissions according to the GHG Protocol

Description	Location	Jurisdiction	Emissions Source/Process	Scope
Installation and Construction	Upstream	State	Indirect GHG emissions generated from activities associated with construction, installation and commissioning* of upstream facilities to process Browse gas and operations (by third parties)	Scope 3
	Upstream	Commonwealth	Indirect GHG emissions generated from activities associated with construction, installation and commissioning* of upstream facilities to process Browse gas and operations (by third parties)	Scope 3
Processing and Reservoir CO ₂ Emissions	Upstream	State	Direct GHG emissions generated in the State Proposal Area from operational activities associated with upstream processing of Browse gas	Scope 1 (BJV)
	Upstream	Commonwealth	Direct GHG emissions from venting of reservoir CO ₂ extracted from the production stream via the FPSOs AGRUs	Scope 1 (BJV)

Description	Location	Jurisdiction	Emissions Source/Process	Scope
	Upstream	Commonwealth	Direct emissions from combustion of hydrocarbon-based fuels required for processing, compression of hydrocarbon gas on the FPSO prior to pipeline export and other operational activities	Scope 1 (BJV)
	KGP	State	Indirect GHG emissions from venting of reservoir CO ₂ extracted from the gas exported from the FPSO and vented from the downstream NWSJV AGRU	Scope 1 (NWSJV)
	KGP	State	Indirect emissions from combustion of hydrocarbon-based fuels required for processing of hydrocarbon gas downstream prior to export	Scope 1 (NWSJV)
Third Party Consumption	Transit	Subject to consumer location**	Indirect emissions from transportation of products to the markets into which they will be sold by each Joint Venture Participant, including Domgas	Scope 3
	Market	Subject to consumer location**	Indirect emissions from combustion of products as part of power generation and other energy solutions within final market environment, including Domgas	Scope 3

* Commissioning emissions in the State Proposal Area are anticipated to be minor, as the FPSO facilities are located in Commonwealth waters.

** There are presently no specific contracts for Browse gas. No transport contracts are in place.

7.4.4 GHG Emissions Estimates

This section provides the carbon emissions estimate for the proposed Browse to NWS Project and describes the approach taken to estimate the forecast GHG emissions for the proposed Browse to NWS Project, based on the GHG Protocol emissions classification scheme. The estimate is based on the current level of concept definition and assumptions regarding commercial arrangements, the feed gas (final composition) and the scale, efficiency, interaction and complexity of the extraction, processing, anticipated production and compression of the product stream.

Forecast GHG emissions incorporate the following sources of GHG emissions:

- + [Section 7.4.4.1](#) Installation and Construction
- + [Section 7.4.4.2](#) Processing Emissions and Reservoir CO₂ Emissions
 - + Processing Emissions Methodology
 - + Reservoir CO₂ Methodology
 - + Processing and Reservoir CO₂ Emissions Estimate
 - + Impact of Browse Gas Export Spec on apportionment of Reservoir CO₂ to the upstream and downstream facilities.
- + [Section 7.4.4.3](#) Third Party Consumption Emissions
 - + Methodology
 - + Estimate.

Key assumptions for all the major sources of GHG emissions relate to:

- + The timing and phasing of production well commissioning and start-up across the Calliance, Torosa and Brecknock fields.
- + The expected average and maximum production rates from those wells and its decline over life of field.

Emissions from the proposed Browse to NWS Project are expected to be broadly linked to the rate of production. For the first five years following production start-up, currently anticipated to be mid-2020s for the Calliance/Brecknock FPSO, CO₂-e emissions from the proposed Browse to NWS Project lifecycle are expected to increase as production increases. Emissions are expected to stabilise as the FPSOs achieve a steady state until circa 2040.

Once reservoir pressure falls such that the FPSOs no longer achieve a steady state production, emissions progressively reduce in line with production. Some variation in forecast CO₂-e emissions year-on-year is expected for numerous factors, in particular due to commencement of compression, which starts up at different times on different fields and which is subject to a step-wise reduction during production decline.

Emissions Estimate Scenarios

Given the inherent uncertainty of estimating GHG emissions, a range of scenarios have been presented. Explanations for these scenarios are presented below in [Table 7-2](#).

Table 7-2 Description of scenarios presented for GHG emissions estimates

Scenario	Description
Annual Scenarios	
Average year	+ Average (mean) GHG emissions produced over expected field life of 31 years. + Range provided for expected (10.2%) and high (11.6%) reservoir CO₂ composition (weighted average of reservoirs).
Peak production year	+ Peak GHG emissions produced at peak possible production rates (2150mmcsfd export), assuming 95% availability. + Range provided for expected (10.2%) and high (11.6%) reservoir CO₂ composition (weighted average of reservoirs).
Total Inventory Scenarios	
Expected field life (31 years)	+ GHG emissions produced over expected field life, achieving expected plateau duration. + Range provided for expected (10.2%) and high (11.6%) reservoir CO₂ composition (weighted average of reservoirs).
Extended Field Life Outcome (44 years)	+ GHG emissions produced over extended field life, achieving extended plateau duration. + Range provided for expected (10.2%) and high (11.6%) reservoir CO₂ composition (weighted average of reservoirs).

7.4.4.1 Installation and Construction

Installation and construction are expected to form a minor component of the overall emissions associated with the proposed Browse to NWS Project. Total installation emissions across the life of the proposed Browse to NWS Project are estimated to be -1.0 MT CO₂-e (total over field life), with approximately -0.4MT CO₂-e of the total occurring within State Proposal Area.

7.4.4.2 Processing emissions and reservoir CO₂ emissions

Processing Emissions Methodology

Processing emissions includes the following emissions sources:

- + fuel gas consumed
- + flaring
- + fugitive emissions.

Processing emissions are predominantly generated through the consumption of fuel gas.

An assessment of the quantity of fuel gas required to power the offshore Browse to NWS Project facilities has been completed. This assessment is based on the estimated efficiency of the equipment that has been selected to provide compression power, electricity generation and surplus heat. The power and heat demand of the system has been estimated based on the estimated compression demand, electrical load list demand and heating system demand. The demand for power is expected to be broadly linked to the rate of production and has been forecast based on the expected production in each year. Using the expected composition of the fuel gas, an emissions factor has been developed in accordance with NGERs Method 2.

An assessment on the average flaring rate per day has also been completed, considering both continuous sources (i.e. pilot gas) and episodic flaring associated with planned and unplanned production system events (start-ups and shutdowns). The assessment of episodic flaring considered both the expected frequency of flaring events and the expected quantity flared during the flaring events. An emissions factor for flaring has been taken from NGERs Method 1.

The expected fugitive emissions has been estimated based on the production rate of the facility. An emissions factor has been taken from NGERs Method 1.

In each instance for upstream processing emissions, the estimate of CO₂-e emissions is equal to the quantity of gas consumed, flared or released as fugitives, multiplied by the respective emissions factor. For a summary of emissions factors used in determining upstream processing emissions, refer to [Table 7-3](#).

GHG emissions associated with the proposed Browse to NWS Project in the State Proposal Area will arise from activities in the Torosa field. Due to the position of the FPSOs outside of the State Proposal Area, operational emissions in the State jurisdiction will be limited to IMR activities on subsea infrastructure and contingent drilling and completions activities on installed wells.

Downstream processing GHG emissions have been apportioned based on the proportion of NWS processing plant capacity that Browse gas utilises, relative to the greenhouse gas footprint currently approved for the facility as per Ministerial Statement 536. These are expected to be further described in the NWSJV's 'North West Shelf Project Extension ERD' (EPA 2186, EPBC 2018/8335).

Table 7-3 Emissions Factors used for Browse to NWS Project Processing Emissions

Source/fuel	Energy Content	kg CO ₂ -e/ GJ (CO ₂)	kg CO ₂ -e/ GJ (CH ₄)	kg CO ₂ -e/ GJ (N ₂ O)	kg CO ₂ -e/ kg Product	NGERs Reference
Fuel Gas Upstream (Scope 1 BJV)	40.0 x 10 ⁻³ (GJ/m ³)	52.7	0.11	0.03	2.88 (per kg fuel gas)	S2.21-2 Method 2
Flaring Upstream	N/A	2.7 (per kg flared)	0.1 (per kg flared)	0.03 (per kg flared)	2.83 (per kg flare)	S3.67 Method 1
Fugitives Total	1.2kg CO ₂ -e (CH ₄) Total (per tonne LNG produced) + 1.4kg CO ₂ -e (CH ₄) Total (per tonne condensate produced)					S3.72 Method 1
Processing Emissions Downstream (Scope 1 NWSJV)	Please refer NWS JV's proposed 'North West Shelf Project Extension ERD' (EPA 2186, EPBC 2018/8335)					

Please note, as the emissions factor for fuel gas upstream has been developed based on the composition of the proposed Browse to NWS Project fuel gas (in accordance with NGERs Method 2), the emissions factor varies slightly from other similar upstream gas projects. The emissions factor used for flaring is the same for all projects described below in [Table 7-4](#), as it takes the emissions factor described in NGERs Method 1 (S3.67).

Table 7-4 Comparison of Emissions Factors used for Fuel Gas across comparable upstream facilities

Project – Fuel Gas	Energy Content (GJ/m ³)	kg CO ₂ -e/ GJ (CO ₂)	kg CO ₂ -e/ GJ (CH ₄)	kg CO ₂ -e/ GJ (N ₂ O)	kg CO ₂ -e/ GJ (Total)
Browse to NWS Project	40.0 x 10 ⁻³	52.7	0.11	0.03	52.84
Barossa	39.3 x 10 ⁻³	51.4	0.1	0.03	51.53
Ichthys	Emissions factor not provided in draft EIS/ERD. Methodology used was consistent with the National Greenhouse Account Factors.				
APLNG	37.7 x 10 ⁻³	51.1	0.2	0.03	51.33

* Note all emissions data for Australian facilities has been sourced from regulatory authorisations (i.e. environmental impact statements, environmental review documents and management plans)

Reservoir CO₂ Emissions Methodology

An assessment of the total quantity of reservoir CO₂ emitted has been completed. The assessment assumed that all reservoir CO₂ must be removed prior to liquefaction of the gas, either at the upstream or downstream facility. The estimate of reservoir CO₂ was based on the expected CO₂ composition of the reservoirs. Due to uncertainty of composition in the reservoir, a high reservoir CO₂ composition case has also been provided.

The amount emitted at each location will be dependent on the proportion of reservoir CO₂ exported from the BJV FPSO to the NWS facilities, i.e. the Browse export gas specification. There is some inherent uncertainty in the Browse export gas specification, which is further addressed below. Upstream and downstream reservoir emissions have been estimated [Table 7-5](#), based on a gas export specification target of 2.5mol% CO₂.

Processing and Reservoir CO₂ Emissions Estimate

A summary inventory of the estimated GHG emissions is provided in [Table 7-5](#). For the proposed Browse to NWS Project, SGM baseline requirements are expected to be achieved through use of offsets (described in [Section 7.7.2](#)). To account for the impact of SGM baseline requirements, estimates for both gross forecast emissions and net forecast emissions have been provided. These terms have the following definitions:

- + **Gross Forecast Emissions:** All greenhouse gas emissions from the final design of the proposed

Browse to NWS Project facilities (upstream and downstream), after energy efficiency and emissions reductions design measures (described in [Section 7.7.1](#)) have been incorporated.

- + **Net Forecast Emissions:** The Gross Forecast Emissions minus those offset by carbon credits (described in [Section 7.7.2](#)).

Forecast Scope 1 (BJV and NWS JV) GHG emissions using the emissions factors are shown in [Table 7-5](#) below.

While CO₂ accounts for the majority of GHG emissions associated with the proposed Browse to NWS Project, other related emissions will also occur across the full scope of proposed project activities, including methane and nitrous oxide. All estimates for CO₂-e include both methane and nitrous oxide. The Global Warming Potential (GWP) adopted to determine the amount of CO₂-e contributed from both methane and nitrous oxide aligns to the *National Greenhouse and Energy Reporting Regulations 2008*, which at time of writing reflected the IPCC's Fourth Assessment Report. A breakdown of the relative contribution of these emissions on a gas-by-gas basis to forecast FPSO GHG emissions by CO₂-e equivalent is presented in [Table 7-6](#).

Note that hydrochlorofluorocarbons/chlorofluorocarbons (HFCs/CFCs) will not be used as refrigerants on the FPSO facilities.

GHG emissions have been estimated based on NGERs emissions factors for Australia.

Table 7-5 Forecast Scope 1 (BJV and NWS JV) GHG emissions summary

CO ₂ -e MT	Average year	Peak production year	Total expected field life	Total extended field life
Upstream (BJV Scope 1)				
Reservoir Emissions ¹	2.3 (2.6) ²	4.0 (4.6)	70 (81)	93 (107)
Fuel Gas	1.3	2.1	40	53
Flaring	0.07	0.07	2	3
Fugitives	0.01	0.02	0.3	0.4
Upstream Total	3.6 (4.0)	6.2 (6.8)	112 (123)	149 (163)
Downstream (Apportioned NWSJV Scope 1)				
Reservoir Emissions ¹	0.5	0.9	16	24
Processing Emissions (fuel and flare)	2.3	4.3	72	98
Downstream Total	2.8	5.2	88	122
Installation				
Installation	Not Estimated		1.0	1.0
SGM Carbon Credit Requirements				
SGM Carbon Credit Requirements	1.61	1.61	50	N/A ³
Totals				

CO ₂ -e MT	Average year	Peak production year	Total expected field life	Total extended field life
Sub-total (reservoir)	2.8 (3.2)	4.9 (5.5)	87 (98)	117 (131)
Gross Total (Upstream + Downstream)	6.4 (6.8)	11.4 (12.0)	200 (211)	272 (285)
Net Total (Upstream + Downstream – Carbon Credits)	4.8 (5.2)	9.8 (10.4)	150 (161)	N/A³

¹ Upstream and downstream reservoir emissions have been estimated based on the maximum expected case given a gas export specification target of 2.5mol% CO₂. The sub-total (reservoir) reflects the total upstream plus downstream emissions, regardless of export CO₂ specification. Estimates of emission implications for a 1 mol% to 2.8 mol% CO₂ gas export specification are presented in [Table 7-7](#). Note the gas export specification is dependent on the outcome of final commercial arrangements.

² Bracketed emissions refer to high reservoir CO₂ composition scenario. Note that downstream reservoir emissions are impacted by the gas export specification and so, in the high reservoir CO₂ scenario, the additional reservoir CO₂ is vented upstream.

³ Based on current SGM requirements, it is anticipated that reservoir CO₂ emissions will contribute to the proposed Browse to NWS Project exceeding facility baseline by approximately 50Mt CO₂-e, which would need to be offset in accordance with the rules of the SGM. This estimate is based on a mid-case reservoir outcome and is subject to change should a different reservoir outcome be realised or if the rules and assumptions which underpin the SGM baseline also change (including the production variables, default and leading practice emission intensities required to define any potential alternative, which are yet to be published in the Schedules associated with the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015).

⁴ As it is a regulatory requirement to determine the baseline on the mid-case forecast emissions, no estimate of baseline or carbon credit requirements has been made for an extended field life scenario.

A gas-by-gas breakdown of gross forecast BJV Scope 1 greenhouse gas emissions has been provided in [Table 7-6](#). Please note that the gas-by-gas breakdown on an annual basis will depend on the availability of the thermal oxidiser on the AGRU vent stream.

Table 7-6 Gross Forecast GHG emissions summary – gas by gas (BJV Scope 1)

CO ₂ -e MT	Average year	Total expected field life	Proportion of CO ₂ -e
Total CO ₂	3.6 (4.0)	112 (123)	99.0%
Total CH ₄	0.03	1.12	1.0%
Total N ₂ O	<0.01	0.03	0.03%

Browse Gas Export Specification - Apportionment of Reservoir CO₂ (Upstream-Downstream)

While an estimate for reservoir emissions based on expected reservoir outcomes is provided in [Table 7-5](#), the individual BJV (Scope 1) and NWSJV (Scope 1) reservoir related emissions are indicative, as the amount emitted at each location is dependent on the proportion of reservoir CO₂ exported from the BJV FPSO to the NWS facilities, i.e. the Browse export gas specification. It is anticipated that the Browse export gas specification will allow a CO₂ composition range of between 1 mol% and 2.8 mol%. However, this is dependent on the outcome of final commercial arrangements between the Browse JV and NWS JV.

To account for this range in potential outcomes, which impacts the relative quantity of reservoir emissions released at each location (but not the total quantity), the reservoir emissions estimated to occur in each jurisdiction under the range of expected export gas specification outcomes has been provided in [Table 7-7](#). This is dependent on the outcome of final commercial arrangements between the Browse JV and NWS JV.

Table 7-7 Forecast individual reservoir related emissions, dependant on the Browse export gas specification

Export Specification Scenario	CO ₂ -e MT	Average year	Peak production year	Total expected field life	Total extended field life
High CO ₂ FPSO Export Specification (Less at FPSO, more at NWS)	Upstream BJV Scope 1	2.2 (2.6) ¹	3.9 (4.5)	68 (79)	91 (105)
	Downstream Apportioned NWSJV Scope 1	0.6	1.1	19	27
	Total (reservoir)	2.8 (3.2)	4.9 (5.5)	87 (98)	117 (131)
Low CO ₂ FPSO Export Spec (More at FPSO, less at NWS)	Upstream BJV Scope 1	2.6 (2.9)	4.5 (5.1)	80 (91)	108 (122)
	Downstream Apportioned NWSJV Scope 1	0.2	0.4	7	10
	Total (reservoir)	2.8 (3.2)	4.9 (5.5)	87 (98)	117 (131)

¹ Bracketed emissions refer to high reservoir CO₂ composition scenario. Note that downstream reservoir emissions are impacted by the gas export specification, and so, in the high reservoir CO₂ scenario, the additional reservoir CO₂ is vented upstream.

7.4.4.3 Third party consumption

Methodology

An estimate of the quantity of greenhouse gas emissions arising from third party consumption has been completed.

For the consumption of LNG anticipated to be produced from the proposed Browse to NWS Project, which is expected to predominately occur internationally, an emissions factor has been sourced from the Ecoinvent v3.5 database. This emissions factor considers the transport, regasification, distribution and final combustion of LNG.

For the consumption of Domgas anticipated to be produced from the proposed Browse to NWS Project, which is expected to predominately occur domestically, an emissions factor has been developed based on NGERs. This emissions factor considers the distribution and final combustion of natural gas. Fugitive emissions of the gas during transmission (i.e. along BTL

pipeline and subsequently the Bunbury to Dampier Pipeline) have been estimated in accordance with NGERs Measurement Determination S3.76 and are not significant. Therefore, they are not presented further.

NGERs end point combustion factors have been used for third party consumption of LPG and condensate, as these constitute a minority of the total products anticipated to be produced from the proposed Browse to NWS Project. The transportation and distribution emissions associated with these products are considered to be negligible when compared to the total Scope 3 emissions estimate.

In each instance for Scope 3 Emissions, the estimate of CO₂-e emissions is equal to the based on the quantity of product consumed, multiplied by the respective emissions factor.

Table 7-8 contains the emissions factors used to inform GHG estimates.

Table 7-8 Emissions Factors used for Browse to NWS Project Transit and Market Emissions

Source/fuel	Energy Content	kg CO ₂ -e/ GJ (CO ₂)	kg CO ₂ -e/ GJ (CH ₄)	kg CO ₂ -e/ GJ (N ₂ O)	kg CO ₂ -e/ GJ (unless otherwise stated)	NGERs Determination Reference
Third Party - LNG	N/A	N/A	N/A	N/A	3.13 (per kg product)	Ecoinvent 3.5
Third Party - Domgas	N/A	N/A	N/A	N/A	2.93 (per kg product)	Schedule 1 (Consumption) S3.80 (Distribution)
Third Party - LPG	25.7 (GJ/kL)	60.2	0.2	0.2	60.6	Schedule 1
Third Party - Condensate	46.5 (GJ/t)	61	0.1	0.2	61.3	Schedule 1

The methodology used by Ecoinvent v3.5 follows the international standards for lifecycle assessment. The Ecoinvent v3.5 emissions factor is based on individual production processes which contain Scope 1 emission factors, covering all greenhouse gas emissions, as connected along a production chain to deliver intermediate or final production processes. The methodology includes infrastructure, manufacturing processes, fugitive emissions as well as all energy-related emissions. Allocation between coproducts is done based on physical parameters, where available, such as energy content for coproduced energy products and, where a physical basis cannot be established, allocation is based on relative economic value of coproducts.

Ecoinvent v3.5 represents arguably the largest public collection of inventory data in the world, covering over 5000 products and containing 17000 unit

processes. It has been recognised as emission factor source for the European Union Renewable Energy Directive greenhouse gas methodology and sits in the background of many of the National Carbon Offset Scheme (NCOS) emission factors. The Ecoinvent factors are therefore aligned in methodology to the principles of the NGERs methodology.

Estimate

Third party consumption emissions, as per the emissions factors used in [Table 7-8](#), reflect emissions associated with the final combustion and use of the product and are shown in [Table 7-9](#). Third party consumption emissions form the largest part of the overall emissions related to the Browse to NWS Project. It is expected that the majority of these GHG emissions will occur internationally and be managed and mitigated through local and international emissions control frameworks.

Table 7-9 Forecast Third Party consumption GHG emissions summary

CO ₂ -e MT	Average year	Peak production year	Total expected field life	Total extended field life
Third Party Consumption (Scope 3)				
Consumption – LNG (transport, regasification and distribution, and combustion)	22	38	691	944
Consumption – Domgas (distribution and combustion)	3.3	5.6	103	134
Consumption – LPG (Combustion only)	0.9	1.5	28	12
Consumption – Condensate (Combustion only)	5.6	10.6	173	241
Total	32	55	995	1330

The sum of all average year Scope 1 (BJV and NWS JV) ([Table 7-5](#), total average year) and Scope 3 ([Table 7-9](#), total average year) emissions is 36.8 MT.

7.4.5 Emissions Lifecycle and Intensity

7.4.5.1 Estimate lifecycle emissions and emissions intensity

Assessing the potential climate change impact of a proposed project requires an understanding of both direct and indirect GHGs. A lifecycle approach is useful to both collate this information into a single value and to compare impact between different products or value chains.

When conducting a lifecycle assessment, boundaries between upstream and downstream value chain components must be set. For example, [Figure 7-2](#) represents the anticipated emissions intensity of proposed processing Browse feedgas at the KGP and delivering product to China for use in a combined cycle gas turbine. This shows that electricity sourced from Browse gas has a lifecycle emissions intensity of 550 kgCO₂-e/MWh.

The IPCC summarised the lifecycle emissions intensity of electricity from various emissions sources (IPCC, 2011). This showed that the median emissions intensity of gas fuelled electricity was circa 450kgCO₂-e/MWh and that the Browse emissions intensity fits within the interquartile range for global gas fired electricity of 400-550kg CO₂-e/MWh. IPCC also showed that oil and coal power electricity generates 1000kg CO₂-e/MWh, whilst renewables and nuclear generate 0-50kg CO₂-e/MWh.

Based on the comparison between electricity generated from Browse LNG and the electricity generated from coal, 121 kgCO₂-e/kWh is emitted in Australia (22% of 550) and 450 kgCO₂-e/kWh is saved in the global energy system. In this case, every tonne of GHG emitted in Australia could displace 3.7 tonnes of GHG elsewhere in the global energy system.

7.4.5.2 Natural gas in the context of global emissions

The scientific consensus on climate change, and the commitment of global governments to reduce emissions, is clear. There is also a need to both improve local air quality and increase access to modern energy sources. Access to clean, affordable and reliable energy improves living standards dramatically and the world's growing population is driving increased energy demand.

Numerous independent energy and climate bodies agree that natural gas has a significant role to play in achieving both a reduction in net global emissions and an increased access to a reliable modern energy supply that supports a progressive transition to renewable energy sources. The IPCC's 2014 Synthesis Report said that "GHG emissions from energy supply can be reduced significantly" by switching to gas. According to the IPCC, electricity generated from gas has on average half the GHG emissions of electricity generated from coal (IPCC, 2014). According to the International Energy Agency (IEA), in 2018 coal-to-gas switching helped avert 95 MT of CO₂ emissions (IEA, 2019).

A key technical challenge with the widespread deployment of renewables is the low capacity factor, as renewable power such as from wind and solar can be intermittent or inconsistent. As a readily dispatchable and reliable power source, gas-fired power is an ideal partner with renewables, as it can be quickly turned on to provide system stability when renewable power generation or electricity demand fluctuates. By providing this firming capacity, gas-fired power allows high renewable penetration in the form of a reliable power source to help resolve intermittency issues.

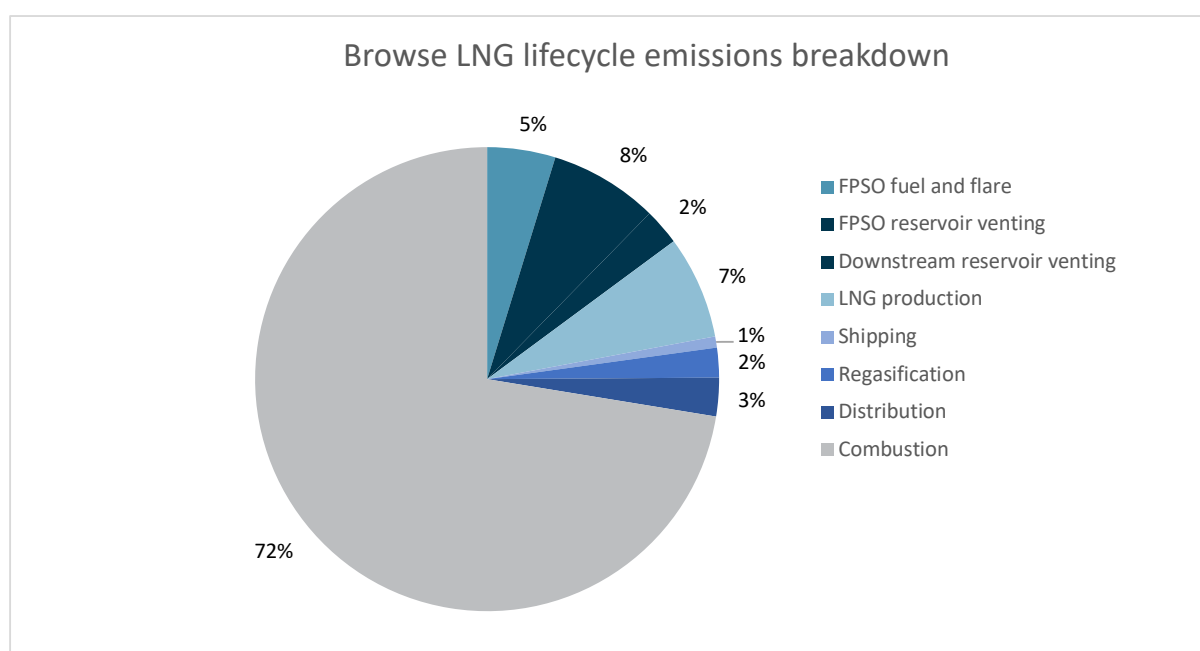


Figure 7-2 Proposed Browse to NWS Project lifecycle emissions intensity

Each year the IEA publishes a World Energy Outlook (WEO). Since 2017, the WEO has included a Sustainable Development Scenario (SDS), which describes an energy system that satisfies the three objectives of mitigating climate change, providing universal energy access by 2030 and reducing the severe health impacts of air pollution. Emissions projections in the SDS are “lower than most published decarbonisation scenarios based on limiting long-term global average temperature rise to 1.7-1.8°C” (IEA, 2019).

The SDS shows that natural gas continues to increase until at least 2040, the end of the period modelled ([Figure 7-3](#)). In the consumer countries relevant to the proposed Browse to NWS Project, gas consumption grows by 130% between 2017 and 2040. This suggests that increased gas use is not only consistent with the SDS but necessary if the goals of climate change mitigation, air quality improvements and energy access are to be achieved.

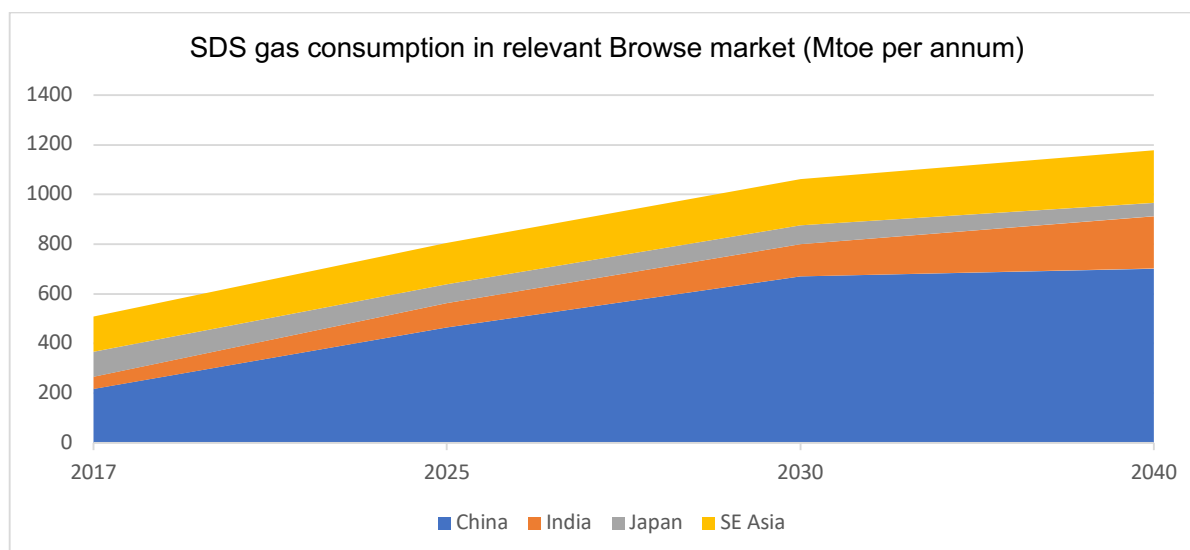


Figure 7-3 Forecast gas consumption in the IEA's SDS in relevant Browse markets (Mtoe)

7.5 Receptors and Receptor Sensitivity to Global GHG emissions

A recent Intergovernmental Panel on Climate Change (IPCC) Report (Hoegh-Guldberg et al., 2018) summarised the potential impact of human-induced climate change (at 1.5 and 2°C) on a range of climatic variables (e.g. temperature, precipitation, drought, extreme events) and the likely consequence to different ecosystems and ecosystem services, at a range of spatial scales.

Modelling indicated that temperatures will increase across Australia, rainfall patterns will change significantly and extreme events such as droughts, floods and wildfires will become more common. These changes are likely to impact on individual species, ecosystems and ecosystem services such as food and water availability. Within decades, environments across Australia may be substantially different. Biodiversity will be affected by climate change in a variety of ways and there will be much spatial variation in ecological change (CSIRO, 2015).

A report by Australia's Biodiversity and Climate Change Advisory Group (Steffen et al., 2009) in 2009 gives a summary of potential impacts to marine and terrestrial species, habitats and ecosystems across Australia. The impacts to taxa are outlined in [Table 7-10](#) and the impacts to ecosystems in [Table 7-11](#).

7.5.1 Species-related Impacts from Global GHG Emissions

Extensive modelling and monitoring studies over the last twenty years provide considerable evidence that global climate change is already affecting and will continue to affect species (Hoegh-Guldberg et al., 2018). In addition, climate-change related impacts to flora and fauna are likely to be highly species-dependent and spatially variable. However, fauna distribution patterns are likely to shift in response to a changing climatic regime. Species distributions are likely to shift towards the poles and upwards in elevation and shifts in phenology (earlier spring and later autumn life history events) are the most frequently observed and cited ecological responses to climate change (Dunlop et al., 2012).

Climate change may not only change species distribution patterns but also life-history traits such as migration patterns, reproductive seasonality and sex-ratios (see [Table 7-10](#)). For example, Dunlop (2009) highlighted that in Australia, migratory birds have undergone changes in the first arrival date (3.5 days/decade), and last date of departure (5.1 days/decade) (Beaumont et al., 2006). Pairing of sleepy lizards has been observed to start earlier and last longer when the last months of winter are warmer (Bull and Burzacott, 2002). Climate change may account for earlier arrival of bird species in the Australian Alps, but the change appears not to be a simple consequence of incremental annual warming resulting from earlier snow-melt (Green, 2006; Normant and Green, 2004).

Table 7-10 Overview of impacts of climate change to the future vulnerability of particular taxa (modified after Steffen et al 2009)

Taxa	Potential vulnerability
Mammals	Narrow-ranged endemics susceptible to rapid climate change in situ (Williams et al., 2003); changes in competition between grazing macropods in tropical savannas mediated by changes in fire regimes and water availability (Ritchie and Bolitho, 2008); herbivores affected by decreasing nutritional quality of foliage as a result of CO ₂ fertilisation.
Birds	Changes in phenology of migration and egg-laying; increased competition of resident species; breeding of waterbirds susceptible to reduction; top predators vulnerable to changes in food supply; rising sea levels affecting birds that nest on sandy and muddy shores, saltmarshes, intertidal zones, coastal wetlands and low-lying islands; saltwater intrusion into freshwater wetlands affecting breeding habitat.
Reptiles	Warming temperatures may alter sex ratios of species with environmental sex determination to cope with warming in situ.
Amphibians	Frogs may be the most at-risk terrestrial taxa. Amphibians may experience altered interactions between; pathogens, predators and fires.
Fish	Freshwater species vulnerable to reduction in water flows and water quality; limited capacity for freshwater species to migrate to new waterways; all species susceptible to flow-on effects of warming on the phytoplankton base of food webs.
Invertebrates	Expected to be more responsive than vertebrates due to short generation times, high reproduction rates and sensitivity to climatic variables.
Plants	Climate change may impact various functional dynamics of plants due to changes in; increasing CO ₂ , fires, plant phenology and specific environmental characteristics.

7.5.2 Projected Climate Change Impacts to Ecosystems from Global GHG Emissions

The results of climate change, such as altering temperature, rainfall patterns and fire regimes, are likely to lead to changes in vegetation structure across all terrestrial ecosystems within Australia (Table 7-11; Dunlop et al., 2012). Increases in fire regimes will impact Australian ecosystems by altering composition structure, habitat heterogeneity and ecosystem processes. Changes in climate variability, as well as averages, could also be important drivers of altered species interactions, both native and invasive species (Dunlop et al., 2012). Climate change could result in significant ecosystem shifts, as well as alterations to species ranges and abundances within those ecosystems (Hoegh-Guldberg et al., 2018).

Table 7-11 Projected impacts of CO₂ rise and climate change on Australian ecosystems (modified after Steffen et al 2009)

Key component of environmental change	Projected impacts on ecosystems
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 frequency of bleaching events exceeds recovery time, reefs will be maintained in an early successional state or be replaced by communities dominated by macroalgae.
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 (1–2 degrees), leading to effects on growth rates, survival, dispersal, reproduction and susceptibility to disease.

Key component of environmental change	Projected impacts on ecosystems
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. 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 concomitant decrease in the availability of carbonate ions.
Estuaries and coastal fringe (including benthic, mangrove, saltmarsh, rocky shore, and seagrass communities)	
Sea level rise	Landward movement of some species as inundation provides suitable habitat, changes to upstream freshwater habitats will have flow-on effects to species.
Increase in water temperature	Impacts 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 northwest region	Increased plant growth will lead to higher fuel loads, in turn leading to fires that are more intense, frequent and occur over large areas.
Tropical rainforests	
Warming and changes in rainfall patterns	Increased probability of fires penetrating into rainforest vegetation resulting in shift from fire-sensitive vegetation to communities dominated by fire-tolerant species.
Change in length of dry season	Altered patterns of flowering, fruiting and leaf flush will affect resources for animals.
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.
Inland waterways and wetlands	
Reductions in precipitation, increased frequency and intensity of drought	Reduced river flows and changes in seasonality of flows.
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.
Sea level rise	Saltwater intrusion into low-lying floodplains, freshwater swamps and groundwater; replacement of existing riparian vegetation by mangroves.
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 impacts on fire frequency. Dryland salinity could be affected by changes in the timing and intensity of rainfall.

Key component of environmental change	Projected impacts on ecosystems
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 snow pack is reduced.

7.5.2.1 Terrestrial Ecosystems

All terrestrial ecosystems are likely to be impacted by a changing climate ([Table 7-11](#); Steffen et al 2009; Hughes 2010; Dunlop et al. 2012; Hoegh-Guldberg et al. 2018). The predicted impact of climate change on these ecosystems is highly variable, both between ecosystems and within individual ecosystems ((Dunlop et al., 2012). Below is a summary of impacts to key terrestrial ecosystems (other ecosystems are summarised in [Table 7-11](#)).

Tropical Rainforests

Projections of future climate changes in the wet tropics of Australia under different scenarios are outlined by McInnes (2015). It is likely that temperatures in the wet tropics will become hotter and potentially fires and cyclones will be more intense. Consequently, there is an increased probability of fires penetrating into rainforest vegetation resulting in a shift from fire-sensitive vegetation to communities dominated by fire-tolerant species; and changing rainforest disturbance regime as cyclones become more intense (Hughes, 2011; Steffen et al., 2009). Changes in the timing of seasons (e.g. extended summer) could cause change in the seasonal response of plants, and alterations to species ranges and abundances (Hoegh-Guldberg et al., 2018).

Alpine/ Montane Areas

Alpine systems are generally considered to be among the most vulnerable to future climate change (Hughes 2003). The extent of true alpine habitat in Australia is very small (0.15% of the Australian land surface) with limited high-altitude refuge (Hughes, 2003).

Australian alpine regions are home to a variety of alpine vertebrates who rely on snow cover for their survival. There is evidence of a reduction in populations of dusky antechinus, broad-toothed rats and the mountain pygmy possum. The first two species are active under the snow throughout winter and are therefore subject to increased predation by foxes when snow is reduced (Hughes, 2003). The pygmy possum depends upon snow cover for stable, low temperatures during hibernation (Hughes, 2003).

7.5.2.2 Marine Ecosystems

Sea surface temperatures have increased across the globe over recent decades which poses a significant threat to marine ecosystems including changes to species abundance, community structure and increased frequency and intensity of thermally induced coral bleaching events (CSIRO, 2017).

Between 1920 and 2000, sea level is estimated to have risen on average 1.2 mm per year due to climate change (Church et al., 2006). In addition to changes in sea level, oceanic warming has also served to alter ocean currents around Australia. In response to both ocean warming and stratospheric ozone depletion the East Australian Current has increased in strength by about twenty percent since 1978 (Cai and Cowan, 2006).

Sea-surface temperatures are projected to continue to increase, with estimates of warming in the Southern Tasman Sea of between 0.6 and 0.9°C and between 0.3 and 0.6°C elsewhere along the Australian coast by 2030 (Church et al., 2006). Sea levels are predicted to increase by 18 to 59 cm by 2100 in response to both thermal expansion and melting of ice-sheets (Solomon et al., 2007). This would lead to some coastal inundation affecting mangroves, salt marshes and coastal freshwater wetlands. Furthermore, as CO₂ is gradually absorbed by oceans and fresh water, the water becomes more acidic, which increases the solubility of calcium carbonate, the principal component of the skeletal material in aquatic organisms (Steffen et al., 2009). Below is a summary of potential climate change impacts to two key ecosystems - mangroves and coral reefs.

Mangroves

Mangrove ecosystems in Australia could face higher temperatures, increased evaporation rates and warmer oceans (McInnes, 2015) as well as an associated sea-level rise (Hoegh-Guldberg et al., 2018). Modelling indicates an increased likelihood of future severe and extended droughts across parts of Northern Australia (Dai, 2013). Consequently, mangrove ecosystems may increase their southern range as a result of warmer temperatures. However, higher temperatures and evaporation rates, and extended droughts could lead to die-offs in northern Australia and a change in mangrove distribution and abundance (Duke et al., 2017). Mangrove systems should cope with rising sea-level by accumulating more peat or mud, giving them the opportunity to adjust to a rising sea level (Field, 1995).

Coral Reefs

Climate change has emerged as a threat to coral reefs, with temperatures of just 1°C above the long-term summer maximum for an area over 4–6 weeks being enough to cause mass coral bleaching and mortality (Baker et al., 2008; Hoegh-Guldberg, 1999; Hughes et al., 2017; Spalding and Brown, 2015). Coral mortality or die off following coral bleaching events can stretch across thousands of square kilometres of ocean (Gilmour et al., 2016; Hoegh-Guldberg, 1999; Hughes et al., 2017). The impacts associated with a warming ocean, coupled

with increasing acidification, are expected to undermine the ability of tropical coral reefs to provide habitat for fish and invertebrates, which together provide a range of ecosystem services (e.g., food, livelihoods, coastal protection); (Hoegh-Guldberg et al., 2018).

As described in [Chapter 5](#), evidence of thermal-induced bleaching and the associated impacts has been observed during long term monitoring of the corals at Scott Reef which lie within the proposed Browse Development Area. These corals have experienced four thermally induced bleaching events since 1998. While Scott Reef showed rapid recovery of corals after bleaching events, the increasing frequency of these events due to climate change has the potential to affect this recovery (Gilmour et al., 2016).

7.5.3 Projected Climate Change Impacts to Social, Economic and Cultural Aspects from Global GHG Emissions

Noting the inherent uncertainty in estimating the impacts of climate change, [Table 7-12](#) below provides a summary of possible impacts of climate change on social and economic components from global GHG emissions. The data is drawn from existing Australian Government resources (Climate Change Authority, 2014; DoEE 2019).

Table 7-12 Possible impacts of CO₂ rise and climate change on Australian social, economic and cultural aspects

Social/economic categories & impact causes		Possible impacts
Cities and the built environment		
Sea level rise, flooding, ocean acidification, wildfire and other extreme events		Both gradual changes (sea-level and temperature rise, ocean acidification) and extreme events (flash floods, heatwaves and bushfires) may increase repair frequency and drive relocation.
Agriculture, forestry, fisheries, broader industries and employees		
Decrease in rain fall		Reduced agricultural yields in Southern Australia.
Change in temperature		Livestock under greater heat stress resulting in reduced productivity and reproductive rates.
Change in climate		Changes in growing season and location may impact food transport costs and availability
		Increased severity and frequency of extreme weather events, water shortages and exposure to tropical diseases may impact industry and labor mobility. Tourism and agricultural industries may be the most vulnerable.
Water resources		
Changes in groundwater		Altered groundwater recharge rates and supplies, seawater intrusion to coastal aquifers, reduction of freshwater availability on small islands, and increased demand from communities and industries.

Social/economic categories & Possible impacts impact causes	
Change in temperature	Potential increase in the risk of bacterial contamination in water supplies, blue-green algal outbreaks and acid-sulphate soil issues.
Health and wellbeing, human factors	
Changes to ecosystem services	Impaired services such as clean air, fresh water, and protection from natural disasters.
Increase in temperature and rainfall patterns	Increased risk of temperature related injury, disease and death. This includes an increased area of land suitable for mosquitoes that transmit disease.
Increase in extreme events	Increased risk of injuries, disease, and disruption to health services.
Change in climate	Drought has been linked to decreased mental health, particularly in rural communities.
	Aboriginal Australians may experience a higher impact from climate change due to close connections to the natural environment (both cultural and income related) and higher rates of socio-economic disadvantage.

7.5.4 Projected Effect of Global Emissions on Receptor Trends

The IPCC Special Report describes the impacts of warming above pre-industrial levels to key receptor groups including terrestrial ecosystems, mangroves, warm-water corals, unique and threatened systems, and arctic regions (Hoegh-Guldberg et al. 2018). These receptor groups show varying sensitivity to warming conditions, with a range of responses shown at 1°C warming; from corals suffering moderate impacts, to mangroves not showing any impacts that are detectable and attributable to climate change (Hoegh-Guldberg et al., 2018). Once warming reaches 1.5°C, all receptor groups show impacts attributable to climate change, with severity ranging from moderate impacts that are detectable and attributable to climate change (mangroves), to impacts that are severe and widespread (warm-water corals) (Hoegh-Guldberg et al., 2018). At the point where global temperature rise due to climate change reaches 2°C, increasing numbers of receptor groups suffer impacts which are high to very high, and

likely to be irreversible (terrestrial ecosystems, warm-water corals, unique and threatened systems, and arctic regions) (Hoegh-Guldberg et al., 2018).

7.6 Browse to NWS Project Relative to Global GHG Emissions

While it is not feasible to directly correlate the potential impact of the proposed Browse to NWS Project GHG emissions on receptors (be that impact negative or positive in the case of replacing higher carbon fuels), the direct contribution of the proposed Browse to NWS Project GHG lifecycle emissions (including NWSJV Scope 1 emissions) to global emissions can be estimated. [Table 7-13](#) shows the estimated average GHG contribution compared to five United Nations Environment Program NDCs Scenarios. As per [Section 7.4.5](#), the proposed Browse to NWS Project total lifecycle emissions are anticipated to be less than if equivalent energy were to be generated from coal.

Table 7-13 Proposed Net Browse to NWS Project average GHG lifecycle emissions contribution to NDC Scenarios

Lifecycle emissions	Total global GHG emissions (MtCO ₂ -e/year) (UN Environment, 2018)	Proposed Browse to NWS Project Scope 1 (Net average (upstream and downstream) of 4.8 MtCO ₂ -e/ year (%))	Proposed Browse to NWS Project total lifecycle emissions (Average of 36.8 MtCO ₂ -e/ year (%))
2030 (no policy baseline)	65,000	0.01	0.06
2030 (current policy scenario)	59,000	0.01	0.06
2030 (2°C pathway)	40,000	0.01	0.09
2030 (1.5°C pathway)	24,000	0.02	0.15

It should be noted that the 2030 emissions forecasts are United Nations Environment Program estimates only and total global GHG emissions reflect anthropogenic emissions only.

Woodside Energy Ltd is operator for and on behalf of a number of Joint Ventures and is currently proposing other developments in the region. For more information on greenhouse gas emissions associated with each development, please refer to:

- + North West Shelf Project Extension ERD (EPA 2186, EPBC 2018/8335)
- + Scarborough OPP (NOPSEMA A679881)
- + Pluto LNG Development (EPA 1632, EPBC 2006/2968).

Please note, greenhouse gas emissions associated with the developments listed above is not addressed further in this draft EIS/ERD, as they are assessed in their respective assessment documents.

Under the Paris Agreement, Australia has a target of reducing emissions by 26-28 per cent below 2005 levels by 2030. Australia stated in its Nationally Determined Contribution that it would develop its target into an emissions budget covering the period 2021-2030. The cumulative emission budget for this period is 4800 MT to reach the 26% reduction target (DoEE, 2018). Scope 1 and 2 GHG emissions from the upstream component of the proposed Browse to NWS Project are expected to contribute to 0.8 % of this cumulative emissions budget. The [Australia's emissions projections 2018](#) report provides an indicative summary of how Australia is tracking to achieve its Nationally Determined Contribution of 26 to 28 per cent below 2005 levels in 2030. Projected emissions to 2030 from the LNG sector (direct combustion and fugitive) are included in the methodology used to underpin these projections. The methodology is based on an export capacity of 80MPTA of LNG in 2020 with the addition of one new LNG train in the mid-2020s.

The emissions reduction task to achieve the 2030 target is currently 328 MT CO₂-e. The Australian government has outlined a plan to closing this gap in the [Climate Solutions Package](#).

7.7 Management and Mitigation of GHG Emissions

7.7.1 Processing Emissions

The following key energy efficiency and emissions reductions measures have been incorporated into the design of the proposed Browse to NWS Project. The associated emissions reductions achieved by these initiatives have been estimated and presented in square brackets next to each initiative. Note that estimates are presented as being across two FPSO facilities, operating at maximum pipeline throughput (i.e. the “max” scenario). The measures are:

- + waste heat recovery units on gas turbines [0.70 MT CO₂-e/annum]
- + active heating system used to prevent hydrate formation in flowlines avoiding the requirement for an energy intensive MEG regeneration plant [0.20 MT CO₂-e/annum]
- + batteries for peak power supply [0.10 MT CO₂-e/annum]
- + efficient aero-derivative gas turbines [0.02 MT CO₂-e/annum]
- + use of nitrogen to purge the flare stack rather than hydrocarbon gas [expected less than <0.1 MT CO₂-e/annum].

Note that without the above key energy efficiency and emissions reductions measures, the Scope 1 forecast gross emissions associated with the Browse to NWS Project would be higher. By saving approximately up to 1 MT of CO₂-e on average per year, this has reduced the expected average annual net Scope 1 Project emissions from up to 5.8 MT CO₂-e to 4.8 MT CO₂-e per year and saved 31 MT CO₂-e of Scope 1 emissions over the expected life of the Project.

To compare processing emissions for upstream facilities, it is important to recognise that for upstream developments such as the Browse to NWS Project, the amount of energy required to process and export the gas is principally driven by:

- + The amount of CO₂ that needs to be removed from the gas stream, as the process to remove the CO₂ from the gas stream is heat-intensive.
- + The distance that the gas needs to be transported, as the amount of energy required to achieve the required gas export rate and pressure increases as the distance increases.

As the above variables are highly reservoir and location specific it is difficult to draw comparisons between projects. However, as Browse has a relatively high reservoir CO₂ content, and the Browse Trunkline is approximately 900 km long to NWS facilities, then the most comparable facilities are those with:

- + Long pipelines or pipeline networks to reach the downstream LNG facility (i.e. have similar compression requirements).
- + High reservoir CO₂ content, and therefore either need to consume energy to remove the CO₂ or consume more energy to export it to the downstream LNG facility.

On this basis the two most comparable facilities identified are the proposed Borossa-Caldita project and the Ichthys project, due to somewhat similar reservoir CO₂ content and distance to the LNG facilities.

For completeness based on distance to LNG facilities an unconventional reservoir for APLNG has also been selected due to its substantial gas gathering network and distance to LNG facilities. **Figure 7-4** provides benchmarking between the processing emissions for the proposed Browse FPSOs and identified comparable facilities in Australia, to demonstrate the effectiveness of the upstream design in consuming energy to process the gas stream and pressurise it for export. Intensity has been calculated on a fuel gas use only and **Figure 7-4** does not include the reservoir CO₂ emissions. The CO₂ percentage has been provided as an indicator of the likely energy expenditure on CO₂ removal for each project. Note the data used to calculate other operators' emissions intensity is of varying quality and has been sourced from regulatory authorisations (i.e. environmental impact statements, environmental review documents and management plans), actual emissions intensity of facilities in operation may differ from that presented.

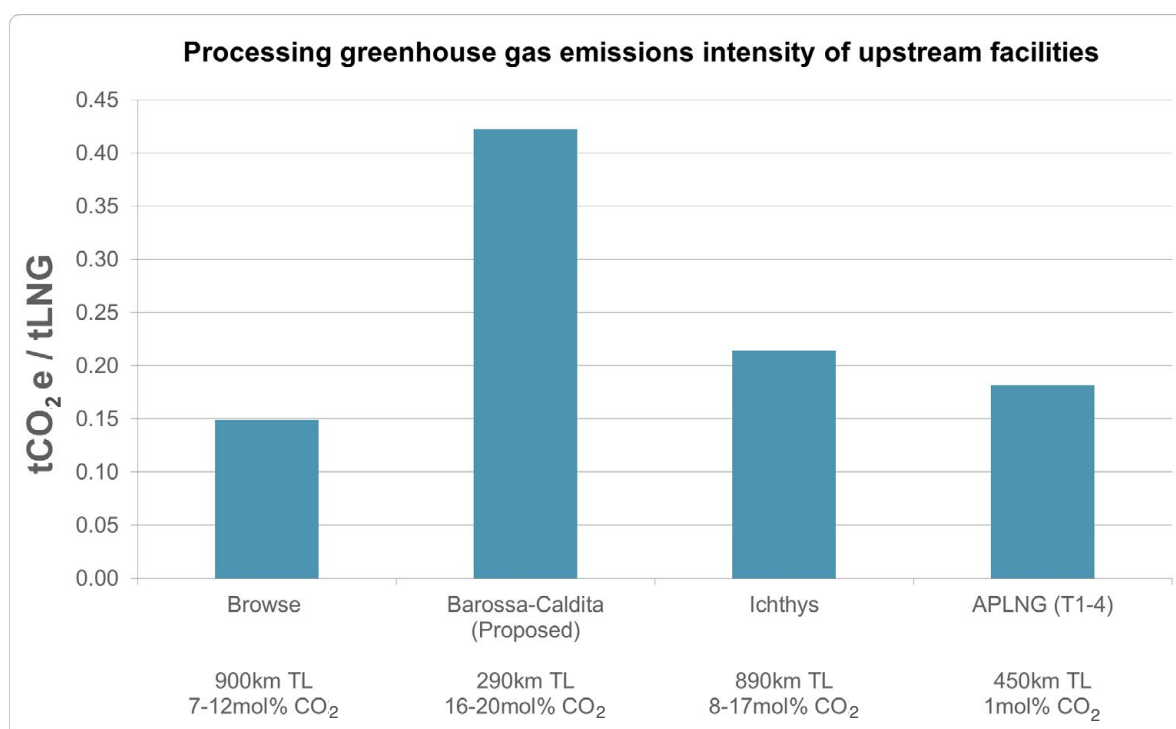


Figure 7-4 Processing CO₂-e Emissions Intensity of Comparable Upstream Facilities*

* Note all emissions data for Australian facilities has been sourced from regulatory authorisations (i.e. environmental impact statements, environmental review documents and management plans)

Mitigation and management measures associated with anticipated processing emissions for the NWS Extension Project are described in the NWSJV's 'North West Shelf Project Extension ERD' (EPA 2186, EPBC 2018/8335).

7.7.2 Carbon Credits

Under the National Greenhouse and Energy Reporting scheme, the BJV will be required to surrender Australian carbon credit units (ACCU) to offset emissions over the SGM baseline. Offsets may be secured by the

Operator (Woodside) or separately by individual Joint Venture Participants for their equity emissions. Offsetting opportunities that will be investigated include industry methods or land-based solutions for carbon sequestration, which may include savanna burning, environmental planning, native tree planting and human induced land restoration.

By way of example, Woodside has recently entered into a Heads of Agreement (HoA) with Greening Australia to co-create large-scale, native tree planting projects that generate quality carbon offsets. Woodside and Greening Australia will assess environmental and economic viability of a range of opportunities across Australia, with an initial focus in Western Australia. The agreement is scalable and the first phase will involve planting up to 5000 hectares in 2020, in an ecologically and scientifically responsible manner, primarily in Western Australia.

The generation of GHG offsets through approved and validated carbon farming methodologies is a significantly lower risk and more cost-effective solution than geosequestration of Browse reservoir CO₂. GHG offsets also offer co-benefits resulting from the additional ecosystem services provided when carbon is bio-sequestered, as well as social, economic and environmental benefits (e.g. improvements to air quality, employment opportunities in remote communities or provision of additional habitat for fauna).

It is also anticipated that there will be emissions associated with the proposed processing of Browse feed gas through third party infrastructure as described above in [Section 7.7.1](#). The BJV is a party seeking long term processing services from the NWSJV. It is anticipated that these emissions will be mitigated and managed by the NWSJV in accordance with regulatory requirements applicable to the proposed NWS Extension Project. It must be noted that the NWSJV will not solely process Browse gas as existing NWSJV reserves will continue to be produced, and there is potential for additional resource owners to secure processing services with NWSJV. The BJV is presently negotiating commercial arrangements with the NWSJV regarding the provision of gas processing services.

7.7.3 Geosequestration

There are two main CO₂ emission streams ([Figure 7-2](#)) that could be considered for geosequestration – the AGRU and emissions from the gas turbines. This would involve the capture of CO₂ at the outlet of a major gas stream, such as the vent stream from the offshore AGRU or from the exhaust stream of the gas turbines. While the offshore AGRU stream is predominantly CO₂, the gas turbine exhaust stream would likely require further processing to strip the CO₂ from the stream for capture. Further processing of the exhaust stream would add significant complexity and is prohibitive in an offshore environment where space is restricted. LNG projects that do geosequester typically geosequester the AGRU vent stream only.

Once CO₂ emissions are captured, the stream would then be pressurised and re-injected into a suitable subsurface disposal target. Over 30 potential re-injection sites near the proposed Browse Development Area were identified and screened based on their cost, subsurface suitability and risk profile (including non-technical

risks such as gaining access to land, complexity of commercial agreements, etc.).

Based on this screening, the Calliance reservoir was identified as a potentially viable re-injection site. As the Calliance reservoir will be a producing gas and condensate field, its use as a geosequestration site would carry significant technical, operational and safety risks. These include:

- + Technical feasibility as offshore geosequestration at the required scale is unproven.
- + Subsurface inject-ability risk; by reinjecting into a producing reservoir, there is a risk that more CO₂ is produced from the reservoir (i.e. the CO₂ 'recycles'), reducing the impact of geosequestration as a mitigation measure.
- + Safety risk during operations as an additional safety hazard (CO₂ asphyxiation) is added to the FPSO, associated with additional processing and compression.

Geosequestration is, therefore, a high risk, high cost mitigation option for Browse reservoir CO₂.

7.8 Acceptability Assessment

An assessment of the acceptability of proposed Browse to NWS Project GHG emissions is provided in [Table 7-10](#).

The assessment of acceptability has been undertaken in consideration of:

- + principles of ESD as defined in Section 3A of the EPBC Act
- + MNES Significant Impact Guidelines (EPBC Act)
- + WA EPA Environmental Factors and Objectives (EP Act)
- + other aspect or receptor requirements including State, Federal and international standards, laws, policies and guidelines, including management plans and conservation advice
- + external requirements
- + internal requirements.

Further details in relation to these criteria are set out in [Chapter 6](#).

Overall, in the context of Australia's international commitments and local legislation and policy, it is considered that given the proposed mitigation of emissions, safeguard mechanism obligations and the importance of gas as a clean and reliable source of energy in the current and future energy mix, GHG emissions from the proposed Browse to NWS Project are acceptable.

Table 7-14 Acceptability Assessment – GHG emissions

Acceptability Assessment**Principals of ESD**

As described in [Section 7.4.5](#) the provision of clean and reliable energy is paramount to the lifting of worldwide living standards. As a clean and reliable energy source, gas is expected to play a key role in the future energy mix (as a partner to renewables). In addition, gas has the potential to contribute significantly to the reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. coal burning).

Given the importance of gas in the current and future energy mix, the planned emissions mitigation and offsetting ([Section 7.7](#)) to reduce GHG emissions; and the broader socio-economic benefits to both Australia and the State of Western Australian of the proposed Browse to NWS Project, it is considered that the principals of ESD have been met.

Conclusion: Acceptable**Significant impacts as defined by the MNES Significant Impact Guidelines**

No direct impacts to listed threatened and migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment are predicted to occur as a result of GHG emissions from the proposed Browse to NWS Project.

Climate change induced impacts to listed or threatened species, threatened ecological communities, the Commonwealth Marine Area or the environment resulting from the proposed Browse to NWS Project are difficult to predict and likely immeasurable. Global GHG emissions will continue to have an effect on trends in receptor condition and potential impacts to listed threatened and migratory species, threatened ecological communities or the Commonwealth Marine Area or environment may occur as a result ([Section 7.5](#)). As a stand-alone project, however, taking into account all planned emissions reduction and offsetting measures ([Section 7.7](#)), it is estimated that Scope 1 and 3 emissions from the proposed Browse to NWS Project could contribute in the range of 0.06% to 0.15% global GHG emissions depending on the NDC scenario considered ([Table 7-13](#)). As a stand-alone project, GHG emissions from the proposed Browse to NWS Project will not have a significant impact (as defined by the MNES Significant Impact Guidelines) on listed threatened species or migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment. The proposed Browse to NWS Project has proposed a GHG Abatement Plan to continuously review mechanisms to mitigate and manage GHG emissions and compliance with NGER/SGM baseline requirements through ACCUs to offset anticipated excess emissions over baseline.

Further, as discussed in [Section 7.7.1](#), gas use is not only consistent with the WEO's SDS but required to achieve the goals of climate change mitigation, air quality improvements and energy access. As such, the proposed Browse to NWS Project may potentially have a positive impact via the reduction of global emissions with potential subsequent reduction in impacts to sensitive receptors resulting from climate change. However, this is acknowledged as being uncertain in a global context and therefore is appropriately categorised as gas having benefits over the use of coal in generating electricity.

Conclusion: Acceptable

Acceptability Assessment

WA EPA Environmental Objectives

No direct impacts to benthic communities and habitats, marine environmental quality or marine fauna are predicted to occur as a result of GHG emissions from the proposed Browse to NWS Project.

Climate change induced impacts to benthic communities and habitats, marine environmental quality or marine fauna resulting from the proposed Browse to NWS Project are difficult to predict and likely immeasurable. Global GHG emissions will continue to have an effect on trends in receptor condition and potential significant impacts to benthic communities and habitats, marine environmental quality or marine fauna may occur as a result ([Section 7.5](#)).

As a stand-alone project however, taking into account all planned emissions reduction and offsetting measures ([Section 7.7](#)), it is estimated that Scope 1 and 3 emissions from the proposed Browse to NWS Project will contribute in the range of 0.06% to 0.15% of global GHG emissions depending on the NDC scenario considered ([Table 7-13](#)).

As such, it is not considered credible that as a stand-alone project, GHG emissions from the proposed Browse to NWS Project will significantly impact benthic communities and habitats, marine environmental quality or marine fauna and, as such, the relevant EPA objectives for these environmental factors will be met.

Further, as discussed in [Section 7.7.1](#), gas has the potential to contribute significantly to the reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. coal-gas energy switch). As such, the proposed Browse to NWS Project may potentially have a positive impact via the reduction of global GHG emissions, with potential subsequent reduction in impacts to sensitive receptors resulting from climate change. However, this is acknowledged as being uncertain in a global context and therefore is appropriately categorised as gas having benefits over the use of coal in generating electricity.

Conclusion: Acceptable

External Context

GHG emissions from petroleum developments was identified as a stakeholder issue during stakeholder engagement ([Chapter 4](#)). It is considered that the proposed mitigation and management of GHG emissions and likely NGER/SGM offset obligations address this issue.

Conclusion: Acceptable

Internal Context

Woodside has a Climate Change Policy and a Woodside Management System ([Chapter 8](#)). For more details on the Policy, see <https://www.woodside.com.au/sustainability/climate-change>.

As part of the management of the proposed Browse to NWS Project, a GHG Abatement Plan will be developed and implemented to achieve the environmental objective ([Section 7.2](#) and [Chapter 8](#)).

Conclusion: Acceptable

Other Requirements

The Paris Agreement

The targets set by the Paris Agreement are detailed in [Section 7.3.1](#). As a clean and reliable energy source (described in [Section 7.7.1](#)), gas is expected to play a key role in the future energy mix and it has the potential to contribute to the reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. coal burning).

Australia's Nationally Determined Contributions

Australia's NDC is for an absolute economy-wide emissions reduction by 2030. Given the emission estimates and the likely NGER/SGM offset obligations, it is not expected that the proposed Browse to NWS Project will prevent Australia meeting its NDC commitments.

Safeguard Mechanism (SGM)

Woodside is committed to its obligations under the NGER/SGM. Based on current regulatory NGER Act SGM emissions baseline requirements, it is anticipated that CO₂ emissions derived from the Browse reservoirs will contribute to emissions from the proposed Browse to NWS Project, exceeding any anticipated facility baseline. This would likely result in SGM offset obligations, which at this stage are anticipated to be met in the form of ACCUs.

It is also anticipated that there will be emissions associated with the processing of Browse feed gas through third party infrastructure as described above in [Section 7.4.1](#). It is anticipated that these emissions will be mitigated and managed by the NWSJV in accordance with regulatory requirements applicable to the proposed NWS Extension Project.

Conclusion: Acceptable

CHAPTER 8

**ENVIRONMENTAL
MITIGATION,
MANAGEMENT AND
MONITORING**

8. ENVIRONMENTAL MITIGATION, MANAGEMENT AND MONITORING

8.1 Introduction

This chapter describes how Woodside intends to implement the environmental management program throughout the life of the proposed Browse to NWS Project. It demonstrates the mitigation and management approach that Woodside will use to avoid or minimise environmental impacts and risks identified in this draft EIS/ERD to an acceptable level.

8.2 Woodside's Health, Safety and Environmental Management System

8.3 Overview

The Woodside Management System (WMS) defines how Woodside will deliver its business objectives and the boundaries within which all Woodside employees and contractors are expected to work. The WMS consists of a mission statement, policies, decision making committees, frameworks of authorities and standards, that when applied, provide management, governance and assurance. Environmental management is one of the components of the overall WMS.

8.4 Health, Safety, Environment and Quality Policy

Within the WMS, the overall direction for Environment is set through Woodside's corporate Health Safety, Environment and Quality Policy ([Figure 8-1](#)). The policy provides a public statement of Woodside's commitment to minimising adverse effects on the environment from its activities and to improving environmental performance. It sets out the principles for achieving the objectives for the environment and how these are to be applied. The policy is applied to all Woodside's activities, and all employees, contractors and Joint Venture partners engaging in activities under Woodside operational control.

In addition, Woodside's Climate Change Policy (refer to [Chapter 7](#)) demonstrates a commitment to be part of a solution to climate change. This includes promoting and pursuing a culture of energy efficiency and improving resource use in design and operation.

WOODSIDE POLICY



Health, Safety, Environment and Quality Policy

OBJECTIVES

Strong health, safety, environment and quality (HSEQ) performance is essential for the success and growth of our business. Our aim is to be recognised as an industry leader in HSEQ through managing our activities in a sustainable manner with respect to our workforce, our communities and the environment.

At Woodside we believe that process and personal safety related incidents, and occupational illnesses, are preventable. We are committed to managing our activities to minimise adverse health, safety or environmental impacts, incorporating a right first time approach to quality.

PRINCIPLES

Woodside will achieve this by:

- implementing a systematic approach to HSEQ risk management
- complying with relevant laws and regulations and applying responsible standards where laws do not exist
- setting, measuring and reviewing objectives and targets that will drive continuous improvement in HSEQ performance
- embedding HSEQ considerations in our business planning and decision making processes
- integrating HSEQ requirements when designing, purchasing, constructing and modifying equipment and facilities
- maintaining a culture in which everybody is aware of their HSEQ obligations and feels empowered to speak up and intervene on HSEQ issues
- undertaking and supporting research to improve our understanding of HSEQ and using science to support impact assessments and evidence based decision making
- taking a collaborative and pro-active approach with our stakeholders
- requiring contractors to comply with our HSEQ expectations in a mutually beneficial manner
- publicly reporting on HSEQ performance

APPLICATION

Responsibility for the application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this policy in non-operated joint ventures.

This policy will be reviewed regularly and updated as required.

Reviewed in December 2019

DRIMS#3475310

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APPROVED

Figure 8-1 Woodside's Corporate Health, Safety, Environment and Quality Policy

8.5 Woodside's Management System

The WMS provides a structured framework of documentation to set common expectations governing how all employees and contractors at Woodside will work. WMS documentation, which is comprised of four elements (Compass & Policies; Expectations; Processes & Procedures; and Guidelines) is outlined below and illustrated in

Figure 8-2:

- + **Compass & Policies:** Set the enterprise-wide direction for Woodside by governing behaviours, actions and business decisions and ensuring Woodside meets its legal and other external obligations.
- + **Expectations:** Set essential activities or deliverables required to achieve the objectives of the Key Business Activities and provide the basis for development of processes and procedures.
- + **Processes & Procedures:** Processes identify the set of interrelated or interacting activities which transforms inputs into outputs, to systematically

achieve a purpose or specific objective. Procedures specify what steps, by whom and when required to carry out an activity or a process.

- + **Guidelines:** Provide recommended practice and advice on how to perform the steps defined in procedures, together with supporting information and associated tools. Guidelines provide advice on how activities or tasks may be performed; information that may be taken into consideration; or how to use tools and systems.

The WMS is organised within a business process hierarchy based upon key business activities to ensure the system remains independent of organisation structure and is globally applicable and scalable as required. These key business activities are grouped into management, support and value stream activities as shown in [Figure 8-3](#). The value stream activities capture, generate and deliver value through the exploration and production lifecycle. The management activities influence all areas of the business, while support activities may influence one or more value stream activities.

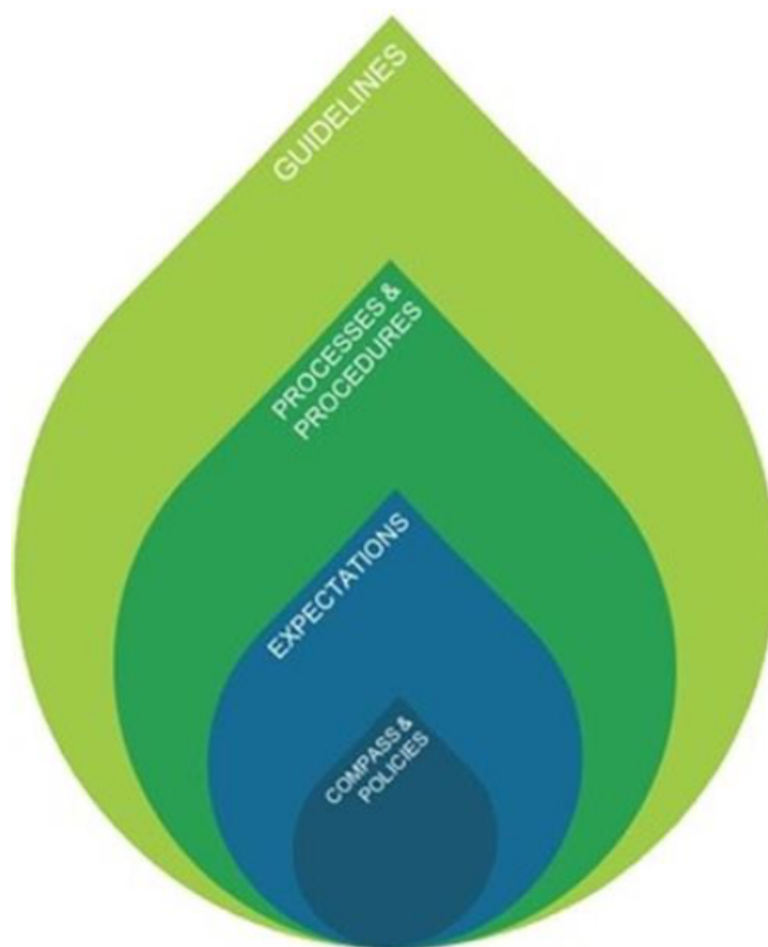


Figure 8-2 The Four Major Elements of the WMS Seed

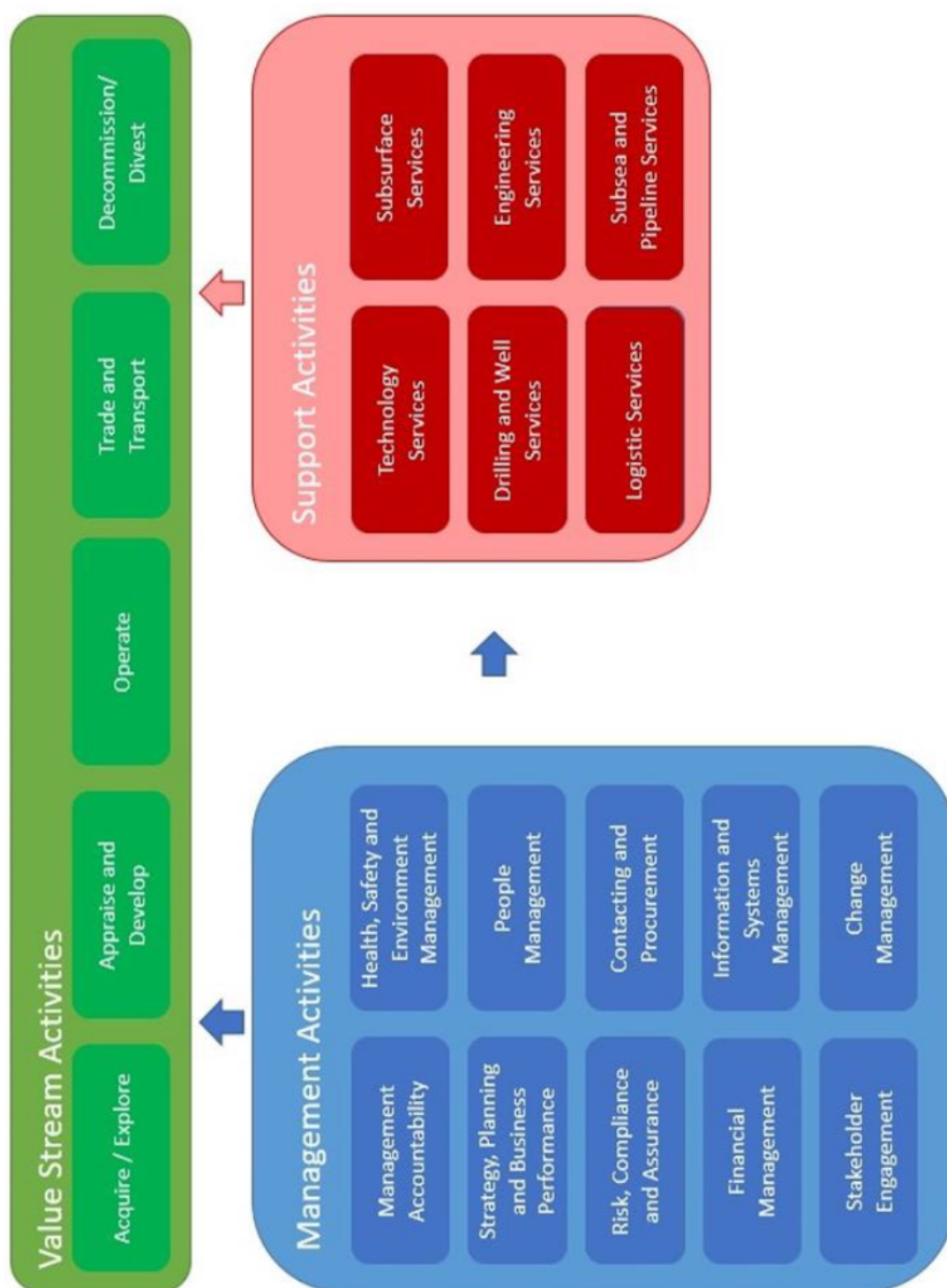


Figure 8-3 The WMS Business Process Hierarchy

8.6 Relationship of the WMS and the draft EIS/ERD

The objectives under the WMS define the mandatory performance requirements that apply to all Woodside activities, and the performance of its employees and contractors within their area of responsibilities. The management commitments made in this draft EIS/ERD and subsequent Environment Plans will be implemented through the WMS and supplemented where required by documentation specific to the proposed Browse to NWS Project.

8.7 Planning framework

Woodside sets environmental performance requirements through the life-cycle of projects and operations. This approach is based on:

- + a robust environmental risk-management process
- + credible and defensible science to underpin this approach
- + strong relationships with local and international researchers
- + ongoing stakeholder engagement
- + transparency of our environmental knowledge.

Credible and defensible science is core to Woodside's environmental management approach and processes. Woodside's strong capability in environmental studies enables the acquisition of environmental data critical to inform impact assessments and decision making. Furthermore, strong relationships, sound research and transparency are the key elements of Woodside's approach to the environment.

Woodside has an established methodology that identifies impacts and risks and assesses the potential consequence of an activity. This methodology mandates that a risk hierarchy of controls be applied to management measures that are identified. This approach identifies ways to eliminate or avoid an impact before measures are considered to reduce or minimise it. The management measures include, as a minimum, those that are considered good international industry practice.

The end result of this risk-based process is that the residual impacts and risks of an activity are at a level considered to be acceptable.

8.8 Environmental record of person(s) undertaking the Proposed Action

8.8.1 Record of environmental management

Woodside, as operator for and on behalf of the BJV, believes excellence in environmental performance is essential to our business success worldwide and is compatible with balancing the economic, social and environmental needs of sustainable development.

Woodside employs a structured approach to the management of the environment via the formal and documented WMS. Through policies, processes, procedures and standards the WMS requires that impacts from Woodside's operations are either avoided or kept to ALARP. It also drives continuous improvement in the company's environmental performance.

Woodside's commitment to responsible environmental management was recognised by the Australian Petroleum Production and Exploration Association (APPEA) as the recipient of the Environment Excellence Award in 2009, 2012, 2015, 2016, 2017 and 2019. Woodside was recognised in 2009 for appraisal activities at Scott Reef, including environmental research undertaken at Scott Reef in association with the Maxima 3D marine seismic survey and the Gigas 2D Pilot Ocean Bottom Cable marine seismic survey. This recognition was for Woodside's approach to undertaking activities in a highly sensitive environmental setting. The 2012 and 2017 APPEA Environment Awards recognised Woodside's partnerships with AIMS and Western Australian Museum (WAM). These long-term relationships have contributed shared scientific knowledge to academic, government, industry and the broader community's understanding of biodiversity and ecological function in WA's tropical marine ecosystems.

8.8.2 Past or present procedures

Woodside has not been subject to any proceedings, either past or present, under a Commonwealth or State law for the protection of the environment or the conservation and sustainable use of natural resources.

8.9 Environmental management and mitigation

8.9.1 Overview

As part of the development of this draft EIS/ERD, management and mitigation measures have been identified and will be implemented to reduce the level of impact and risk of the proposed Browse to NWS Project to an acceptable level in consideration of the EPBC Act, EP Act and other relevant policy instruments ([Chapter 6](#)). This includes any practices that will reduce the impacts and risks in order to meet the identified environmental objectives, any relevant legal requirements (related specifically to the impact/risk), internal company requirements and any practices that will be adopted to manage stakeholder concerns identified through the consultation process. It should be noted that further review and potential adoption of additional controls will be undertaken in subsequent phases of the project, such as during the preparation of Environment Plans for activities under the scope of the approved action.

In accordance with Woodside's risk procedures and processes and for the purpose of the draft EIS/ERD, where an impact or risk has been assessed to be acceptable, no further management beyond legislative requirements and industry codes and standards will be required. Where the impact or risk level is not acceptable, additional management and mitigation measures have been considered.

The following framework tools have been applied, as appropriate, to assist with identifying appropriate management and mitigation measures:

- + Good Industry Practice – identifies further engineering control standards and guidelines which may be applied by Woodside in addition to those required to meet the legislation, codes and standards.
- + Professional Judgement – uses relevant personnel with the knowledge and experience to identify alternative controls.

Using these tools, the following hierarchy of controls have been used to identify appropriate management and mitigation measures for the proposed Browse to NWS Project:

- + eliminate the risk by removing the hazard
- + substitute a hazard with a lesser one
- + prevent a credible impact from occurring by implementing additional engineering control measures
- + reduce the magnitude of a credible impact by implementing additional engineering control measures (e.g. solids control equipment onboard MODU to manage cuttings discharge)
- + mitigate the credible impact on the environment by reducing the extent, scale, duration of impact (e.g. bunding, oil spill booms, relief well)

- + emergency response and contingency planning to facilitate recovery from the credible impact of an event.

Environmental objectives and proposed mitigation and management measures are presented in [Chapter 6](#).

8.9.2 Central management and monitoring commitments

The central management and monitoring commitments are detailed in [Chapter 6](#) and summarised in [Chapter 1](#) and [Chapter 9](#).

The measures presented in this draft EIS/ERD will be incorporated into activity-specific Environment Plans ([Section 8.14.1.1](#)) to be submitted for acceptance by NOPSEMA for Commonwealth waters and DMIRS for State waters, prior to the activity commencing where required.

8.10 Management Plans

Under the environmental management framework, specific environmental management plans will be prepared for the proposed Browse to NWS Project. These will include activity-specific Environment Plans ([Section 8.14.1.1](#)) and an Environmental Quality Management Plan applicable to the State Proposal Area ([Section 8.14.1.2](#)). Contractors will also be required to prepare environmental management plans for Woodside approval that detail how the project requirements will be met.

8.10.1 Environment Plans

8.10.1.1 Environment Plans

Accepted activity-specific Environment Plans will be required under both the OPGGS (E) Regulations (for Commonwealth waters) and the Petroleum (Submerged Lands) (Environment) Regulations 2012 (for State waters).

The Environment Plans must be appropriate for the nature and scale of the activity and describe the activity, the existing environment, details of environmental impacts and risks and the control measures for the activity. In addition, the Environment Plans must include an implementation strategy to demonstrate that the impacts and risks can be managed to ALARP and to describe how appropriate environmental performance outcomes, standards and measurement criteria outlined in the Environment Plans will be met. The Environment Plans must also provide a summary of all consultation undertaken with relevant persons.

The Environment Plans required in support of the proposed Browse to NWS Project will address activities related to:

- + drilling development wells in both State and Commonwealth waters
- + installing, commissioning and operating subsea

infrastructure in both State and Commonwealth waters

- + installing, commissioning and operating the FPSO facilities (Commonwealth waters only)
- + installing, commissioning and operating the BTL and Inter-field spur line (Commonwealth waters only)
- + decommissioning activities at the end of the proposed Browse to NWS Project life.

Environment Plans will be supported by appropriate Oil Pollution Emergency Plans (OPEPs) and Operational and Scientific Monitoring Programs (OSMPs), which are required as a part of an Environment Plan's implementation strategy, noting that these may be developed to support a range of activities or phases of a project. The Environment Plans will be submitted for acceptance by NOPSEMA (Commonwealth waters) or DMIRS (State waters) before the activities listed above can commence.

8.10.1.2 Environmental Quality Management Plan (State Proposal Area)

As recommended in the WA EPA Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016), an Environmental Quality Management Plan (EQMP) will be prepared and implemented for the Proposal. The EQMP will only apply to the State Proposal Area. The EQMP will be developed using the principles and approaches outlined in the EPA's technical guidance. Refer to State ERD ([Chapter 10, Appendix B](#)).

8.10.1.3 Environmental Offset Plan

In the event that impacts cannot be avoided or mitigated to an acceptable level, an Environmental Offset Plan will be developed. Offsets associated with GHG emissions are specifically addressed in [Chapter 7](#) and will not be included in this offset plan.

The Environmental Offset Plan will provide details of offsets proposed to compensate for residual impacts on EPBC listed species, including the following:

- + the type of offsets proposed
- + the extent to which the proposed offset actions correlate to, and adequately compensate for, the impacts to EPBC listed species
- + for proposed land-based offsets, the suitability of the location of proposed offset sites, including the current land tenure and method of securing and managing the offset for the life of the impact
- + for non-land-based offsets, details of the proposed offset and how it will compensate for the proposal's residual significant impacts
- + the conservation gains to be achieved by the offset (for example, positive management strategies that improve the site, or how the future loss, degradation

or damage of the protected matter will be averted or mitigated)

- + the time it will take to achieve the proposed conservation gains
- + the level of certainty that the proposed offset will be successful.

The Environmental Offset Plan would be developed in accordance with the EPBC Act Environmental Offsets Policy (Commonwealth of Australia, 2012). (Commonwealth of Australia, 2012) or other relevant legislation or policy applicable at the time.

8.10.1.4 Environmental management Implementation approach

Roles and Responsibilities

Key roles and responsibilities for Woodside and Contractor personnel in relation to the implementation of controls identified in this draft EIS/ERD and subsequent Environment Plans are described in [Table 8-1](#). In addition to these identified roles, it is the responsibility of all Woodside employees and contractors to implement the Woodside Corporate Health, Safety, Environment and Quality Policy in their areas of responsibility and that the personnel are suitably trained and competent in their respective roles.

Table 8-1 Roles and Responsibilities

Title (role)	Environmental Responsibilities
Woodside Project Manager	+ Verify implementation of the receptor or aspect-specific environmental management plans related to the proposed Browse to NWS Project. + Verify systems and procedures are in place to manage the activity so it is undertaken as per the relevant standards and commitments in this draft EIS/ERD and subsequent Environment Plans. + Verify that contractors meet environmental related contractual obligations.
Woodside Delivery Manager (FPSO, SURF, BTL)	+ Verify that environment expectations are understood by team members in line with the commitments set out in this draft EIS/ERD and subsequent Environment Plans. + Communicate environment performance, relevant information and Lessons Learnt to team members and contractors. + Verify application of contractor's management of environment requirements, in accordance with the draft EIS/ERD and subsequent Environment Plans.
Woodside Environment Adviser	+ Track and report on compliance against environmental commitments as per the requirements of this draft EIS/ERD and subsequent Environment Plans. + Prepare environmental components of relevant Induction Package. + Provide advice to Woodside personnel and contractors to assist them with understanding their environment responsibilities.
Woodside Drilling Superintendent	+ Verify that the drilling program meets the requirements detailed in this draft EIS/ERD and subsequent Environment Plans.
Woodside Drilling and Subsea Engineers	+ Verify that all chemicals and drilling fluids proposed to be used for Browse drilling and completion activities are assessed and approved as per the requirements of the draft EIS/ERD and subsequent Environment Plans.
Woodside Corporate Affairs Adviser	+ Prepare and implement the Stakeholder Consultation Plan for the proposed Browse to NWS Project activities.
Woodside Marine Assurance Superintendent	+ Conduct relevant audits and inspections to confirm vessels are compliant with relevant Marine Orders and Woodside Marine Charters Instructions requirements to meet safety, navigation and emergency response requirements.
Offshore Installation Manager (OIM) (MODU, FPSOs)	+ Verify that the WMS is implemented. + Verify that personnel receive an environmental induction that meets the requirements specified in this draft EIS/ERD and subsequent Environment Plans.
Woodside Site Representative	+ Verify that proposed Browse to NWS Project scopes are undertaken as detailed in this draft EIS/ERD and subsequent Environment Plans. + Verify the management measures detailed in this draft EIS/ERD and subsequent EPs are implemented on the MODU/FPSO/Vessels.
Offshore HSE Adviser/ Vessel HSE Advisers	+ Support Woodside Site Representatives to ensure that the controls detailed in this draft EIS/ERD and subsequent Environment Plans, relevant to offshore activities are implemented and assist in collection and recording of evidence of implementation. + Confirm that periodic environmental inspections/reviews are completed and corrective actions from inspections are developed, tracked and closed out in a timely manner.
Vessel Master	+ Verify that the vessel management system and procedures are implemented. + Verify that personnel commencing work on the vessel receive an environmental induction that meets the requirements specified in this draft EIS/ERD and subsequent Environment Plans.
Vessel Logistics Coordinators	+ Confirm that waste is managed appropriately on the relevant support vessels as per the requirements of this draft EIS/ERD and subsequent Environment Plans.
Contractor Project Manager	+ Verify that activities are undertaken in accordance with this draft EIS/ERD and subsequent EPs, as detailed in the Woodside approved Contractor's Environmental Management Plans. + Verify that personnel commencing work on the project receive a relevant environmental induction that meets the requirements of this draft EIS/ERD and subsequent Environment Plans.

Emergency Preparedness and Response

Woodside will have an Emergency Response Plan (ERP) in place for all petroleum activities associated with the proposed Browse to NWS Project. The ERP will provide procedural guidance specific to the activity to control, coordinate and respond to an emergency or incident, including hydrocarbon spills.

Under Regulations 14(8) of the OPGGS (E) Regulations, the implementation strategy for Environment Plans in Commonwealth waters 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. For State waters Environment Plans under the Petroleum (Submerged Lands) (Environment) Regulations 2012, an oil spill contingency plan (OSCP) is required under regulation 12 (as part of the Environment Plan).

A significant hydrocarbon spill during the petroleum activities associated with the proposed Browse to NWS Project is unlikely but, should such an event occur, it will be managed in accordance with Woodside's overarching emergency response system and supporting documents. Supporting documents include the relevant ERPs, OPEPs, OSCP and specific plans that provide tactical response guidance to the activity/area.

Monitoring of Environmental Performance

Environmental objectives have been developed for each environmental aspect ([Section 6](#)). In addition, Environmental Performance Objectives (EPOs) standards and measurement criteria will be developed and monitored as part of the development and subsequent implementation of Environment Plans.

To verify that requirements are met, Woodside and its contractors will monitor compliance during execution of the proposed Browse to NWS Project. The monitoring will be described in detail in the various management plans ([Section 8.14](#)) and Environment Plans for the specific activities and will make use of tools and systems that are appropriate to the activity and the project teams.

Auditing

During the execution of project activities, environmental performance auditing will be undertaken to:

- + identify potential new environmental impacts and risks or changes to existing environmental impacts and risks
- + confirm that any controls that are applied to manage impacts and risks to an acceptable level are effective
- + confirm compliance with the controls and environmental performance standards detailed in future Environment Plans.

Reporting

Woodside will undertake external reporting at a number of levels. These reporting arrangements are outlined below.

Environmental Performance Reporting

In accordance with applicable environmental legislation, Woodside, as operator for and on behalf of the BJV, is required to report information on environmental performance during the implementation of the proposed Browse to NWS Project including:

- + Annual compliance reporting addressing compliance with any conditions of approvals under the EPBC Act and EP Act.
- + Monthly Recordable Incident Reports – submitted monthly to NOPSEMA and DMIRS, with details of recordable incidents that have occurred during the previous month (if any).
- + Environmental Performance Reports – submitted annually to NOPSEMA and DMIRS and addressing compliance with the EPOs outlined in subsequent Environment Plans developed for activities associated with the proposed Browse to NWS Project.
- + Notification of reportable incidents to NOPSEMA or DMIRS according to the requirements of Regulations 26, 26A and 26AA of the Environment Regulations or Regulation 28 of the Petroleum (Submerged Lands) (Environment) Regulations 2012, respectively.

Management of Change

Management of changes to activity scope that are relevant to this draft EIS/ERD ([Chapter 3](#)) will be in accordance with Regulation 17 of the Environment Regulations. These changes may include:

- + review of advances in technology at stages where new equipment may be selected
- + changes in understanding of the environment, including all current advice on species protected under the EPBC Act
- + current requirements for AMPs ([Chapter 5](#))
- + potential new advice from external stakeholders ([Chapter 4](#)).

Risk will be assessed in accordance with the Environmental Risk Management Methodology ([Chapter 6](#)) to determine the significance of any potential new environmental impacts or risks not provided for in this draft EIS/ERD or subsequently submitted Environment Plans. Risk assessment outcomes will be reviewed in compliance with Regulation 17 of the Environment Regulations.

CHAPTER 9

OVERALL CONCLUSIONS



9. OVERALL CONCLUSIONS

9.1 Summary

Woodside, on behalf of the BJV, has prepared this draft EIS/ERD for the proposed Browse to NWS Project to meet the requirements of the EPBC Act and EP Act, as set out in the approved EISG/ESD. Significant work has been completed by Woodside and the BJV participants to understand the environmental context of the proposed Browse to NWS Project and develop a proposal for the development of the Browse resources that aligns with the principles of Ecologically Sustainable Development (ESD).

This Chapter provides a qualitative assessment of the cumulative impacts by receptor, based on the detailed aspect-based impact and risk assessment provided in [Chapter 6](#). It also provides an overall conclusion as to the environmental acceptability of the proposed Browse to NWS Project and includes discussion on alignment with the principles of ESD and the objectives and requirements of the EPBC Act and EP Act. Consideration has also been made of the potential cumulative environmental impacts of the proposed Browse to NWS Project and any existing and future concurrent activities.

The significance of the potential impacts to key receptor groups associated with each aspect of the proposed Browse to NWS Project are detailed in [Chapter 6](#), including the acceptability of predicted impacts and potential risks for each aspect in terms of the defined acceptability criteria. In addition, [Chapter 7](#) specifically addresses GHG emissions, including estimated contributions to global emissions.

9.2 Overall Assessment of Impacts on Receptors (Cumulative Impacts)

9.2.1 Aspect-based cumulative impacts

An aspect-based cumulative impact assessment (i.e. assessment of cumulative impacts from the same aspect resulting from multiple project activities and other developments in the area) is presented for each aspect in [Chapter 6](#). This assessment has shown that aspect-based cumulative impacts resulting from the proposed Browse to NWS Project are unlikely to result in significant impacts. The majority of emissions and discharges will be within the Browse Development Area, which is in a remote, offshore location and unlikely to result in significant interactions with other activities/developments.

9.2.2 Receptor based cumulative impacts

[Table 6-2](#) outlines all the aspect-receptor relationships identified during the assessment of impacts and risks associated with the proposed Browse to NWS Project. Each of these relationships are discussed in [Chapter 6](#) and [Table 6-2](#) also highlights where multiple aspects may impact common receptors (i.e. receptor-based cumulative impacts). The cumulative impact assessment focuses on predicted impacts from planned routine and non-routine activities and evaluates the nature of any aspect interaction (e.g. whether one aspect exacerbates the impact of another) and the scale of the cumulative impact as a result. This assessment has not been completed for risks, as the likelihood of the events coinciding is low. An overall assessment of the environmental risks from unplanned events and incidents is presented in [Section 9.3](#).

Regional facility/activity context

The Prelude, Ichthys and Crux facilities are located >100 km to the north east of the Browse Development Area and the south western end of the BTL is located in close proximity to the North Rankin Complex (NRC).

Shipping activity in and around the Browse Development Area is sparse, with the main commercial shipping routes located approximately 50 to 100 km west of the Development Area, intersecting the proposed BTL route at various locations depending on the port. Future seismic survey activities may be undertaken by Woodside and/or other operators in the region.

9.2.2.1 Physical Receptors

Marine sediment quality (medium value (open waters))

Table 9-1 Marine sediment quality cumulative assessment

Receptor	Sediment Quality		
Local environment context	Sediments in the Project Area are typical of an undisturbed tropical offshore environment, with low concentrations of metals and nutrients and no hydrocarbons detected from marine sediment quality seabed sampling (refer to Section 5.2.10).		
Receptor sensitivity	Medium value (open waters) Ambient sediment quality is typical of the surrounding environment, with low sensitivity to change and no features of conservation value		
Environmental objective	Objective 1: To not result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Objective 2: To not result in 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.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Seabed disturbance	No lasting effect	Negligible (F)
	Marine Discharges: Produced water	No lasting effect	Negligible (F)
	Marine Discharges: Drilling discharges	Minor	Minor (D)
	Marine Discharges: Subsea control fluids	Slight	Slight (E)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Negligible (F)
Aspect Interaction Assessment and Conclusion			
Given the isolated FPSO locations, cumulative impacts on sediment resulting from interactions with other facilities and regional vessel/air traffic are not considered credible. As described throughout Chapter 6, discharges from construction activities and during operations will be managed to ensure no change to sediment quality within the Scott Reef shallow water benthic habitats (<75 m water depth), therefore impacts to sediment will be confined to deep water. Impacts to sediment from the Browse to NWS Project are expected to primarily result from drilling discharges (e.g. cementing, cuttings/fluids). There is potential for overlap of impact from drilling discharges and subsea control fluids in the immediate vicinity around the wells. Control fluid impacts will occur in the area previously impacted by drilling discharges. Impacts associated with hydrotest discharges may overlap with impacts from prior drilling discharges where the discharge point is in the vicinity of a drill centre, however, they will be short lived and localised. There is also potential for interaction between BTL hydrotest discharges at NRC and existing discharges (e.g. PW) from that facility. These impact interactions are not expected to exacerbate the aspect-based impacts previously described in Chapter 6, due to their localised scale and temporary nature (e.g. hydrotest discharges), dynamic receiving environment and general lack of reactivity between the discharges. The overall impact significance level of impacts on sediment quality has been assessed as Minor (D) (based on the assessment of impacts resulting from drilling discharges). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objectives for this receptor will be achieved and this impact is assessed as Acceptable.			

Water quality (medium value (open waters))**Table 9-2 Water quality cumulative assessment**

Receptor	Water Quality		
Local environment context	Water quality in the Project Area near the location of the proposed subsea infrastructure and facilities is typical of an undisturbed tropical offshore environment. Much of the surface waters in this area is nutrient-poor, influenced by the Indonesian Throughflow, with low levels of primary productivity (Section 5.2.9).		
Receptor sensitivity	Medium value (open water) Ambient water quality is typical of an open water environment, with low sensitivity to change.		
Environmental objective	Objective 3: To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. ¹		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Seabed Disturbance	No lasting effect	Negligible (F)
	Marine Discharges: Sewage and Sullage	Slight	Slight (E)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	Slight	Slight (E)
	Marine Discharges: Putrescible Waste	Slight	Slight (E)
	Marine Discharges: Produced Water	Minor	Minor (D)
	Marine Discharges: Cooling Water	Minor	Minor (D)
	Marine Discharges: Drilling and Completions	Slight	Slight (E)
	Marine Discharges: Subsea control fluids	Slight	Slight (E)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Negligible (F)

Receptor	Water Quality
Aspect Interaction Assessment and Conclusion	
Given the isolated FPSO locations, cumulative impacts on water quality resulting from interactions with other facilities and regional vessel/air traffic are not considered credible. There is potential for interaction between the BTL hydrotest discharge at NRC and existing discharges (e.g. PW) from that facility, however, this is likely to be of a short duration (Section 6) and the peak concentrations will be physically separated as the BTL will be discharged near seabed and the NRC PW plume is positively buoyant. Impacts to water quality are predicted to primarily arise from the discharge of PW (Section 6.3.12) and cooling water (Section 6.3.13) from the FPSO facilities during the operations phase, as these discharges are persistent for the field life. Less significant impacts are predicted as a result of short-term or temporary discharges (i.e. discharge of drill cuttings and fluids during development drilling, subsea control fluids, hydrotest fluids, treated sewage and sullage, treated utility water and putrescible waste). As described in Chapter 6, operational discharges (PW and cooling water from the FPSO facilities) will be managed to meet the defined threshold values (i.e. 99% species protection or no effect concentrations) at the edge of the mixing zone and at the State waters 3 nm boundary 95% of the time, based on dispersion modelling results. As such, no impacts from operational discharges to water quality within the Scott Reef shallow water benthic habitat (<75m) are predicted. It is recognised that plumes from operational discharges (PW, cooling water and sewage and sullage) occur simultaneously from the same facility. This has the potential to result in chemical interactions between the constituents of the discharges. However, given the reactive and volatile nature of constituents as well as the low concentrations of constituents in the discharges (ie chlorine <1ppm), it is considered that the constituents of a single discharge will react faster with the marine environment than they will with other plumes. For example, dosing of cooling water with chlorine (as sodium hypochlorite) may give rise to chlorine-produced oxidants comprising weak hypochlorous acid, hypochlorite ions and hypobromous acid, depending on the conditions of the marine environment. The decay of these chlorine-produced oxidants is already rapid in the marine environment (DHI 2011a), and therefore unlikely to react with other discharges. This is particularly true as the plumes caused by the discharges dilute rapidly in the marine environment, and are unlikely to immediately come into contact with other plumes before they are diluted. It is therefore highly likely that any undesirable molecular compounds generated from temporary plume co-occurrence and chemical reactions will be below detectable/background thresholds, particularly towards sensitive receptors ie Scott Reef. As per the management approach for Produced Water, baseline and periodic monitoring in the receiving environment will be undertaken to detect changes to water and sediment quality as a result of FPSO facility PW discharge. The effect of these changes in water quality is not expected to be cumulative in the context of the broader region, given the assimilative capacity of the open ocean receiving environment, physical separation of discharge point and the localised scale of the impacts. As such, the overall impact significance level of impacts on water quality has been assessed as Minor (D) (based on the assessment of impacts resulting from PW and cooling water discharges from the FPSO facilities). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.	

Air quality (medium value (open waters))**Table 9-3: Air quality cumulative assessment**

Receptor	Air Quality		
Local environment context	Given the distance from any significant anthropogenic emissions sources, air quality within the Project Area is expected to be high (Section 5.2.6).		
Receptor sensitivity	Medium value (open water) Ambient air quality is typical of an open water environment, with low sensitivity to change		
Environmental objective	Objective 4: To not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Atmospheric emissions: offshore activities	Slight	Slight (E)
Aspect Interaction Assessment and Conclusion			
Given the isolated FPSO locations, cumulative impacts on air quality resulting from interactions with other facilities and regional vessel/air traffic are not considered credible. Impacts to local air quality resulting from atmospheric emissions (excluding GHG) associated with the offshore activities are predicted to be negligible (Section 6.3.5) and, therefore, the potential for cumulative impacts from multiple sources is considered low. As such, the overall impact significance level of impacts on air quality has been assessed as Slight (E). As per the criteria outlined in Section 6.2.3.4, this impact is assessed as Acceptable. Potential impacts associated with atmospheric emissions resulting from the onshore processing of the Browse gas by the NWS JV on the national heritage values of the listed National Heritage Place on the Dampier Archipelago (including aboriginal heritage values) are assessed in the ERD associated with the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). Given the distance between the offshore activities and the NWS JV onshore facility, no cumulative impacts are predicted. GHG emissions, including estimated contributions of NWS scope 1 emissions attributable to the proposed processing of Browse feed gas by the NWS JV and scope 1 and 3 emissions from the proposed Browse to NWS Project to global GHG emissions, are addressed in Chapter 7. This assessment considered the Principals of ESD, MNES Significant Impact Guidelines and the WA EPA Environmental Objectives; as well as GHG specific requirements such as the Paris Agreement, Australia's Nationally Determined Contributions and the Safeguard Mechanism (SGM). The assessment concluded that in consideration of these requirements the proposed Browse to NWS Project is Acceptable.			

Ambient light (medium value (open waters))**Table 9-4: Ambient light cumulative assessment**

Receptor	Ambient light		
Local environment context	The Project Area is located approximately 260 km from the shore where there are no existing significant sources of artificial light. The proposed BTL route is also distant from sources of light emissions, except where the proposed BTL route ties in near the existing NRC facilities (Section 5.2.7).		
Receptor sensitivity	Medium value (open water) Ambient light is typical of an open water environment, with low sensitivity to change.		
Environmental objective	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical presence: light	Slight	Slight (E)
Aspect Interaction Assessment and Conclusion			
Given the isolated FPSO locations, cumulative impacts on ambient light resulting from interactions with other facilities and regional shipping activities are not considered credible. Impacts to ambient light levels resulting from light emissions associated with the proposed Browse to NWS Project, including the FPSO facilities, vessels and MODUs, are predicted to be slight (Section 6.3.3) and, therefore, the potential for cumulative impacts from multiple sources is considered low. As such, the overall impact significance level of impacts on ambient light has been assessed as Slight (E). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.			

Ambient noise (medium value (open waters))**Table 9-5: Ambient noise cumulative assessment**

Receptor	Ambient noise		
Local environment context	Atmospheric noise The existing anthropogenic noise environment within the vicinity of the Project Area is expected to be primarily associated with commercial shipping activities, as well as occasional petroleum exploration activities. Similar sources of anthropogenic underwater ambient noise may be expected along the proposed BTL route. Underwater noise Underwater noise in the Project Area is characterised by occasional general vessel traffic, seismic surveys, suspected illegal blast fishing at Scott Reef and marine fauna. Underwater noise from marine fauna recorded at the Browse Development Area included calls from humpback whales, minke and dwarf minke whales, pygmy blue whales, Bryde's whales, as well as calls from unidentified whales and fish chorus (Section 5.2.8).		
Receptor sensitivity	Medium value (open water) Ambient noise is typical of an open water environment, with low sensitivity to change.		
Environmental objective	Objective 5: To not result in a substantial change in ambient light or ambient noise which may adversely impact on biodiversity, ecological integrity, social amenity or human health.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Atmospheric Noise Emissions	No lasting effect	Negligible (F)
	Underwater Noise Emissions	Slight	Slight (E)
Aspect Interaction Assessment and Conclusion			
Given the isolated FPSO locations, cumulative impacts on ambient noise resulting from interactions with other facilities and regional shipping activities are not considered credible. There may, on occasion, be overlap between facility operational noise and regional seismic surveys completed by Woodside and/or other operators. This interaction would be managed in Environment Plans required under Petroleum Legislation. Atmospheric (Section 6.3.7) and underwater (Section 6.3.8) noise emissions are predicted to occur during all phases of the proposed Browse to NWS Project. Impacts of these noise emissions on ambient atmospheric noise levels are, however, expected to be Negligible (F). Impacts from underwater noise are expected to be Slight (E). Sensitive receptors to underwater noise are generally different to the receptors for atmospheric noise, and primary sources of atmospheric noise at the Browse Development Area (helicopters, piling, flaring) will be intermittent, no significant cumulative impact to ambient atmospheric noise levels is predicted. As such, the overall impact significance level of impacts on ambient noise has been assessed as Slight (E). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.			

9.2.2.2 Ecological Receptors

Plankton communities (medium value (open waters))

Table 9-6: Plankton communities cumulative assessment

Receptor	Plankton Communities		
Local environment context	Plankton communities have a naturally variable distribution in both space and time, noting that the NWMR is typically characterised by low planktonic productivity. Estimates of the phytoplankton biomass (measured as chlorophyll a) close to Scott Reef are approximately twice that of open waters (sampled at distances greater than 50 km to the south-west of South Scott Reef). The open water location sampled is likely to be representative of the general outer shelf open water environment and so is representative of the oceanic waters of the Project Area (Section 5.3.1.1).		
Receptor sensitivity	Medium value (open water) Plankton populations are typical of an open water environment, with low sensitivity to change due to high turnover/recovery and no species of high importance or quality.		
Environmental objective	Objective 7: To not have a substantial adverse effect on a population of plankton, including its lifecycle and spatial distribution.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Seabed Disturbance	No lasting effect	Negligible (F)
	Physical Presence: Light	No lasting effect	Negligible (F)
	Underwater Noise Emissions	No lasting effect	Negligible (F)
	Marine Discharges: Sewage and Sullage	No lasting effect	Negligible (F)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Negligible (F)
	Marine Discharges: Putrescible Waste	No lasting effect	Negligible (F)
	Marine Discharges: Produced water	Slight	Slight (E)
	Marine Discharges: Cooling Water	Slight	Slight (E)
	Marine Discharges: Drilling Discharges	No lasting effect	Negligible (F)
	Marine Discharges: Subsea control fluids	No lasting effect	Negligible (F)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Negligible (F)

Receptor	Plankton Communities
Aspect Interaction Assessment and Conclusion	
Given the isolated FPSO locations, cumulative impacts on plankton resulting from interactions with other facilities and regional vessel/air traffic are not considered credible. Slight impacts to plankton communities may result from multiple but separated discharge streams, including PW (Section 6.3.12) and cooling water (Section 6.3.13) discharges from the FPSO facilities during operations. Less significant impacts, expected to have no lasting effect on plankton populations, may occur during construction, commissioning and operations as a result of discharges including hydrotest fluid, vessel cooling water, treated utility water and putrescible waste; as well underwater noise emissions. As described above, no significant increase in toxicity is predicted as a result of potential comingling of the PW and cooling water plumes after discharge. Furthermore, plankton populations are widespread and have a high turnover. The predicted cumulative impacts resulting from the multiple discharge streams are not expected to be significant. As such, the overall impact significance level of impacts on plankton has been assessed as Slight (E) (based on the assessment of impacts resulting from PW and cooling water discharges from the FPSO facilities). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.	

Shallow water benthic communities and habitats (<75 m water depth) (high value habitat)

As detailed in [Chapter 6](#), no infrastructure is planned to be placed on or near any shallow water benthic habitats (e.g. Scott Reef and the Rowley Shoals). In addition, discharges during construction, commissioning and operations will be managed to avoid impact to these shallow water benthic habitats. This will include a commitment to manage operational discharges (PW and cooling water from the FPSO facilities) to meet the defined threshold values (i.e. 99% species protection or lowest no effect concentration) at the edge of the mixing zone and at the State waters 3 nm boundary, 95% of the time; and a commitment to manage drilling discharges (in particular bottom hole discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD, TRE and TRF) in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth). These management objectives are supported by a range of both feasible and industry proven management measures. As such, no cumulative impact assessment is warranted for this receptor.

Deepwater benthic communities and habitats (>75 m water depth) (medium value habitat)

Table 9-7: Deepwater benthic communities and habitats cumulative assessment

Receptor	Deepwater benthic communities and habitats
Local environment context	The benthic communities inhabiting the predominantly soft, fine sediments of the deepwater benthic habitats are characterised by infauna such as polychaetes and sparsely distributed sessile and mobile epifauna. The density of benthic fauna is typically lower in deep-sea sediments (greater than 200 m) than in shallower coastal sediment habitats, but the diversity of communities may be similar. As confirmed by deepwater surveys (Section 5.3.1.2).
Receptor sensitivity	Medium value No species of high importance.
Environmental objective	Objective 6: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

Receptor	Deepwater benthic communities and habitats		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Seabed Disturbance	Minor	Minor (D)
	Underwater Noise Emissions	No lasting effect	Negligible (F)
	Marine Discharges: Sewage and Sullage	No impact expected	
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No impact expected	
	Marine Discharges: Putrescible Waste	No impact expected	
	Marine Discharges: Produced water	No impact expected	
	Marine Discharges: Cooling Water	No impact expected	
	Marine Discharges: Drilling Discharges	Slight	Slight (E)
	Marine Discharges: Subsea control fluids	No lasting effect	Negligible (F)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Negligible (F)
Aspect Interaction Assessment and Conclusion			
Cumulative impact from oil and gas infrastructure within the Browse Development Area and broader Browse Basin effects a relatively small proportion of deepwater benthic habitat and community types present in these areas. The habitat types affected are typically of low sensitivity (relatively benign, see above) as infrastructure typically avoids areas of complex bathymetry and inferred higher habitat sensitivity. Minor impacts to the deepwater benthic habitats and communities are predicted within the Project Area as a result of the localised physical footprint of the installed subsea infrastructure, BTL and inter-field spur line (including seabed preparation and installation activities) (Section 6.3.1). In addition, discharges during construction, commissioning and operations (including the drilling discharges, subsea control fluids and hydrotest fluids) may impact these deepwater benthic habitats and communities. Combined impacts to deepwater benthic habitats and communities within the Project Area as a result of the installation of the subsea infrastructure and drilling discharges (Section 6.3.15) are not expected to be significant as they will be restricted to areas largely composed of sediment habitat and sparse benthic biota and the physical footprint represents a small fraction of the widespread and representative deepwater benthic habitat type within the region. Further, there are no predicted lasting impacts to these deepwater benthic habitats from other discharges related to the proposed Browse to NWS Project. As such, the overall impact significance level of impacts on deepwater benthic habitats has been assessed as Minor (D) (based on the assessment of impacts resulting from seabed disturbance (Minor (D)) and drilling discharges (Slight (S)). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.			

Fauna (high value species)**Seabirds and migratory shorebirds****Table 9-8: Seabirds and migratory shorebirds cumulative assessment**

Receptor	Seabirds and migratory shorebirds		
Local environment context	As the only emergent land mass within the immediate vicinity of the Browse Development Area, Scott Reef serves to provide nesting and/or roosting for seabirds, albeit in small numbers in comparison to other breeding and roosting sites in the region. This includes the little tern, which has a resting BIA at Scott Reef, associated with Sandy Islet. In addition, due to the large geographical range of seabirds, most species occurring within the wider NWMR have the potential to occur and transit through the Project Area. The islands of the Rowley Shoals (which the BTL route passes by at a distance of a few kilometres) are known to support a wide range of seabird species, including WA's second largest breeding colony of red-tailed tropicbird. The Rowley Shoals have also been identified as BIAs for the white-tailed tropicbird. Migratory shorebirds are occasionally observed in very low numbers at Scott Reef and Sandy Islet may be used as a staging ground during the migration between the Northern Hemisphere and Australia. However, given its small size, Sandy Islet is unlikely to support large numbers of migratory shorebirds. Due to the large geographical ranges of migratory shorebirds, many of the species known to occur within the wider NWMR have the potential to transit through the Project Area, which overlaps with the migratory shorebird corridor. Shorebird presence in the Project Area is expected to be transitory and seasonal (Section 5.3.2.3).		
Receptor sensitivity	High value species MNES species known to be present.		
Environmental objective	Objective 11: To not have a substantial adverse effect on a population of seabirds or migratory shorebirds, or the spatial distribution of the population. Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Light	Slight	Minor (D)
	Atmospheric Emissions: Offshore Activities	No lasting effect	Slight (E)
	Atmospheric Noise Emissions	No lasting effect	Slight (E)
	Marine Discharges: Putrescible Waste	No lasting effect	Slight (E)
	Production Activities: Seabed Subsidence	No lasting effect	Slight (E)

Receptor	Seabirds and migratory shorebirds
<i>Aspect Interaction Assessment and Conclusion</i>	
Given the isolated FPSO locations, cumulative impacts on seabirds and migratory shorebirds resulting from interactions with other facilities and regional vessel/air traffic are not considered significant. As nesting and feeding aggregation areas are generally in coastal locations, the greatest potential for cumulative industrial impacts in the region is due to increased prevalence of light sources that may interrupt migratory behaviour. Given the extremely low density of oil and gas infrastructure, cumulative impact at a population level is considered unlikely. Some slight behavioural impact on seabirds and migratory shorebirds may occur as a result of atmospheric noise from helicopters and flaring and light emissions from vessels, MODUs and the FPSO facilities. However, the slight magnitude of these light impacts and the infrequent nature of the atmospheric noise emissions means that no increase to the significance of the predicted impacts due to exposure to multiple aspects is predicted. As such, the overall impact significance level of impacts on seabirds and migratory shorebirds has been assessed as Minor (D) (based on the assessment of impacts resulting from light emissions (Minor (D)) and atmospheric noise (Slight (S)). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objectives for this receptor will be achieved and this impact is assessed as Acceptable.	

Fish

Table 9-9: Fish cumulative assessment

Receptor	Fish
Local environment context	Fish assemblages within the Browse Development Area occupy a diverse range of habitats and are typical of the fish communities and species representative of the Timor Province. These fish assemblages include : + shallow-water, site-attached coral reef fish communities with characteristically high diversity and abundance + open water pelagic fish + deepwater, demersal fish communities (Section 5.3.2.8). EPBC Act listed fish species that may occur within the Project Area include the whale shark, shortfin mako, longfin mako, green sawfish and largetooth sawfish. The whale shark foraging BIA extends north along the northern WA coastline (predominately inshore of the Project Area) from Ningaloo almost to the Northern Territory (NT) border (Section 5.3.2.2). Based on studies undertaken of the whale shark's migratory behaviours, this species may occur within the Project Area, albeit in low numbers (Section 5.3.2.7).
Receptor sensitivity	High value species MNES species known to be present.
Environmental objective	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 14: To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.

Receptor	Fish		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Light	No lasting effect	Slight (E)
	Physical Presence: Electromagnetic Emissions	No lasting effect	Slight (E)
	Atmospheric Noise Emissions	No lasting effect	Slight (E)
	Underwater Noise Emissions	No lasting effect	Slight (E)
	Marine Discharges: Sewage and Sullage	No lasting effect	Slight (E)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Slight (E)
	Marine Discharges: Putrescible Waste	No lasting effect	Slight (E)
	Marine Discharges: Produced water	No lasting effect	Slight (E)
	Marine Discharges: Cooling Water	No lasting effect	Slight (E)
	Marine Discharges: Drilling Discharges	No lasting effect	Negligible (F)
	Marine Discharges: Subsea control fluids	No lasting effect	Slight (E)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Slight (E)
Aspect Interaction Assessment and Conclusion			
Given the isolated FPSO locations, cumulative impacts on fish resulting from interactions with other facilities and regional vessel/air traffic are not considered credible. Mitigation measures detailed in Chapter 6 for whale sharks will ensure no impact on migration patterns. Slight impacts with no lasting effect may occur to fish as a result of discharges during construction, commissioning and operations, including hydrotest fluid, cooling water, PW, treated utility water, sewage and sullage and putrescible waste. Slight impacts with no lasting effect may also occur as a result of underwater noise emissions during construction (e.g. piling, VSP, MODU on DP) and operations (e.g. subsea infrastructure operations, routine FPSO operations, use of DP). Given the nature of these discharges and emissions (location and frequency) it is possible that any fish may be exposed to multiple aspects concurrently (e.g. concurrent exposure to underwater noise emissions and marine discharges from the FPSO facilities such as PW and cooling water). However, given no lasting effect on fish are expected to occur from these aspects, no significant cumulative impacts are predicted. As such, the overall impact significance level of impacts on fish has been assessed as Slight (E). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objectives for this receptor will be achieved and this impact is assessed as Acceptable.			

Marine mammals**Table 9-10: Marine mammals cumulative assessment**

Receptor	Marine mammals
Local environment context	The PMST identified 27 marine mammal species as potentially occurring within the Project Area. Of these, the pygmy blue whale (endangered and migratory), humpback whale, sei whale, fin whale (vulnerable and migratory) and Bryde's whale (migratory) are considered most likely to occur (albeit representing a low percentage of each species populations) within the Project Area and/or interact with the proposed Browse to NWS Project (Section 5.3.2.4). There are BIAs for migration and breeding and calving for the humpback whale along the WA coast and within the NWMR, but there are no known BIAs within the Project Area. A migratory BIA for the pygmy blue whale extends for most of the length of the NWMR within offshore waters and encompasses Scott Reef. The Conservation Plan for Blue Whales (Commonwealth of Australia, 2015) also documents a possible foraging area which encompasses the majority of Scott Reef and its surrounds. It is expected pygmy blue whales may occur within the Browse Development Area, albeit in low numbers, and it is acknowledged that pygmy blue whales have been recorded in the channel between North and South Scott Reef; and that they may forage opportunistically in and around Scott Reef (given it is a possible foraging BIA). Other marine mammal species identified as likely to occur in the Project Area (such as the sei whale, fin whale and Bryde's whales) are expected to be limited to infrequent transient individuals (Section 5.3.2.4.3).
Receptor sensitivity	High value species MNES species known to be present.
Environmental objective	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 15: To not have a substantial adverse effect on a population of marine mammals, or the spatial distribution of the population.

Receptor	Marine mammals		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Electromagnetic Emissions	No lasting effect	Slight (E)
	Atmospheric Noise Emissions	No lasting effect	Slight (E)
	Underwater Noise Emissions	Slight	Minor (D)
	Marine Discharges: Sewage and Sullage	No lasting effect	Slight (E)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Slight (E)
	Marine Discharges: Produced water	No lasting effect	Slight (E)
	Marine Discharges: Cooling Water	No lasting effect	Slight (E)
	Marine Discharges: Drilling Discharges	No lasting effect	Slight (E)
	Marine Discharges: Subsea control fluids	No lasting effect	Slight (E)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Slight (E)
Aspect Interaction Assessment and Conclusion			
Given the isolated FPSO locations, cumulative impacts on marine mammals resulting from interactions with other facilities and regional vessel/air traffic are considered minor. Regional oil and gas infrastructure is located in the migratory pathways, but not in known aggregation areas for key marine mammal species such as Pygmy Blue Whales and Humpback Whales. Both species have shown recovery since the cessation of whaling despite increased oil and gas (and general shipping) activities on the North West Shelf (Chapter 5). The primary source of potential impacts to marine mammals such as pygmy blue whales is from underwater noise emissions during construction (e.g. piling, VSP, MODU on DP) and operations (e.g. subsea infrastructure operations, routine FPSO operations, use of DP) (Section 6.3.8). No lasting effect on marine mammals is predicted as a result of other aspects, including marine discharges. As described in Section 6.3.8, modelling has indicated that while no injury or mortality to marine mammals is predicted to occur, there is potential for some degree of behavioural disturbance as a result of underwater noise emissions associated with the proposed Browse to NWS Project. These impacts are expected to be localised behavioural disturbance of marine mammals within the vicinity of the noise source. Modelling of a representative cumulative scenario indicated that this behavioural response would be limited to less than 2% of the area identified as a possible foraging area for pygmy blue whales, leaving 98% available for uninterrupted foraging. Given no other aspect is predicted to have any lasting effect on marine mammals and cumulative impact from multiple aspects is not expected to be significant. As such, the overall impact significance level of impacts on marine mammals has been assessed as Minor (D) (based on the assessment of impacts resulting from underwater noise emissions). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objectives for this receptor will be achieved and this impact is assessed as Acceptable.			

Marine reptiles**Table 9-11: Marine reptiles cumulative assessment**

Receptor	Marine reptiles		
Local environment context	The PMST identified six species of marine turtle species as potentially occurring within the Project Area; the leatherback turtle, loggerhead turtle, olive ridley turtle, green turtle, hawksbill turtle and flatback turtle. These species are described in Section 5.3.2.5. The Recovery Plan for Marine Turtles identifies Habitat Critical to the Survival of a Species and this has been identified for the Scott Reef – Browse Island green turtle genetic stock within the Project Area (Section 5.3.2.5.1). The habitat includes Sandy Islet at Scott Reef and a 20 km internesting buffer (Commonwealth of Australia, 2017). There are also nesting and internesting BIAs at Scott Reef (associated with nesting at Sandy Islet) for both the green turtle and hawksbill turtle (Section 5.3.2.5.2).		
Receptor sensitivity	High value species MNES species known to be present.		
Environmental objective	Objective 12: To not substantially modify, destroy or isolate an area of important habitat for a threatened or migratory species. Objective 13: To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a threatened or migratory species. Objective 16: To not have a substantial adverse effect on a population of marine reptiles, or the spatial distribution of the population.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Light	Slight	Minor (D)
	Physical Presence: Electromagnetic Emissions	No lasting effect	Slight (E)
	Atmospheric Noise Emissions	No lasting effect	Slight (E)
	Underwater Noise Emissions	Slight	Minor (D)
	Marine Discharges: Sewage and Sullage	No lasting effect	Slight (E)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Slight (E)
	Marine Discharges: Produced water	No lasting effect	Slight (E)
	Marine Discharges: Cooling Water	No lasting effect	Slight (E)
	Marine Discharges: Drilling Discharges	No lasting effect	Slight (E)
	Marine Discharges: Subsea control fluids	No lasting effect	Slight (E)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Slight (E)

Receptor	Marine reptiles
<i>Aspect Interaction Assessment and Conclusion</i>	
Given the isolated FPSO locations, cumulative impacts on marine reptiles resulting from interactions with other facilities and regional vessel/air traffic are considered minor. The greatest potential for cumulative impact to marine reptiles in the region is considered to result from light pollution on nesting areas. The primary sources of potential impacts to marine turtles are artificial light emissions from the MODU and FPSO facilities operating at Torosa; and underwater noise emissions resulting from potential pile driving activities, drilling and the MODU DP. Chemical discharges are noted as a threat to marine turtles in the Recovery Plan for Marine Turtles in Australia 2017-2027' (Commonwealth of Australia, 2017), however, marine discharges from the proposed Browse to NWS Project are not predicted to result in any last lasting affect on marine turtles. As described in Chapter 6, impacts from these aspects on marine turtles are not predicted to be significant and it is considered that they can be managed to an acceptable level through the implementation of mitigation measures. Cumulative impacts may occur as a result of simultaneous exposure to these aspects. For example, nesting turtles or hatchling attracted by light emissions from the Torosa FPSO facility or a MODU operating at Torosa would subsequently be exposed to noise emissions and marine discharges from the FPSO or MODU (e.g. DP noise). These cumulative impacts would be limited to behavioural responses in a small number of adult marine turtles and are not expected to be significant. Cumulative impacts to marine turtles may also occur as a result of attraction resulting from light emissions and concurrent exposure to other temporary, higher intensity noise emissions such as pile driving and VSP noise emissions. However, with the implementation of a proposed 500 m shut down zone during pile driving and VSP operations, as well as pre-start up visual observations, soft starts, operational and shutdown procedures; significant cumulative impacts resulting from light and noise emission from pilling and VSP operations are not expected to occur. Cumulative impacts could also occur as a result of non-simultaneous exposure to light and noise emissions. For example, decreased nesting success as a result of behavioural impacts from noise emissions (i.e. females avoiding nesting habitat at Sandy Islet) combined with decreased hatchling survival rates due to disorientation from light emissions would have a combined impact on the overall population success of green turtles. However, as described in Chapter 6, light and noise emissions are not expected to significantly impact the breeding cycle of marine turtles at Sandy Islet, Scott Reef (predominately green turtles) and given the temporary nature of pile driving activities and the MODU's presence at a single location, no significant cumulative impacts on the nesting success or hatchling survival rates are expected as a result of the proposed Browse to NWS Project. Potential impacts may also occur to sea snakes as a result of marine discharges and underwater noise emissions resulting from the proposed Browse to NWS Project. As described in Chapter 6, impacts to water quality are not expected to be significant and impacts to sea snakes from noise emissions are expected to be limited to slight behavioural/avoidance impacts. No significant cumulative impacts to sea snakes within the Project Area are predicted. As such, the overall impact significance level of impacts on marine reptiles has been assessed as Minor (D) based on the assessment of impacts resulting from underwater noise emissions (Minor (D)) and light emissions (Minor (D)). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.	

Key Ecological Features (KEF) (medium value)**Table 9-12: KEF Features cumulative assessment**

Receptor	KEF Features		
Local environment context	The Browse Development Area overlaps with the Continental slope demersal fish communities and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs. The proposed BTL route traverses the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF and the Ancient coastline at 125 m depth contour KEF (Section 5.3.3.1).		
Receptor sensitivity	Medium value Designated sensitive Area. Values protected by legislation.		
Environmental objective	Objective 17: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Seabed Disturbance	No lasting effect	Negligible (F)
	Underwater noise	No lasting effect	Negligible (F)
	Marine Discharges: Sewage and Sullage	No lasting effect	Negligible (F)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Negligible (F)
	Marine Discharges: Putrescible Waste	No lasting effect	Negligible (F)
	Marine Discharges: Produced water	No lasting effect	Negligible (F)
	Marine Discharges: Cooling Water	No lasting effect	Negligible (F)
	Marine Discharges: Drilling Discharges	No lasting effect	Negligible (F)
	Marine Discharges: Subsea control fluids	No lasting effect	Negligible (F)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Negligible (F)

Receptor	KEF Features
Aspect Interaction Assessment and Conclusion	
Seabed disturbance and marine discharges will occur within these KEFs, however, no lasting effect is predicted to occur to the conservation values of these KEFs. The Project will be the first permanent infrastructure installed in the following KEFs: + Seringapatam Reef and Reef and Commonwealth waters in the Scott Reef Complex KEF + Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF Existing anthropogenic impacts for these KEFs include climate change related impacts, physical habitat modification (shipping anchorage, offshore construction and fishing practices (Commonwealth of Australia, 2012). The Project is likely to represent the largest (yet negligible) impact in terms of physical habitat modification in these KEFs therefore the impact described in Chapter 6 is considered an accurate depiction of cumulative impact. The Continental Slope Demersal Fish Communities and Ancient Coastline at 125 m depth contour KEFs contain other existing oil and gas infrastructure (pipelines and the North Rankin Complex). Given the small Project footprint relative to the total KEF area, and narrow footprint of pipeline infrastructure (allowing connectivity to be retained), the cumulative increase is not considered significant. The values of the Continental slope demersal fish communities KEF, the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF and the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF are primarily related to high productivity and aggregations of marine life. As described earlier, no significant cumulative impacts to plankton or fish are expected to occur from concurrent exposure to localised reduced water quality (resulting from marine discharges) and underwater noise emissions. As such, no cumulative impacts to the values of these KEFS (high productivity and aggregations of marine life) are expected. Likewise, seabed disturbance is unlikely to significantly impact productivity or marine life aggregation, and is not expected to contribute to any cumulative impacts to the values of the KEFs. Similarly, impacts to the Ancient coastline at 125 m depth contour KEF may occur where the proposed BTL crosses this KEF near the NRC tie-in point, as a result of the permanent installation of the BTL and temporarily due to vessel-based marine discharges during construction and IMR activities. The values of the Ancient coastline at 125 m depth contour KEF relate primarily to its unique seafloor geology, which are unlikely to be impacted by marine discharges associated with the proposed Browse to NWS Project. As such, no cumulative impacts to this KEF are predicted. As such, the overall impact significance level of impacts on KEFs has been assessed as Negligible (F). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.	

Australian Marine Parks (medium value (multiple use zones))**Table 9-13: AMP Features cumulative assessment**

Receptor	AMP Features		
Local environment context	The proposed BTL route traverses the Multiple Use Zones (IV) of the ArgoRowley Terrace and Kimberley Marine Parks. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park National Park Zone. Rationale for the route selection of the BTL is provided in Chapter 3 .		
Receptor sensitivity	Medium value (multiple use zones) Designated sensitive area. Values protected by legislation.		
Environmental objective	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Seabed Disturbance	No lasting effect	Negligible (F)
	Underwater noise	No lasting effect	Negligible (F)
	Physical Presence: Light	No lasting effect	Negligible (F)
	Marine Discharges: Sewage and Sullage	No lasting effect	Negligible (F)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Negligible (F)
	Marine Discharges: Putrescible Waste	No lasting effect	Negligible (F)
	Marine Discharges: Cooling Water	No lasting effect	Negligible (F)
Aspect Interaction Assessment and Conclusion			
Impacts to AMPs may occur as a result of the permanent installation of the proposed BTL and temporarily due to vessel-based marine discharges of cooling water, putrescible waste and sewage and sullage during construction and IMR activities. Threatening processes for the Kimberley Marine Park and Argo-Rowley Terrace Marine Park are similar to those described above for the affected KEFs and cumulative impacts are also considered similar. The impact of seabed disturbance on the Multiple Use Zone of the two AMPs has been minimised, as far as practicable, based on the route selection process (Chapter 3). Impacts have been assessed as negligible as the area traversed by the proposed BTL represents a small proportion of the total area of the AMPs. The activities are considered to be consistent with the objective of the Multiple Use Zone (VI) to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. As described in Chapter 6, given their temporary and transient nature, the impact of the vessel-based marine discharges are not expected to result in any lasting effect on the values of the two AMPs traversed (i.e. the Kimberley Marine Park and Argo-Rowley Terrace Marine Park). No cumulative impacts are expected to occur to AMPs as a result of marine discharges and seabed disturbance related to the installation of the subsea infrastructure. As such, the overall impact significance level of impacts on AMPs has been assessed as Negligible (F). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.			

State marine parks and nature reserves (high value)**Table 9-14: State marine parks and nature reserves cumulative assessment**

Receptor	State marine parks and nature reserves		
Local environment context	There are no State marine parks within the Project Area, however, the BTL route passes approximately 3 km from the Rowley Shoals Marine Park (Section 5.3.3.2). The Scott Reef Nature Reserve which was designated in 1993 and encompasses South Scott Reef (including Sandy Islet) down to the low mean water mark (Atlas of Marine Protection, 2019). This Nature Reserve protects the physical and ecological features of Scott Reef which are described throughout Chapter 5, including important nesting habitat (Habitat Critical for Survival of a Species) for the green turtle.		
Receptor sensitivity	High value Designated sensitive area. Values protected by legislation.		
Environmental objective	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Light	No lasting effect	Slight (E)
	Atmospheric noise emissions	No lasting effect	Slight (E)
	Marine Discharges: Produced water	No impact expected	
	Marine Discharges: Cooling water	No impact expected	
	Production Activities: Seabed Subsidence	Slight	Minor (D)
Aspect Interaction Assessment and Conclusion			
Given the distance of the proposed activities from State Marine Parks (the Rowley Shoals Marine Park is located approximately 3 km from the BTL route at its closest point), no impacts to State Marine Parks as a result of the proposed activities are predicted. Slight impacts are predicted to occur to the Scott Reef Nature Reserve as a result of potential seabed subsidence. As described above, no significant cumulative impacts are expected to occur to Scott Reef or the fauna that utilise the reef and Sandy Islet. No cumulative impacts to the Scott Reef Nature Reserve are expected. As such, the overall impact significance level of impacts on State marine parks and nature reserves has been assessed as Minor (D) (based on the assessment of impacts resulting from subsea subsidence). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.			

Other protected places (high value)

Table 9-15: Other protected places cumulative assessment

Receptor	Other protected places		
Local environment context	There are no National Heritage Sites within the Project Area. The closest National Heritage Sites are the Dampier Archipelago (including the Burrup Peninsula) and the Ningaloo Coast (Section 5.4.3.2). There are no World Heritage Sites within the Project Area (Section 5.4.3.3). Commonwealth Heritage Places located within or within the vicinity of the Project Area include Scott Reef and Surrounds – Commonwealth Area, and Mermaid Reef – Rowley Shoals (Section 5.4.3.1).		
Receptor sensitivity	High value Designated sensitive area. Values protected by legislation.		
Environmental objective	Objective 18: To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of a Protected Place.		
	Objective 19: To not have a substantial adverse impact on heritage values ¹		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Seabed Disturbance	No impacts predicted	
	Physical Presence: Light	No lasting effect	Slight (E)
	Marine Discharges: Sewage and Sullage	No lasting effect	Negligible (F)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Slight (E)
	Marine Discharges: Putrescible Waste	No lasting effect	Slight (E)
	Marine Discharges: Produced water	No impact expected	
	Marine Discharges: Cooling water	No impact expected	
	Marine Discharges: Drilling Discharges	No impact expected	
	Marine Discharges: Hydrotest Fluid	No impact expected	
Aspect Interaction Assessment and Conclusion			
As described above, project activities will be managed to avoid impacts occurring to Scott Reef shallow habitats (<75m) or the waters surrounding the reef and no cumulative impacts to the Scott Reef and Surrounds Commonwealth Heritage Place are expected. Likewise, no impacts are predicted to occur to the Mermaid Reef – Rowley Shoals Commonwealth Heritage Place. As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.			

9.2.2.3 Socio-Economic Receptors

State and Commonwealth managed fisheries (high value user)

Table 9-16: State and Commonwealth managed fisheries cumulative assessment

Receptor	State and Commonwealth managed fisheries		
Local environment context	State managed commercial fisheries in close proximity to the Project Area include Northern Demersal Scalefish, Mackerel, WA North Coast Shark, Onslow Prawn, Abalone, South West Coast Salmon, Pilbara Fish Trawl, Specimen Shell, Marine Aquarium Fish, West Coast Deep Sea Crustacean and Pearl Oyster Managed Fisheries. The Commonwealth managed fisheries located within the vicinity of the Project Area include the North West Slope Trawl Fishery, the Western Tuna and Billfish Fishery, the Southern Bluefin Tuna Fishery and the Skipjack Tuna Fishery (Western Skipjack Tuna Fishery). In 1974 the Australia-Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf – 1974 (MoU 74) was signed by the Governments of Australia and Indonesia, allowing allowed Indonesian fishers to continue to fish in designated areas using traditional methods only (Section 5.4.2.1 and Section 5.4.2.2).		
Receptor sensitivity	High value marine user Key fishing area, with high importance to stakeholders.		
Environmental objective	Objective 20: To not have a substantial adverse effect on the sustainability of commercial fishing. Objective 21: To not interfere with other marine users to a greater extent than is described in the draft EIS/ERD.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Disturbance to Other Users	Slight	Minor (D)
	Physical Presence: Light	No lasting effect	Slight (E)
	Marine Discharges: Sewage and Sullage	No lasting effect	Slight (E)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Slight (E)
	Marine Discharges: Putrescible Waste	No lasting effect	Slight (E)
	Marine Discharges: Produced water	No lasting effect	Slight (E)
	Marine Discharges: Cooling water	No lasting effect	Slight (E)
	Marine Discharges: Subsea control fluids	No lasting effect	Slight (E)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Slight (E)

Aspect Interaction Assessment and Conclusion

The cumulative impact of the Project through disturbance to other users in addition to other anthropogenic sources is unlikely to be significant due to relatively small exclusion zones (typically 500 m) and compatibility with certain fishery types, such as line and trap fishing, which may benefit from the creation of artificial habitat. The total seabed area restricted from trawling activities (due to snag risk) in the region as a result of anthropogenic seabed infrastructure is a relatively small proportion of the available fishery managed zones. Where the functions, interests or activities of other users involve marine fauna (e.g. fisheries), any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. As described above, no lasting effect on fish are expected to occur as a result of the proposed activities, with the impact significance level of impacts on fish assessed as Slight (E). Further, slight impacts (disturbance to other users) are predicted to occur to managed fisheries as a result of the physical presence of infrastructure (exclusion from a very small portion of potential fishing grounds) associated with the proposed Browse to NWS Project.

Given no lasting impact to target fish species is predicted, no cumulative impacts to managed fisheries are expected as a result of impacts to target fish species and the exclusion from some fishing grounds as a result of the physical presence of infrastructure.

As such, the overall impact significance level of impacts on State and Commonwealth fisheries has been assessed as Minor (D) (based on the assessment of impacts of disturbance to other users from the physical presence of infrastructure). As per the criteria outlined in [Section 6.2.3.4](#), it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as **Acceptable**.

Tourism and Recreation/Scientific Studies (high value user)

Table 9-17: Tourism and Recreation/Scientific studies cumulative assessment

Receptor	Tourism and Recreation/ Scientific studies
Local environment context	Recreation and tourism activities in the NWMR occur predominantly in WA State waters adjacent to coastal population centres (e.g. Broome), with a peak in activity during the winter months (dry season) (Section 5.4.2.6). Only one to two recreational fishing charter operators run trips to Scott Reef. The location has the potential to provide significant opportunities for pelagic sport fishing; however, given the distance from Broome and closest landfall and associated costs, only a limited number of charter operators are prepared to take recreational fishers out to Scott Reef. Those companies that do visit Scott Reef tend to make the trip only four to five times per year, spending around five days at the reef each time. Fishing is mainly focused on the south, west and north extremities of Scott Reef, generally only going into the South Scott Reef lagoon for snorkelling and for layover at night.
Receptor sensitivity	High value users Project area has low to medium level of utilisation by stakeholders.
Environmental objective	Objective 21: To not interfere with other marine users to a greater extent than is described in the draft EIS/ERD.

Receptor	Tourism and Recreation/ Scientific studies		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Disturbance to Other Users	Slight	Minor (D)
	Physical Presence: Light	No lasting effect	Slight (E)
	Atmospheric noise emissions	No lasting effect	Slight (E)
	Underwater noise emissions	No lasting effect	Slight (E)
	Marine Discharges: Sewage and Sullage	No lasting effect	Slight (E)
	Marine Discharges: Treated Utility Water, Chemical and Deck Drainage	No lasting effect	Slight (E)
	Marine Discharges: Putrescible Waste	No lasting effect	Slight (E)
	Marine Discharges: Produced water	No impacted expected	
	Marine Discharges: Cooling water	No lasting effect	Slight (E)
	Marine Discharges: Drilling Discharges	No lasting effect	Slight (E)
	Marine Discharges: Hydrotest Fluid	No lasting effect	Slight (E)
	Production Activities: Seabed Subsidence	No lasting effect	Slight (E)
Aspect Interaction Assessment and Conclusion			
No lasting effect is predicted to occur to the tourism, recreation, or scientific studies values in the Project Area (and in particular Scott Reef). As described above, no significant cumulative impacts are expected to occur to the Scott Reef system or fauna that may be present in the surrounding waters. Given this, no significant cumulative impacts to tourism, recreation or scientific studies values are expected to occur as a result of the proposed Browse to NWS Project. As such, the overall impact significance level of impacts on tourism, recreation and scientific studies has been assessed as Slight (E). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable.			

Shipping (medium to high value user)**Table 9-18: Shipping cumulative assessment**

Receptor	Shipping		
Local environment context	Shipping activity in and around the Browse Development Area is sparse, with the main commercial shipping routes located approximately 50 to 100 km west, intersecting the proposed BTL route at various locations, depending on the port. The main shipping activity in the NWMR relates to transits to and from Broome and transportation of goods between Australian and international ports. Major ports are adjacent to the Roebuck, Montebello and Dampier Commonwealth marine reserves (Section 5.4.2.4).		
Receptor sensitivity	Medium/high value users Busy shipping area is located outside of Project Area, but shipping traffic still likely to be high.		
Environmental objective	Objective 21: To not interfere with other marine users to a greater extent than is described in the draft EIS/ERD.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Disturbance to Other Users	Slight	Minor (D)
Aspect Interaction Assessment and Conclusion			
Impacts to shipping will be limited to slight temporary impacts during construction of the proposed BTL and infrequent IMR activities. As no other activities are expected to impact shipping, no cumulative impacts to shipping are expected to occur as a result of the proposed Browse to NWS Project.			
The overall impact significance level of impacts on shipping has been assessed as Minor (D). As per the criteria outlined in Section 6.2.3.4 , it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable .			

Industry (low value user)**Table 9-19: Industry cumulative assessment**

Receptor	Industry		
Local environment context	The NWMR supports a number of industries including petroleum exploration and production, as well as minerals extraction. There are seven sedimentary petroleum basins in the NWMR: the Northern and Southern Carnarvon basins, Perth, Browse, Roebuck, Offshore Canning and Bonaparte basins. Of these, the Northern Carnarvon, Browse and Bonaparte basins hold large quantities of gas and comprise most of Australia's reserves of natural gas (Section 5.4.2.5).		
Receptor sensitivity	Low value The Project Area is not of extensive use by other Industry.		
Environmental objective	Objective 21: To not interfere with other marine users to a greater extent than is described in the draft EIS/ERD.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Disturbance to Other Users	Slight	Negligible (F)

Aspect Interaction Assessment and Conclusion

Displacement of, or interference with, other oil and gas activities is not expected within the Browse Development Area. However, activities associated with the BTL, such as BTL installation, may result in short term interference, particularly at the NRC location (5-10 km away). No cumulative impacts to industry are expected to occur as a result of the proposed Browse to NWS Project.

As such, the overall impact significance level of impacts on industry has been assessed as Negligible (F). As per the criteria outlined in [Section 6.2.3.4](#), it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as **Acceptable**.

Settlements (medium value users)

Table 9-20: Settlements cumulative assessment

Receptor	Settlements		
Local environment context	The proposed Browse to NWS Project presents potential social benefits and impacts to communities within WA and particularly Broome and the Dampier Peninsula, with Broome being the potential primary supply chain and logistics support location (Section 5.4.4).		
Receptor sensitivity	Medium value users Regionally important, low sensitivity to change.		
Environmental objective	Objective 22: To protect social surroundings from significant harm.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Atmospheric Noise Emissions	No lasting effect	Negligible (F)

Aspect Interaction Assessment and Conclusion

Atmospheric noise emissions from helicopters (transiting from logistic locations and the Project Area) are not predicted to have any lasting effect on settlements.

Atmospheric noise emissions from helicopters are the only aspect predicted to result in potential impacts to settlements. As such, there are no predicted receptor-based cumulative impacts for settlements.

As such, the overall impact significance level of impacts on settlements has been assessed as Negligible (F). As per the criteria outlined in [Section 6.2.3.4](#), it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as **Acceptable**.

Aboriginal and indigenous heritage (high value users)**Table 9-21: Aboriginal and indigenous heritage cumulative assessment**

Receptor	Aboriginal and indigenous heritage		
Local environment context	No known sites of Aboriginal Heritage significance are located within the Development Area, according to the WA Department of Aboriginal Affairs' Aboriginal Sites Inquiry System. The existence of any unknown Aboriginal sites or artefacts of significance within the Browse Development Area, or the wider NWMR, is considered highly unlikely due to the site's remote location offshore (Section 5.4.3.1).		
Receptor sensitivity	High value users Browse Development Area is of high importance to stakeholders		
Environmental objective	Objective 21: To not interfere with other marine users to a greater extent than is described in the draft EIS/ERD.		
Relevant aspects: Proposed Browse to NWS Project	Aspect	Magnitude	Impact significance level
	Physical Presence: Disturbance to Other Users	Slight	Minor (D)
	Marine Discharges: Produced water	No lasting effect	Slight (E)
	Marine Discharges: Cooling water	No lasting effect	Slight (E)
	Marine Discharges: Drilling Discharges	No lasting effect	Slight (E)
Aspect Interaction Assessment and Conclusion			
No impact to aboriginal heritage is expected to occur as a result of the proposed Browse to NWS Project. Slight impacts to traditional Indonesian fisher utilising the MOU 74 area may occur as a result of the physical presence of infrastructure. As no lasting impacts to fish are predicted, no cumulative impacts to Indonesian fishers as a result of impacts to target species and disturbance from the physical presence of infrastructure are predicted. As such, the overall impact significance level of impacts on settlements has been assessed as Minor (D) (based on the assessment of impacts of disturbance to other users from the physical presence of infrastructure on Indonesian fishers). As per the criteria outlined in Section 6.2.3.4, it is considered that the environmental objective for this receptor (Table 6-7) will be achieved and this impact is assessed as Acceptable. It is noted that potential impacts associated with atmospheric emissions resulting from the onshore processing of the Browse gas by the NWS JV on the national heritage values of the listed National Heritage Place on the Dampier Archipelago (including aboriginal heritage values) are addressed in the North West Shelf Project Extension ERD (EPA 2186, EPBC 2018/8335).			

Maritime archaeology

Table 9-22: Maritime archeology cumulative assessment

Receptor	Maritime archeology		
Local environment context	The Australian National Shipwreck Database and the WA Maritime Museum Shipwreck Database list one protected historic wreck within the Browse Development Area. The historic shipwreck of the Yarra is located at South Scott Reef. The Yarra was an iron barque vessel carrying a load of guano which struck the reef during a gale in 1884 (Section 5.4.3.2).		
Receptor sensitivity	High value Maritime archaeology protected by legislation exists within the Browse Development Area		
Environmental objective	Objective 19: To not have a substantial adverse impact on heritage values.		
Relevant aspects:	Aspect	Magnitude	Impact significance level
Proposed Browse to NWS Project	Physical Presence: Seabed Disturbance	No impact predicted	
	Production Activities: Seabed Subsidence	No impact predicted	
Aspect Interaction Assessment and Conclusion			
No impacts to the marine archaeology within the Project Area (i.e. shipwrecks at Scott Reef) are predicted and, therefore, no cumulative impacts to maritime archaeology are expected to occur as a result of the proposed Browse to NWS Project. As per the criteria outlined in Section 6.2.3.4 , it is considered that the environmental objective for this receptor will be achieved and this impact is assessed as Acceptable .			

9.3 Overall Assessment of Risks from Unplanned Events or Incidents

Environmental risks from unplanned events or incidents may have significant consequences to multiple high value receptors on a regional scale. However, it is important to note that with the implementation of industry best practice mitigation and management measures by Woodside, a highly experienced operator, as well as significant legislative requirements and regulatory oversight, the likelihood of a significant risk event occurring and resulting in significant impacts is highly unlikely to remote.

[Chapter 6](#) provides an assessment of the risk events identified during the impact and risk assessment. The following risks were identified as having a low risk rating due to the likelihood of the risk event occurring, along with the subsequent consequence:

- + accidental dropped objects from vessels, the MODU or the FPSO facilities impacting benthic habitats – [Section 6.3.1](#)
- + damage to unidentified maritime archaeology (ship or plane wrecks) during the placement of subsea infrastructure or the BTL and inter-field spur line – [Section 6.3.1](#)
- + unplanned release of treated sewage and sullage above regulatory limits – [Section 6.3.9](#)

- + unplanned release of treated utility water above regulatory limits – [Section 6.3.10](#)
- + unplanned release of PW at significantly elevated discharge concentrations that would lead to water quality impacts within the State waters 3 nm boundary – [Section 6.3.12](#)
- + unplanned release of cooling water at significantly elevated discharge concentrations that would lead to water quality impacts within the State waters 3 nm boundary – [Section 6.3.13](#)
- + unplanned discharge of hazardous and non-hazardous inorganic waste – [Section 6.3.14](#)
- + dispersal of drill cuttings and fluids being greater than predicted, resulting in impacts to high value Scott Reef shallow water benthic habitats (<75 m depth) be greater than predicted – [Section 6.3.15](#)
- + unplanned discharge of subsea control fluid at a volume significantly greater than predicted – [Section 6.3.16](#)
- + unplanned vessel interactions with marine turtles and fish (whale sharks) – [Section 6.3.18](#).

Environmental risks that were ranked as moderate or high included the following:

- + the risk posed by the potential higher utilisation of the Browse Development Area by pygmy blue whales and subsequent increased impact of underwater noise (moderate risk) – [Section 6.3.8](#)

- + the unplanned vessel interactions with marine mammals (moderate risk) – [Section 6.3.18](#)
- + the introduction and establishment of IMS at Scott Reef (moderate risk) – [Section 6.3.19](#)
- + unplanned hydrocarbon releases (moderate to high risk) – [Section 6.3.21](#).

It should be noted that the moderate and high-risk rating for these risks was driven by the significance of the potential consequences to high value receptors, on a regional scale. The likelihood of these risks occurring and resulting in subsequent impacts is considered highly unlikely to remote. It is also noted that different receptor groups would be impacted by each of the risk events. As such, it is considered that the likelihood of multiple risk events occurring, cumulatively resulting in a significant impact (inclusive of impacts from planned activities) on receptors, is remote.

With respect to the risks that are assessed as moderate or high risk, as significant impacts from one of these risk events could occur on a regional scale, cumulative impacts could take place if an unplanned risk event and other regional (natural or anthropogenic) stressors occurred at the same time. For example, a significant hydrocarbon spill impacting Scott Reef would potentially impact the recovery of the reef from recent natural perturbations (i.e. the 2016-2017 coral bleaching event). Likewise, the introduction and establishment of an IMS at Scott Reef could also potentially impact the ecosystem integrity of the reef system.

The planned mitigation and management actions for each of these risk events are described in [Chapter 6](#). Given that the likelihood of any of these risk events occurring is considered unlikely to remote, the planned mitigation and management measures, and in consideration of the criteria outlined in [Section 6.2.3.4](#), it is considered that the environmental objective for each receptor ([Table 6-7](#)) potentially impacted by these risk events will be achieved and, as such, these risks are assessed as **Acceptable**.

9.4 Mitigation, Management and Monitoring

[Chapter 8](#) presents the overarching HSE management approach that Woodside will implement for the proposed Browse to NWS Project. It demonstrates the mitigation and management approach that Woodside will use to avoid environmental impacts and risks identified in this draft EIS/ERD or minimise them to an acceptable level. Where practicable, potential impacts have been avoided through the design and engineering process. Additional work will be undertaken during the detailed engineering phase of the proposed Browse

to NWS Project to further refine design and reduce potential impacts.

Specific proposed measures to mitigate and manage unavoidable impacts from planned activities and reduce the environmental risk associated with unplanned events and incidents are presented in [Chapter 6](#). These measures include compliance with regulatory requirements as well as industry best practice.

Central management and monitoring commitments for the proposed Browse to NWS Project include, but not limited to the following:

- + Key management strategies:
 - + Underwater noise monitoring of a RFSU operational well will be undertaken to inform an adaptive management approach for noise management for the TRD and TRE wells if required.
 - + FPSO PW will be treated prior to being discharged overboard using a tertiary treatment system, such as a Macro Porous Polymer Extraction (MPPE) system that meets Woodside and accepted industry standards.
 - + Project vessels will not travel at speeds greater than 12 knots with the State Proposal Area, or 6 knots in the Scott Reef channel.
 - + Fast Crew Transfer Vessels (FCTVs) will operate under an approved FCTV Management strategy (to be detailed in subsequent Environment Plans as required) which will describe the appropriate additional control measures to manage vessel strike risk for the FCTV. Without additional engineering controls, FCTVs will not travel at speeds greater than 30 knots in sensitive areas at sensitive times.
 - + Project vessels and MODUs will be subject to a risk assessment process to assess the likelihood of introducing IMS when transiting to the Project Area. Based on the outcomes of risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented.
 - + Internationally sourced Project vessels and MODUs required within 3 nm of Scott Reef (State Proposal Area) for longer than 48 hours will be inspected by an experienced IMS expert/marine scientist for IMS; and cleaned where required¹.

¹ Subject to confirmation, vessel/rig may be permitted re-entry within Scott Reef State waters (3 nm) without re-inspection provided its movements outside Scott Reef State waters at stationary or at slow speeds (less than three knots) in waters less than 50 metres deep do not exceed a period totalling greater than seven accumulative days prior to returning to Scott Reef State waters (3 nm).

+ Assurance:

- + Light monitoring will occur during drilling and completion of a well at TRE drill centre to verify modelling predictions.
- + Periodic and ‘for cause’ toxicity testing and characterisation of the physical and chemical composition of the PW stream prior to discharge will be undertaken.
- + During steady state FPSO operations, PW modelling and infield verification will be completed to verify the modelling predictions.
- + Baseline and periodic water and sediment quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to detect changes because of FPSO PW discharge.
- + During steady state FPSO operations, cooling water modelling and infield verification will be completed to verify the modelling predictions.
- + Verification monitoring for seabed subsidence will be undertaken.
- + IMS surveillance program will be undertaken at Scott Reef, consisting of baseline survey prior to the commencement of activities in the State Proposal Area, and periodic surveys over the life of the proposed Browse to NWS Project.
- + Project vessels will not use heavy fuel oil or intermediate fuel oil.

+ Verifying science:

- + Continuation of the Scott Reef long term monitoring program to monitor the functionality and status of the reef system, throughout the full lifecycle of the proposed Browse to NWS Project.
- + The existing pygmy blue whale data will be updated by targeted monitoring programs to verify impact predictions and inform adaptive management approaches at relevant times throughout the proposed Browse to NWS Project life cycle.
- + The existing turtle data will be updated by targeted monitoring programs to verify impact predictions at relevant times throughout the proposed Browse to NWS Project life cycle.
- + Targeted monitoring programs of pygmy blue whales and green turtles will be undertaken to verify impact predictions and inform adaptive management approaches at relevant times throughout the proposed Browse to NWS Project life cycle.

In the event that impacts cannot be avoided or mitigated to an acceptable level, an environmental offset plan will be developed as described in [Section 8.7](#).

The measures presented in this draft EIS/ERD will be incorporated into activity-specific Environment Plans to be submitted for acceptance by NOPSEMA for Commonwealth waters and DMIRS for State waters, prior to the activity commencing where required. As described in [Chapter 8](#), these Environment Plans will include strategies to reduce the impacts from planned (routine and non-routine) activities and risks from unplanned events and incidents to ALARP. In addition, EPs will include response strategies to be implemented in the highly unlikely event of a moderate to high risk event being realised.

9.5 Overall Assessment of Acceptability

This draft EIS/ERD presents the predicted impacts from planned activities and the environmental risks associated with unplanned events and incidents.

[Chapter 6](#) presents the assessment of these impacts and risks for each aspect as well as an assessment of the acceptability of the impacts and risks in terms of the defined acceptability criteria which considers the Principals of ESD, the EPBC Act Significant Impacts Guidelines, the WA EPA Environmental Objectives, external and internal context and other requirements such as the requirements of the North-west Marine Parks Network Management Plan, specific EPBC Act conservation management and recovery plans and conservation advices for protected fauna. The conclusion of this assessment is that the impacts and risks presented by each aspect are **Acceptable**.

[Section 9.2.2](#) presents an overall qualitative assessment of the cumulative impacts to the key sensitive receptors that may be affected by the proposed Browse to NWS Project. This assessment concludes that no significant receptor based cumulative impacts are expected to occur, the stated environmental objective for each receptor ([Table 6-7](#)) is expected to be achieved; and that the impacts to each sensitive receptor are **Acceptable**.

[Section 9.3](#) presents an overall assessment of the environmental risks associated with unplanned events or incidents. The assessment finds that the stated environmental objective for each receptor ([Table 6-7](#)) is expected to be achieved and the overall risk posed in relation to unplanned events or incidents is **Acceptable**.

[Chapter 7](#) presents the GHG emissions predicted to occur in a range of scenarios as a result of the proposed Browse to NWS Project and also provides a framework for consideration of those emissions in a cumulative context. The assessment details the emissions abatement measures that have been undertaken to date in the design process to reduce predicted emissions to an acceptable level. It also provides an overview of the potential benefits natural gas can present in the context of reducing global

greenhouse gas emissions, whilst acknowledging the uncertainties associated with predicting future global greenhouse gas emissions. The assessment concludes that GHG emissions from the proposed Browse to NWS Project are considered **Acceptable**.

Finally, an assessment of the predicted impacts from the proposed Browse to NWS Project to the environment as a whole has been undertaken and is presented below. This assessment has been undertaken against the requirements of the principles of ESD and the objectives,

requirements of the EPBC Act and EP Act, and other requirements such as the requirements of the North-west Marine Parks Network Management Plan and specific EPBC conservation plans.

Principles of Environmentally Sustainable Development

An assessment of the proposed Browse to NWS Project against the principles of ESD as defined in the EPBC Act is provided in [Table 9-23](#).

Table 9-23 Assessment of proposed Browse to NWS Project against the principles of Environmentally Sustainable Development

Principles of ESD	Assessment
Decision making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	As described in Section 3.8, the selection of the concept for the proposed Browse to NWS Project was based on a set of primary drivers including environment, safety, economic performance and optimising economic recovery and supported by key drivers including global competitiveness, flexibility and robustness, stakeholder acceptance and marketability. The stakeholder acceptance driver is underpinned by the ability to achieve stakeholder alignment and government approvals, with all health, safety and environmental impacts and risks managed to an acceptable level, and to seek to apply inherently safe principles. Ongoing decision making will be driven by the objectives of the proposed Browse to NWS Project outlined in Chapter 2, which include the minimisation of the environmental footprint, managing HSE in accordance with industry standards and maximising socio-economic benefits. Chapter 7 presents a climate change impact assessment and concludes that Browse gas has the potential to play a significant role in enabling provision of clean and reliable energy as a partner to renewables. In addition, gas has the potential to contribute significantly to the reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. coal combustion). As such, it is considered that this principle of ESD has been considered in determining appropriate management and mitigation measures.
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.	Key aspects of the project will not result in any significant impacts (as defined in the MNES significant impact criteria) to endangered and vulnerable species—refer to Chapter 6. The available threatened species data (pygmy blue whales and green turtles), 2002 to 2017 and 2002 to 2010 respectively, were determined to be reliable and adequate for an assessment of impacts and risks to vulnerable species, and for the identification of suitable control measures, to ensure that the environmental objectives for the project are met. The existing data will be updated by a targeted monitoring program to verify impact predictions and inform adaptive management approaches at relevant times throughout the project life cycle, refer to Chapter 8, Table 8-1. Scientific knowledge will continue to be a key input into the detailed engineering phase and the implementation of the environmental mitigation, management and monitoring programs. Woodside has committed to the continuation of the Scott Reef long-term monitoring program to monitor the functionality and status of the reef system throughout the full lifecycle of the proposed Browse to NWS Project.

Principles of ESD	Assessment
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.	As described above and in Chapter 6, all of the stated environmental objectives of the proposed Browse to NWS Project (Table 6-7) are predicted to be achieved and all impacts from planned activities have been assessed as acceptable. In addition, environmental risks have been reduced to an acceptable level, with the likelihood of significant impacts occurring as a result of unplanned events or incidents considered highly unlikely to remote. As such, it is considered that maintenance of the health, diversity and productivity of the environment will not be adversely impacted by the proposed Browse to NWS Project. Further, environmental benefits are expected to be realised as part of the ongoing monitoring of the remote reef systems within and outside the Project Area and research collaborations with appropriate science partners. Design and management measures set out in Chapter 8 will ensure key environmental features in the Browse Development Area (Scott Reef) will be preserved for and accessible to future generations. As such, it is considered that this principle of ESD has been and will continue to be met.
The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.	As described above and throughout this draft EIS/ERD, the conservation of biological diversity and ecological integrity has been and will continue to be integral to the decision making process associated with the proposed Browse to NWS Project. This is demonstrated by: + integration of conservation of biological diversity and ecological integrity into decision making during the selection of the development concept for the commercialisation of the Browse reservoirs + selection of environmental objectives that align with the principles of Ecologically Sustainable Development and the adoption of management and migration measures to achieve each objective + The commitment to manage operational discharges (PW and cooling water from the FPSO facilities) from the FPSOs to meet the defined threshold values (i.e. 99% species protection or lowest no effect concentration) at the State waters 3 nm boundary, 95% of the time + a commitment to manage drilling discharges (in particular bottom hole discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD, TRE and TRF) in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats (<75 m water depth) + monitoring programs for marine reptiles, cetaceans, and coral reef communities to verify impact predictions and aid management. As such, it is considered that this principle of ESD has been and will continue to be met.
Improved valuation, pricing and incentive mechanisms should be promoted.	In line with its corporate policies and procedures, Woodside will endeavour to use valuation, pricing and incentive mechanisms during procurements associated with the proposed Browse to NWS Project to balance economic and HSE outcomes. As such, it is considered that this principle of ESD has been and will continue to be met.

EPBC Act Controlling Provisions

An assessment of the proposed Browse to NWS Project against the MNES Significant Impact Guidelines for the controlling provisions is provided in [Table 9-24](#). The significant impact criteria is provided in [Table 6-3](#).

Table 9-24 Assessment of proposed Browse to NWS Project against the significant impact criteria for the controlling provisions

Controlling Provisions	Assessment
Listed Threatened Species and Ecological Communities	As per the overall impact assessment provided in Section 9.2.2: + No impact to any species listed as extinct in the wild is predicted as a result of the proposed Browse to NWS Project. + No significant impact is predicted to occur to any critically endangered, endangered or vulnerable species. This includes no significant impact, at a population level, to a species habitat (including habitat critical to a species survival) or to a species breeding cycle as a result of the proposed Browse to NWS Project. + The proposed Browse to NWS Project is not expected to affect the recovery of any species that has a species recovery plan in place (see EPBC conservation management plans below). + The likelihood that the proposed Browse to NWS Project results in the introduction and establishment of IMS or disease that may affect listed threatened species has been assessed as Remote. + No impact to Threatened Ecological Communities is predicted as a result of the proposed Browse to NWS Project. The environmental objectives for the proposed Browse to NWS Project have been developed in consideration of the significant impact criteria outline in Table 6-5. The assessment has concluded that all environment objectives relevant to listed threatened species are predicted to be achieved. As such, no significant impacts, as defined by MNES Significant Impact Guidelines, are expected to occur in relation to this controlling provision.
Listed Migratory Species	As per the impacts and risk assessment provided in Chapter 6 and cumulative impact assessment provided above: + It is not expected that the proposed Browse to NWS Project will modify, destroy, fragment or isolate important areas for migratory species. + The proposed Browse to NWS Project is not expected to result in the introduction and establishment of IMS or disease that may affect listed threatened species. + It is not expected that the proposed Browse to NWS Project will seriously disrupt the lifecycle of an ecologically important proportion of the population of a migratory species. The environmental objectives for the proposed Browse to NWS Project have been developed in consideration of the significant impact criteria outline in Table 6-5. The assessment has concluded that all environment objectives relevant to listed migratory species are predicted to be achieved. As such, the assessment has concluded that no significant impacts, as defined by MNES Significant Impact Guidelines, are expected to occur in relation to this controlling provision.

Controlling Provisions	Assessment
The Commonwealth marine area, the protected matter being the environment generally.	As per the impacts and risk assessment provided in Chapter 6 and cumulative impact assessment provided above: + The proposed Browse to NWS Project is not expected to result in the introduction and establishment of IMS or disease that may affect listed threatened species. + It is not expected that the proposed Browse to NWS Project will modify, destroy, fragment, isolate or disturb substantial areas of habitat, such that an adverse impact results in a reduction of marine ecosystem function or integrity within the Commonwealth marine area. + It is not expected that the proposed Browse to NWS Project will have a substantial adverse effect on a population of a marine species, including its life cycle and distribution. + It is not expected that the proposed Browse to NWS Project will result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity, social amenity or human health. + It is not expected that the proposed Browse to NWS Project will result in 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. + It is not expected that the proposed Browse to NWS Project will have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck or plane wreck. The environmental objectives for the proposed Browse to NWS Project have been developed in consideration of the significant impact criteria outline in Table 6-5. The assessment has concluded that all environment objectives relevant to the Commonwealth Marine Environment are predicted to be achieved. As such, the assessment has concluded that no significant impacts, as defined by MNES Significant Impact Guidelines, are expected to occur in relation to this controlling provision.
National heritage values of a National Heritage Place	There are no National Heritage Places identified within the Project Area that may be affected by the proposed Browse to NWS Project. The assessment of any potential impacts on the national heritage values, including aboriginal heritage values, of the listed National Heritage Place on the Dampier Archipelago that may be associated with the onshore processing of the Browse gas by the NWS JV, is addressed within the ERD associated with the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335).

WA EPA Environmental Objectives

An assessment of the State waters component of the proposed Browse to NWS Project against the relevant WA EPA's Environmental Objectives (as determined by the WA EPA) is provided in [Table 9-25](#).

Table 9-25 Assessment of State waters component of the proposed Browse to NWS Project against the relevant WA EPA Environmental Objectives

EPA Environmental Objective	Assessment
Benthic Communities and Habitats - To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.	As per the impacts and risk assessment provided in Chapter 6 and above, the environmental objectives in relation to deepwater benthic habitat (>75 m water depth) and Scott Reef shallow water benthic habitats (<75 m water depth) are predicted to be met. As detailed in Chapter 8 and as recommended in the WA EPA Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016), Levels of Ecological Protection (LEPs) have been assigned within the State Proposal Area which include a maximum LEP for all Scott Reef shallow water benthic communities (<75 m water depth) and the majority of deepwater benthic communities (> 75 m water depth) during both construction and operations. A Environmental Quality Management Plan will be prepared and implemented to achieve these LEPs. As such, it is predicted that the WA EPA environmental objective <i>“to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained”</i> will be achieved.
Marine Environmental Quality - To maintain the quality of water, sediment and biota so that environmental values are protected.	As per the impacts and risk assessment provided in Chapter 6 and above, the environmental objectives in relation to marine environmental quality (specifically sediment quality, water quality and biota) are predicted to be met. As detailed in Chapter 8 and as recommended in the WA EPA Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016), Levels of Ecological Protection (LEPs) have been assigned within the State Proposal Area which include a maximum LEP for all Scott Reef shallow water benthic communities (<75 m water depth) and the majority of remaining State Proposal area, with High or Moderate LEPs assigned directly around the proposed subsea infrastructure within deepwater benthic communities (> 75 m water depth) during both construction and operations. An Environmental Quality Management Plan will be prepared and implemented to achieve these LEPs. As such, it is predicted that the WA EPA environmental objective <i>“to maintain the quality of water, sediment and biota so that environmental values are protected”</i> will be achieved.
Marine Fauna - To protect marine fauna so that biological diversity and ecological integrity are maintained.	As per the impacts and risk assessment provided in Chapter 6 and above, the environmental objectives in relation to marine fauna (specifically seabirds and migratory shorebirds, fish, marine mammals, marine reptile, epifauna and infauna) are predicted to be met. As per the impacts and risk assessment provided in Chapter 6 and cumulative impact assessment presented in Section 9.2, no significant impacts to marine fauna, including their life cycle or distribution are expected to occur. Potential impacts that may occur are expected to be limited to temporary behavioural (avoidance) impacts as a result of noise emissions, however, these are not expected to be significant. As such, it is predicted that the WA EPA environmental objective <i>“To protect marine fauna so that biological diversity and ecological integrity are maintained”</i> will be achieved.
Air Quality - To maintain air quality and minimise emissions so that environmental values are protected.	No significant impacts to air quality from offshore atmospheric emissions are expected to occur as a result of the proposed Browse to NWS Project. As such, it is predicted that the WA EPA environmental objective <i>“To maintain air quality and minimise emissions so that environmental values are protected”</i> will be achieved”. Atmospheric Emissions from third party processing of Browse Gas are addressed in the NWS JV 'North West Shelf Project Extension ERD' (EPA 2186, EPBC 2018/8335).

North-west Marine Parks Network Management Plan

As described in [Section 9.2.2.2](#), the proposed BTL route traverses the Multiple Use Zones (IV) of the Argo-Rowley Terrace and Kimberley Marine Parks. It should also be noted that the proposed BTL route passes approximately 2 km from the boundary of the Mermaid Reef Marine Park National Park Zone. Rationale for the route selection of the BTL is provided in [Chapter 3](#).

The conservation values and objectives of the marine parks are outlined in the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

Impacts to AMPs will occur as a result of the permanent installation of the proposed BTL and temporarily due to vessel-based marine discharges of cooling water, putrescible waste and sewage and sillage during construction and IMR activities.

The impact of seabed disturbance on the Multiple Use Zone of the two AMPs has been minimised as far as practicable during the route selection process ([Chapter 3](#)). Impacts have been assessed as negligible as the area traversed by the proposed BTL represents a small proportion of the total area of the AMPs and the activities are considered to be consistent with the objective of the Multiple Use Zone (VI) to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.

As described in [Chapter 6](#), given their temporary and transient nature, the impact of the vessel-based marine discharges is not expected to result in any lasting effect on the values of the two AMPs traversed (i.e. the Kimberley Marine Park and Argo-Rowley Terrace Marine Park). As such, no cumulative impacts are expected to occur to AMPs as a result of marine discharges and seabed disturbance related to the installation of the subsea infrastructure.

As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).

Assessment against EPBC conservation plans

Wildlife Conservation Plan for Migratory Shorebirds

Sandy Islet is used for roosting by seabirds and supports minor seabird breeding colonies, including for the little tern. Scott Reef is recognised as a resting BIA for the little tern. The Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a) has an objective that “Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated”.

Mitigation and management measures described in [Chapter 6](#) (particularly with respect to light emissions ([Section 6.3.3](#)), atmospheric noise emissions ([Section 6.3.7](#)), hazardous and nonhazardous waste ([Section 6.3.14](#)) and unplanned hydrocarbon releases ([Section 6.3.21](#))), have been specifically developed to reduce the impact of planned activities and reduce the risk of unplanned events and incidents to an acceptable level.

As described in [Section 9.2.2.2](#), the overall impact significance level of impacts on seabirds and migratory shorebirds has been assessed as Minor (D), based on the assessment of impacts resulting from light emissions (Minor (D)) and atmospheric noise (Slight (S)). These impacts are predicted to be limited to temporary behavioural impacts. Therefore, it is considered that the proposed activities are not inconsistent with the Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015a).

The Recovery Plan for Marine Turtles in Australia (2017-2027)

Sandy Islet and the surrounding waters (20 km interneresting buffer) are recognised as habitat critical to the survival of green turtles for the Scott Reef-Browse Island genetic stock in the Recovery Plan for Australian Marine Turtles 2017-2027 (Commonwealth of Australia, 2017) ([Figure 5-27](#)). In addition, a BIA exists for interneresting green and hawksbill turtles around Sandy Islet. ([Figure 5-26](#)).

The Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017) has specific requirements to:

- + Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival.
- + Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue.
- + In relation to the Scott Reef – Browse Island green turtle genetic stock, the priority action is to manage anthropogenic activities to ensure marine turtle populations are not displaced from identified habitat critical to their survival.

Mitigation and management measures described in [Chapter 6](#) (particularly with respect to light emissions ([Section 6.3.3](#)), underwater noise emissions ([Section 6.3.8](#)) and unplanned hydrocarbon releases ([Section 6.3.21](#))) have been specifically developed to reduce the impact of planned activities and reduce the risk of unplanned events and incidents to an acceptable level.

As described in [Section 9.2.2.2](#), the overall impact significance level of impacts on marine turtles has been assessed as Minor (D), based on the assessment of impacts resulting from underwater noise emissions (Minor (D) and light emissions (Minor (D))). These impacts are predicted to be limited to temporary behavioural impacts which are not expected to reduce nesting success. No displacement of marine turtles from identified habitat critical to the survival is predicted.

Therefore, it is considered that the proposed activities are not inconsistent with the objectives of the Recovery Plan for Marine Turtles in Australia (2017-2027) (Commonwealth of Australia, 2017).

Conservation Management Plan for the Blue Whale

The Project Area overlaps the pygmy blue whale migration BIA and possible foraging area located at Scott Reef, as identified in Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b). The conservation plan identifies noise interference and vessel disturbance as threats to the recovery of pygmy blue whales and notes an action that “Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a possible foraging area”.

Mitigation and management measures described in [Chapter 6](#) (particularly with respect to underwater noise emissions ([Section 6.3.8](#)), unplanned vessel interactions with fauna ([Section 6.3.18](#)) and unplanned hydrocarbon releases ([Section 6.3.21](#))) have been specifically developed to reduce the impact of planned activities and reduce the risk of unplanned events and incidents to an acceptable level.

As described in [Section 9.2.2.2](#), the overall impact significance level of impacts on marine mammals has been assessed as Minor (D). The impacts from underwater noise emissions have been assessed as minor. Behavioural modification of pygmy blue whales accessing a possible foraging area is not predicted as only 2% of the potential foraging area is predicted to be ensonified at levels above behaviour impact thresholds, leaving 98% of the possible foraging area available to pygmy blue whales and uninterrupted foraging. Potential impacts are likely to be restricted to a small number of individuals that may be travelling through the area and have been demonstrably minimised.

Therefore, it is considered that the proposed activities are not inconsistent with the Conservation Management Plan for the Blue Whale.

Overall conclusion

Woodside has considered the outcomes of the impact and risk assessment process and developed a range of mitigation and management measures to be implemented throughout the life cycle of the proposed Browse to NWS Project. In consideration of the unique values of Scott Reef and surrounds, the principles of ESD, the objects of the EPBC Act and EP Act and other relevant requirements, Woodside has concluded that the nominated environmental objectives for the proposed Browse to NWS Project will be met, the predicted impacts from planned activities and the potential risks from unplanned events and incidents have been reduced to an **Acceptable** level and that the proposed Browse to NWS Project can be implemented in a manner that will result in significant socio-economic benefits, while avoiding unacceptable environmental impacts.



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Chapter 6

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