

ENVIRONMENT PLAN

Beehive-1 Exploration Drilling

WA-488-P

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Rev 6

8-Environmental Risk Assessment - Unplanned Events

eog resources

8. Environmental Risk Assessment – Unplanned Events

This chapter presents the environmental risk assessment (ERA) for the environmental risks identified for the activity using the methodology described in Chapter 6, as required under Regulations 21(5)(6) of the OPGGS(E).

This chapter presents the control measures, EPO, EPS and measurement criteria required to manage (i.e., avoid, minimise or mitigate) the identified risks. The definitions for these terms as listed at the start of Chapter 7 apply here. A summary of the risk rankings for each hazard identified and assessed in this chapter is presented in Table 8.1.

Table 8.1. Summary of environmental risk rankings

Identifier	Hazard	Inherent	Residual
1	Accidental release of waste overboard	Low	Negligible
2	Vessel collision with megafauna	Low	Negligible
3	Introduction and establishment of IMS	High	Medium
4	Interference with other marine users	Medium	Low
5	Unplanned discharge of drilling muds, chemicals or hydrocarbons	Negligible	Negligible
6	MDO release	Negligible	Negligible
7	Loss of Well Control		
	- Benthic fauna	High	Medium
	- Macroalgal and seagrass	High	Medium
	- Coral	High	Medium
	- Mangroves and saltmarsh	High	Medium
	- Sandy beaches	High	Medium
	- Rocky shores	Low	Low
	- Plankton	Low	Low
	- Fish	Low	Low
	- Marine mammals	High	Medium
	- Marine reptiles	High	Medium
	- Seabirds and shorebirds	High	Medium
	- Commercial fisheries	High	Medium
	- Protected areas	High	Medium
8	Hydrocarbon spill response activities		
	- Source control; relief well	Negligible	Negligible
	- Monitor and evaluate	Negligible	Negligible
	- Dispersant application	Low	Low
	- Nearshore containment and recovery	Negligible	Negligible

Identifier	Hazard	Inherent	Residual
	- Shoreline protection and deflection	Negligible	Negligible
	- Shoreline assessment and clean up	Low	Low
	- Oiled wildlife response	Low	Low
	- Waste management	Negligible	Negligible
	Faunal receptors		
	- Fauna disturbance	Negligible	Negligible
	- Fauna injury	Negligible	Negligible
	- Fauna death	Negligible	Negligible

The following sections assess the environmental risks associated with the activity, and Figure 8.1 presents a simplified pictorial representation of these risks.

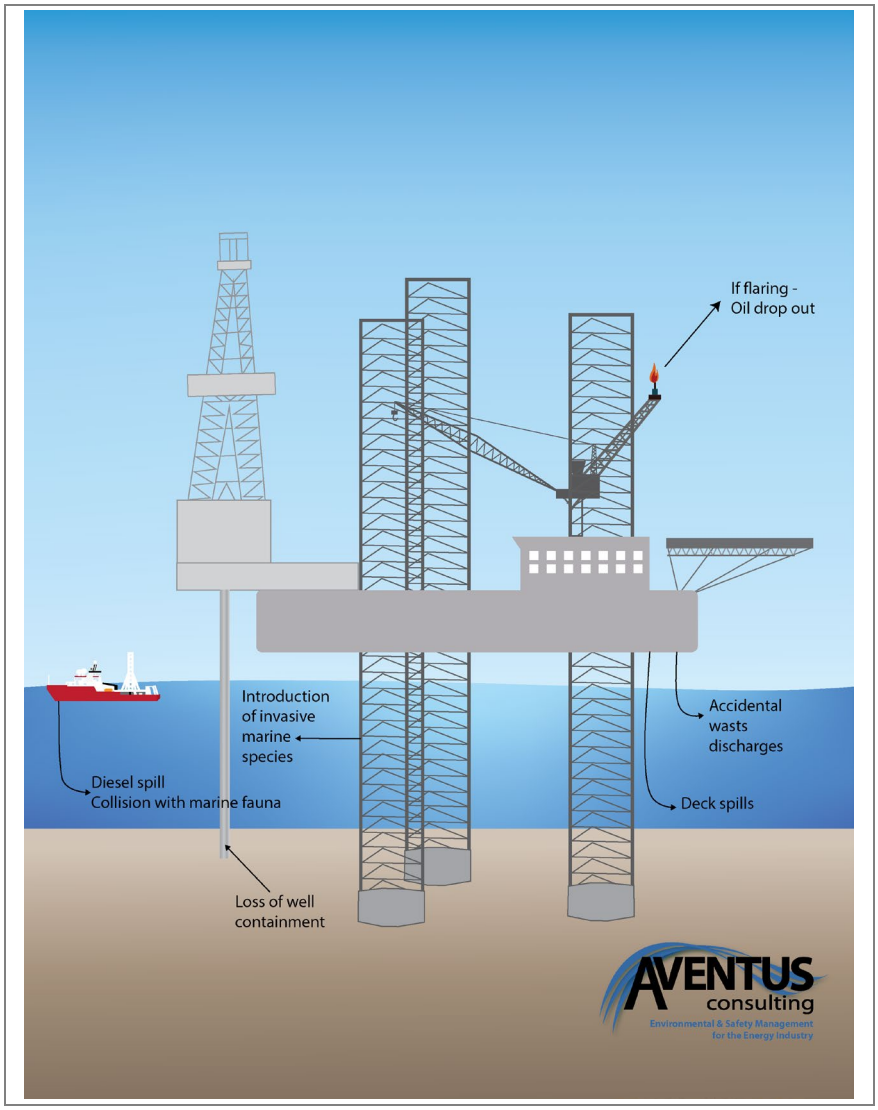


Figure 8.1. Simplified pictorial representation of the risks associated with the drilling activity

8.1 RISK 1 – Accidental Release of Waste Overboard

8.1.1 Hazard

The handling and storage of materials and waste on board the MODU and support vessels has the potential to result in accidental overboard disposal of hazardous and non-hazardous materials, waste, chemicals and fuel, creating marine debris and pollution.

Small quantities of hazardous and non-hazardous materials are used in routine operations and maintenance and waste is created, and then handled and stored on the MODU or support vessels. In the normal course of operations, solid and liquid hazardous and non-hazardous materials and wastes will be stored until it is disposed of via port facilities for disposal, reuse or recycling at licensed onshore facilities. However, accidental releases to sea are a possibility, especially in poor weather and ocean conditions when items may roll off or be blown off the deck.

The following non-hazardous materials and wastes will be disposed of to shore, but have the potential to be accidentally dropped or disposed overboard due to poor waste management (e.g., overfull bins), strong winds, high seas or crane operator error:

- Paper and cardboard;
- Wooden pallets;
- Scrap steel, metal and aluminium;
- Glass;
- Foam (e.g., ear plugs); and
- Plastics (e.g., hard hats).

The following hazardous materials (defined as a substance or object that exhibits hazardous characteristics, is no longer fit for its intended use and requires disposal, and as outlined in Annex III to the Basel Convention, may be toxic, flammable, explosive and poisonous) may be used and waste generated through the use of consumable products and will be disposed to shore, but may be accidentally dropped or disposed overboard or could be lost as a result of hose connection failure, overfilling of tanks or emergency disconnection of hoses:

- Hydrocarbons, hydraulic oils and lubricants;
- Hydrocarbon-contaminated materials (e.g., oily rags, pipe dope, oil filters);
- Batteries, empty paint cans, aerosol cans and fluorescent tubes;
- Contaminated personal protective equipment (PPE);
- Laboratory wastes (such as acids and solvents); and
- Larger dropped objects (that may be hazardous or non-hazardous) may be lost to the sea through accidents (e.g., crane operations) include:
    - Sea containers;
    - Towed equipment;
    - ROV; and
    - Entire skip bins/crates.

8.1.2 Potential Environmental Risks

The risks of the release of hazardous and non-hazardous materials and waste to the ocean are:

- Marine pollution (litter and a temporary and localised reduction in water quality);
- Acute toxicity to marine fauna through ingestion or absorption;
- Injury and entanglement of individual animals (such as seabirds and seals); and
- Localised (and normally temporary) smothering or pollution of benthic habitats.

8.1.3 EMBA

The EMBA for the accidental disposal of hazardous and non-hazardous materials and waste is likely to extend for kilometres from the release site (as buoyant waste drifts with currents) or localised for non-buoyant items that sink and settle on the seabed.

Receptors susceptible to waste that may occur within this EMBA, either as residents or migrants, are:

- Benthic fauna;
- Benthic habitat (sandy seabed);
- Pelagic fauna (fish, cetaceans and turtles); and
- Seabirds.

The EPBC Act-listed species documented as being negatively impacted by the ingestion of, or entanglement in, harmful marine debris (and known to occur in the operational area or EMBA) are:

- The six turtle species (loggerhead, green, flatback, olive ridley, leatherback and hawksbill);
- Sawfish and river sharks;
- Seabirds (Australian noddy, shearwater); and
- Cetaceans (Australian snubfin dolphin, Australian humpback dolphin, PBW).

8.1.4 Evaluation of Environmental Risks

Non-hazardous Materials and Waste

If discharged overboard, non-hazardous wastes can cause smothering of benthic habitats as well as injury or death to marine fauna or seabirds through ingestion or entanglement (e.g., plastics caught around the necks of turtles or ingested by seabirds and fish). For example, the TSSC (2015d) reports that there have been 104 records of cetaceans in Australian waters impacted by plastic debris through entanglement or ingestion since 1998 (humpback whales being the main species).

Marine fauna including cetaceans, turtles and seabirds can be severely injured or die from entanglement in marine debris, causing restricted mobility, starvation, infection, amputation, drowning and smothering (DoEE, 2018). Seabirds entangled in plastic packing straps or other marine debris may lose their ability to move quickly through the water, reducing their ability to catch prey and avoid predators, or they may suffer constricted circulation, leading to asphyxiation and death. In marine mammals and turtles, this debris may lead to infection or the amputation of flippers, tails or flukes (DoEE, 2018). Plastics have been implicated in the deaths of a number of marine species including marine mammals and turtles, due to ingestion.

The following turtles may be at risk from waste at sea:

- Green turtle – foraging BIA is overlapped by the operational area. They generally feed in shallow waters far from the operational area, so their risk of ingesting waste (such as plastics) is low given their distance of their preferred habitats from Beehive-1.
- Flatback turtle – inter-nesting BIA is overlapped by the operational area. Their foraging BIA is about 90 km from the operational area, but because adults consume soft-bodied invertebrates, they may be at risk of ingesting plastic wastes floating in the ocean. This risk is low given the distance of the foraging BIA from the operational area.
- Olive ridley turtle – foraging BIA is overlapped by the operational area. Although this species forages primarily at the seabed, they also consume soft-bodied invertebrates and therefore may be at risk of ingesting plastic wastes floating in the ocean. This risk is moderate given the foraging BIA overlaps the operational area.

If dropped objects such as skip bins are not retrievable (e.g., by crane), these items may permanently smother small areas of seabed (tens of square metres), resulting in the loss of benthic habitat. However, as with most subsea infrastructure, the items themselves are likely to become colonised by benthic fauna over time (e.g., sponges and corals) and become a focal area for sea life, so the net environmental impact is likely to be neutral. The benthic habitats in this EMBA are broadly similar to those elsewhere in the region (e.g., extensive sandy seabed, see Section 5.4.1), so impacts to small areas of seabed will not result in the long-term loss of benthic habitat or species diversity or abundance. Seabed substrates can rapidly recover from temporary and localised impacts.

Hazardous Materials and Waste

Hazardous materials and wastes released to the sea cause pollution and contamination, with either direct or indirect effects on marine organisms. For example, chemical or hydrocarbon spills can (depending on the volume released) impact marine life from plankton to pelagic fish communities, causing physiological damage through ingestion or absorption through the skin. Impacts from an accidental release would be limited to the immediate area surrounding the release, prior to the dilution of the chemical with the surrounding seawater. In an open ocean environment such as the JBG, it is expected that any minor release would be rapidly diluted and dispersed, and thus temporary and localised. The absence of particularly sensitive seabed habitats and the widespread nature of the sandy seabed present in the activity area further limits the extent of potential impacts.

Solid hazardous materials, such as paint cans containing paint residue, batteries and so forth, would settle on the seabed if dropped overboard. Over time, this may result in the leaching of hazardous materials to the seabed, which is likely to result in a small area of substrate becoming toxic and unsuitable for colonisation by benthic fauna. The benthic habitats of the activity area are broadly similar to those elsewhere in the region (e.g., extensive sandy seabed), so impacts to very small areas of seabed will not result in the long-term loss of benthic habitat or species diversity or abundance.

All hazardous waste will be safely transported offshore in suitable receptables and disposed of at appropriately licensed facilities, by licenced contractors, so impacts such as illegal dumping or disposal to an unauthorised onshore landfill that is not lined are highly unlikely to result from the activity.

The conservation advice for the humpback whale (TSSC, 2015c) lists entanglement from marine debris as a threat to the species. Marine debris includes plastic garbage such as bags, bottles, ropes, derelict fishing gear and non-biodegradable floating materials list or disposed of at sea.

There have been 104 records of cetaceans in Australian waters impacted by plastic debris through entanglement or ingestion since 1998. The vast majority (92.2%) of cetacean incidents relate to entanglement (TSSC, 2015c), and humpback whales dominated the available records, with around 48 entanglement incidents recorded. An assessment of the entanglement management actions against the activity is provided in Table 8.2. Though the relevant management actions target the commercial fishing industry, the guiding principle of the management action has been applied to the activity.

Table 8.2. Assessment of the relevant management actions of the Approved Conservation Advice for the Humpback Whale

Management Action	Assessment
Reducing commercial fishing entanglement	
Commonwealth and state governments with the pot and set net fishing industries to develop and implement codes of conduct to minimise interactions between commercial fishers and humpback whales.	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with these management actions.
Investigate alternative fishing techniques and technologies to reduce the risk of entanglement.	

TSSC (2015c).

The Threat Abatement Plan for the Impacts of Marine Debris on the Vertebrate Wildlife of Australia's Coasts and Oceans (DoEE, 2018) lists specific management actions and objectives. Given that the activity has the potential (albeit low) to contribute to marine debris, an assessment of the management actions and objectives has been provided in Table 8.3.

Table 8.3. Assessment of the objectives and management actions of the Threat Abatement Plan for the Impacts of Marine Debris on the Vertebrate Wildlife of Australia's Coasts and Oceans

Objective and associated management actions	Assessment
1. *Contribute to long-term prevention of the incidence of marine debris*	
Establish a threat abatement plan (TAP) team to coordinate actions for the life of the TAP.	The activity will not have any impacts on this management action.
Limit the amount of single-use plastic material lost to the environment in Australia.	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with these management actions.
Encourage development of a circular economy in Australia.	The activity will not have any impacts on this management action.
Encourage innovation in recovery and waste treatment technologies.	The activity will not have any impacts on this management action.
Improve management of abandoned, lost and discarded fishing gear.	The activity will not have any impacts on this management action.
Improve shipping waste management.	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a

Objective and associated management actions	Assessment
	manner that is not inconsistent with these management actions.
2. *Understand the scale of impacts from marine plastic and microplastic on key species, ecological communities and locations*	
Update the list of marine debris impacted EPBC Act-listed vertebrate species as scientific evidence is published.	The activity will not have any impacts on this management action.
Monitor relevant ecological research to determine if further EPBC Act-listed ecological communities are threatened by marine debris.	The activity will not have any impacts on this management action.
Identify locations where aggregations of debris intersect with the temporal and spatial distribution of EPBC Act-listed species, especially during vulnerable life stages (e.g., whale and turtle migrations).	The activity will not have any impacts on this management action.
Build understanding related to plastic and microplastic pollution.	The activity will not have any impacts on this management action.
Survey marine plastic pollution in the Southern Ocean, sub-Antarctic islands and other high value offshore island environments.	The activity will not have any impacts on this management action.
Determine the relevance of microplastics to the Australian Government's Science and Research Priorities and corresponding Practical Research Challenges.	The activity will not have any impacts on this management action.
3. *Remove existing marine debris*	
Support beach-based clean-up efforts.	The activity will not have any impacts on this management action.
Improve the effectiveness of Australian Government grants in relation to marine debris outcomes.	The activity will not have any impacts on this management action.
Remove derelict fishing gear from Australia's oceans and coasts.	The activity will not have any impacts on this management action.
Develop understanding of the potential for biological breakdown of plastic to prevent it entering the marine environment or aid its removal.	The activity will not have any impacts on this management action.
4. *Monitor the quantities, origins, types and hazardous chemical contaminants of marine debris, and assess the effectiveness of management arrangements for reducing marine debris*	
Continue collection of data in long-term beach surveys.	The activity will not have any impacts on this management action.
Develop a nationally consistent monitoring system for land-based plastic pollution.	The activity will not have any impacts on this management action.
Maintain a national database for long-term marine debris beach survey data and promote	The activity will not have any impacts on this management action.

Objective and associated management actions	Assessment
standard methods for collecting and ongoing monitoring of beach clean-up debris.	
Assess the effectiveness of Australia's product stewardship and waste management in reducing the levels of plastics entering the marine environment.	The activity will not have any impacts on this management action.
Continue to monitor persistent organic pollutant contamination using plastic resin pellets from Australian beaches.	The activity will not have any impacts on this management action.
Regularly assess mean surface plastic loads and associated hazardous chemical contaminants across Australian jurisdictions and territories.	The activity will not have any impacts on this management action.
Enhance collection of data related to ghost net retrievals from Commonwealth waters across northern Australia.	The activity will not have any impacts on this management action.
Improve understanding of the impact and origins of ghost nets.	The activity will not have any impacts on this management action.
5. *Increase public understanding of the causes and impacts of harmful marine debris, including microplastic and hazardous chemical contaminants, to bring about behaviour change*.	
Raise the profile of marine debris impacts on marine vertebrate species, especially EPBC Act-listed threatened species.	The activity will not have any impacts on this management action.
Improve public communication about consumer waste and litter.	The activity will not have any impacts on this management action.

DoE (2018).

Marine debris is identified as a threat to turtles in the Recovery Plan for Marine Turtles 2017-2027 (DoEE, 2017c). As such, an assessment of relevant interim recovery objectives and targets with the activity is provided in Table 8.4.

Table 8.4. Assessment of the relevant interim recovery objectives and targets of the Recovery Plan for Marine Turtles 2017-2027 with the activity

Interim Objective or Target	Assessment
Interim Objective 3: Anthropogenic threats are demonstrably minimised.	
Target 3.1: Robust and adaptive management regimes that lead to a reduction in anthropogenic threats to marine turtles and their habitats are in place	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with this recovery target.
Target 3.2: Threat mitigation strategies are supported by high quality information	The activity will not have any impacts on this recovery target.

DoEE (2017c).

Habitat degradation and modification (e.g., through the presence of marine debris following accidental discharge) are a listed threat in the Sawfish and River Sharks Multispecies Recovery Plan

(DoE, 2015a). Threatened species addressed in this plan that are relevant to the activity include the largetooth sawfish, green sawfish, dwarf sawfish and the northern river shark. An assessment of the relevant objectives and management actions of the Sawfish and River Sharks Multispecies Recovery Plan (DoE, 2015a) with the activity is provided in Table 8.5.

Table 8.5. Assessment of the relevant recovery objectives and relevant actions of the Sawfish and River Sharks Multispecies Recovery Plan with the activity

Objective or management action	Assessment
Objective 5: Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification on sawfish and river shark species	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with this objective.
Action 5a. Ensure all future developments will not significantly impact upon sawfish and river shark habitats critical to the survival of the species or impede upon the migration of individual sawfish or river sharks.	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with this management action.
Action 5b. Determine the effect of river and estuarine barriers on the movements of sawfish and river sharks and undertake an audit of barriers to establish whether removal or modification is feasible to allow for the riverine migration of sawfish and river sharks.	The activity will not have any impacts on this management action.
Action 5c. Identify risks to important sawfish and river shark habitat and measures needed to reduce those risks.	The activity will not have any impacts on this management action.
Action 5d. Implement measures to reduce adverse impacts of habitat degradation and/or modification	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with this management action.
Objective 6: Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life.	The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with this objective.
Action 6a. Assess the impacts of marine debris including ghost nets, fishing gear and plastics on sawfish and river shark species.	The activity will not have any impacts on this management action.
Action 6b. Partner with marine debris organisations to support initiatives that reduce marine debris likely to impact on sawfish and river sharks.	The activity will not have any impacts on this management action. The EPS listed in Table 8.6 will reduce the likelihood of accidental discharge of wastes to the ocean to ALARP and ensure the activity is conducted in a manner that is not inconsistent with this management action.

DoE (2015c).

8.1.5 Risk Assessment

Table 8.6 presents the risk assessment for the accidental disposal of hazardous and non-hazardous materials and waste.

Table 8.6. Risk assessment for the accidental release of waste overboard

Summary		
Summary of risk	Marine pollution (litter and a temporary and localised reduction in water quality), injury and entanglement of individual animals (such as seabirds, cetaceans, turtles and sawfish) and smothering or pollution of benthic habitats.	
Extent of risks	Non-buoyant waste may sink to the seabed near where it was lost. Buoyant waste may float long distances with ocean currents and winds.	
Duration of risks	Short-term to long-term, depending on the type of waste and location.	
Level of certainty of risk	HIGH – the effects of inappropriate waste discharges are well known.	
Risk decision framework context	Decision type	A - good industry practice required.
	Activity	Nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
	Risk & uncertainty	Risks are well understood, uncertainty is minimal.
	Stakeholder influence	No conflict with company values, no partner interest, no significant media interest.
Defined acceptable level	No unplanned release of hazardous or non-hazardous solid waste or materials.	

Risk Assessment (inherent)		
Likelihood	Consequence	Risk rating
Occasional	Minor	Low

Assessment of Proposed Control Measures			
Control measure	Control type	Adopt	Justification
Transfer wastes from the MODU and support vessels to shore-based facilities during the activity.	Eliminate	No	**EB:** Reduces likelihood of accidental waste disposal through transfer to shore-based facilities, noting that there are risks of waste overboard during the transfer process. **C:** High costs for the use of a dedicated vessel to take waste, which also results in additional routine vessel impacts and risks. **Ev:** Cost to implement is grossly disproportionate to the benefit given the low inherent risk rating.
MODU and vessel wastes are managed in accordance with the GMP **(RSK-01: EPS-01, -02, -03, -04).**	Engineering	Yes	**EB:** Reduces the likelihood of waste being discharged to sea, reducing potential impacts to marine fauna and water quality. **C:** Negligible; it is a standard MARPOL requirement. Minor administrative cost to produce documents and educate personnel.

			Ev: Benefits of ensuring responsible waste management outweighs the negligible cost.
Recover accidentally discharged solid wastes or lost equipment (if safe to do so) **(RSK-01: EPS-05)**	Administrative	Yes	**EB:** Removes debris from the environment, thereby reducing impacts to marine fauna and water quality. **C:** Medium to high costs dependent on the duration of down-time to retrieve materials. **Ev:** Environmental benefit of recovering marine debris outweighs the costs.
Handling and storage procedures **(RSK-01: EPS-06, -12, -13, -14, -15).**	Administrative	Yes	**EB:** Reduces the likelihood that materials will be accidentally lost overboard. **C:** Negligible; it is a standard maritime requirement. Minor administrative cost to produce documents and educate personnel. **Ev:** Environmental benefit outweighs the negligible costs.
Dropped object prevention procedure **(RSK-01: EPS-07, -09, -10, -11).**	Engineering	Yes	**EB:** Reduces the likelihood that materials will be accidentally lost overboard and impacts on marine fauna and water quality. **C:** Negligible; it is a standard maritime requirement. Minor administrative cost to produce documents and roll out to personnel. **Ev:** Environmental benefit outweighs the negligible costs.
PMS **(RSK-01: EPS-08)**	Engineering	Yes	**EB:** The maintenance of lifting equipment minimises the likelihood of dropped objects. **C:** Negligible; it is a standard maritime requirement. Minor administrative costs associated with maintaining the PMS. **Ev:** Environmental benefit outweighs the negligible costs.

Environmental Controls and Performance Measurement		
EPO	EPS	Measurement criteria
No unplanned release of hazardous or non-hazardous solid wastes or materials.	**(RSK-01: EPS-01)** A MARPOL Annex V-compliant GMP is in place for the vessel (if >100 gross tonnes or certified to carry 15 persons or more) that sets out the procedures for minimising, collecting, storing, processing and discharging garbage.	A GMP is in place, readily available on board and kept current.
	(RSK-01: EPS-02) Waste is stored, handled and disposed of in accordance with the GMP. This includes measures including:	GMP is available and current.
		Inspections verify that waste is stored and handled according to its waste classification.

	• No discharge of general operational or maintenance wastes or plastics or plastic products of any kind. • Waste containers are covered with secure lids to prevent solid wastes from blowing overboard. • All solid wastes are stored in designated areas before being sent ashore for recycling, disposal or treatment. • Any liquid waste storage on deck must have at least one barrier to minimise the risk of spills to deck entering the ocean. This can include containment lips on deck (primary bunding) and/or secondary containment measures (bunding, containment pallet, transport packs, absorbent pad barriers) in place. • Correct segregation of solid and hazardous wastes.	Inspections verify that waste receptacles are properly located, sized, labelled, covered and secured for the waste they hold. A licensed shore-based waste contract is in place for the management of onshore waste transport and disposal.
	(RSK-01: EPS-03) MODU and vessel crews and visitors are inducted into waste management procedures to ensure they understand how to implement the GMP.	Induction and attendance records verify that all crew members are inducted.
	(RSK-01: EPS-04) Waste types and volumes are tracked and logged.	Waste manifest is available and current.
	(RSK-01: EPS-05) Solid waste that is accidentally discharged overboard is recovered if reasonably practicable.	Incident records are available to verify that credible and realistic attempts to retrieve the materials lost overboard were made.
	(RSK-01: EPS-06) A chemical locker is available, bunded and used for the storage of all greases and non-bulk chemicals (i.e., those not in tote tanks) so as to prevent discharge overboard.	Site inspection verifies that greases and chemicals are stored in a chemical locker.
Avoid objects being dropped overboard	**(RSK-01: EPS-07)** Large bulky items are securely fastened to or stored on the deck to prevent loss to sea.	A completed pre-departure inspection checklist verifies that bulky goods are securely sea-fastened.
	(RSK-01: EPS-08) The MODU and vessel PMS are implemented to ensure that lifting equipment remains in certification and fit for use at all times to minimise the risk of dropped objects.	PMS records verify that lifting equipment is maintained to schedule and in accordance with Original Equipment Manufacturer (OEM) requirements.
	(RSK-01: EPS-09) The crane handling and transfer procedure is in place and implemented by crane operators (and others, such as dogmen) to prevent dropped objects.	Completed handling and transfer procedure checklist, permit to work (PTW) and/or risk assessments verify that the procedure is implemented prior to each transfer.

	(RSK-01: EPS-10) Crane operators are trained to be competent in the handling and transfer procedure to prevent dropped objects.	Training records verify that crane operators are trained in the loading and unloading procedure.
	(RSK-01: EPS-11) Visual inspection of lifting gear is undertaken every quarter by a qualified competent person (e.g., maritime officer) and lifting gear is tested regularly in line with the MODU and vessel PMS.	Inspection of PMS records and Lifting Register verifies that inspections and testing have been conducted to schedule.
Chemicals and hydrocarbons are stored and transferred in a manner that prevents bulk release.	**(RSK-01: EPS-12)** All hydrocarbons and chemicals are stored within secure receptacles within bunded areas or dedicated chemical lockers that drain to bilge tanks.	Visual inspection verifies that hydrocarbons and chemicals are stored within secure receptacles within bunded areas or dedicated chemical lockers that drain to bilge tanks.
	(RSK-01: EPS-13) MODU and vessel PMS is implemented to ensure the integrity of chemical and hydrocarbon storage areas and transfer systems are maintained in good order.	Vessel PMS records verify that chemical and hydrocarbon storage areas and transfer systems (e.g., bunds, tanks, pumps and hydraulic hoses) are maintained to schedule and in accordance with OEM requirements.
	(RSK-01: EPS-14) Where hydrocarbons and chemicals are stored within open draining decks, receptacles are stored on/in temporary bunds.	Visual inspection verifies that where hydrocarbons and chemicals are stored within open draining decks, receptacles are stored on/in temporary bunds.
	(RSK-01: EPS-15) Crane transfers of bulk chemicals and hydrocarbons are undertaken in accordance with the vessel contractor lifting and loading procedure, or equivalent, and under a PTW.	PTW records verify that crane transfers of bulk chemicals and hydrocarbons are undertaken in accordance with the procedure.

Risk Assessment (residual)		
Likelihood	Consequence	Risk rating
Rare	Minor	Negligible

The risk of accidental discharge of waste to the ocean is assessed as negligible because:

- Volumes of waste generated will be small due to the nature of the activity; and
- Implementation of the control measures reduces the likelihood to accidental discharge of waste to the ocean to ALARP.

Demonstration of ALARP

A 'negligible' residual risk rating is considered to be ALARP and a 'lower order' risk. The adopted controls and associated EPS have lowered the risk to the point that any additional or alternative control measures either fail to lower the residual risk rating any further or are grossly disproportionate to the residual risk rating.

Demonstration of Acceptability		
Policy compliance	EOG's Safety and Environmental Policy objectives are met.	
EMS compliance	Chapter 10 outlines the EP implementation strategy to be employed for this activity.	
Risk matrix standard compliance	The residual risk is negligible, which is considered acceptable.	
External context	No objections or claims have been raised by relevant persons regarding accidental release of wastes to the ocean.	

Legislative context	The EPS align with the requirements of:
	• *Navigation Act* 2012 (Cth):
	  ○ Chapter 4 (Prevention of Pollution).
	  ○ Marine Orders Part 94 (Marine pollution prevention – packaged harmful substances).
	  ○ Marine Orders Part 95 (Marine pollution prevention – garbage).
	• *Protection of the Sea (Prevention of Pollution from Ships) Act* 1983 (Cth):
	  ○ Part III (Prevention of pollution by noxious substances).
	  ○ Part IIIA (Prevention of pollution by packaged harmful substances).
	  ○ Part IIIC (Prevention of pollution by garbage).	

Industry practice	The consideration and alignment of EPS with the mitigation measures outlined in the below-listed codes of practice and guidelines demonstrates that BPEM will be implemented for this activity	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS developed for this activity are in line with the management measures listed for hazardous waste and non-hazardous waste discharges in Sections 4.6.2 and 4.6.3 of the guidelines, which include: • Segregating hazardous and non-hazardous wastes prior to disposal **(RSK-01: EPS-01)**. • Managing hazardous waste in accordance with their SDS and tracking it to final destination. • Not deliberately discharging waste overboard.
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	The EPS listed in this table meet these guidelines for offshore activities with regard to: • Risk management for handling and storage of chemicals (item 19). The BAT are met for the activity with regard to implementing chemical transfer procedures and ensuring chemicals are stored in separate, labelled containers (**RSK-01: EPS-12, -14, -15**).
	Health, Safety and Environmental Case Guidelines for Mobile Offshore Drilling Units (IADC, 2015)	The EPS developed for this activity meet the following requirements. • Section 2.3.6.2 (management of waste) of the guideline states that regulatory requirements should be identified, waste tracking methods be developed and that waste minimisation opportunities should be identified.

		• Section 2.3.6.1 (environmental protection) states that location- and well-specific environmental protection plans should be prepared.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	Guidelines met with regard to: • Waste management (items 46). Materials should be segregated offshore and shipped to shore for reuse, recycling or disposal. A waste management plan should be developed and contain a mechanism allowing waste consignments to be tracked **(RSK-01: EPS-01)**. • Hazardous materials management (item 72). Principles relate to the selection of chemicals with the lowest environmental and health risks.
	AEP CoEP (APPEA 2008)	The EPS for this activity meet the code's following objectives for offshore drilling activities: • To reduce the risk of any unplanned release of material into the marine environment to ALARP and to an acceptable level **(All EPS for RSK-01)**.
	Waste management-specific	
	Guidelines for the Development of GMPs (IMO, 2012)	The MODU and vessels' GMPs are developed in accordance with these guidelines **(RSK-01: EPS-01)**.
	International Dangerous Goods Maritime Code (IMO, 2014)	The storage and handling of dangerous goods on the vessels is managed in accordance with this code **(RSK-01: EPS-02, -06, -12, -14)**.
Environmental context	MNES	
	AMPs	The unplanned discharge of solid or hazardous waste is highly unlikely to intersect nearby AMPs. The North Marine Parks Network Management Plan 2018 (DNP, 2018a) identifies marine debris as a threat to the AMP network. The EPS listed in this table aim to minimise the generation of marine debris and potential for accidental discharge and are aligned with the strategies outlined in the plan.
	Ramsar wetlands	The unplanned discharge of solid or hazardous waste is highly unlikely to reach Ramsar wetlands.
	TECs	The unplanned discharge of solid or hazardous waste is highly unlikely to reach any TECs.
	Nationally threatened and migratory species	The unplanned discharge of solid or hazardous waste is highly unlikely to have any impacts on threated or migratory species.

	Other matters	
	KEFs	The unplanned discharge of solid or hazardous waste will not affect any KEFs.
	NIWs	The unplanned discharge of solid or hazardous waste is highly unlikely to reach any NIWs.
	State marine parks	The unplanned discharge of solid or hazardous waste is highly unlikely to reach any state marine parks.
	Species Conservation Advice/ Recovery Plans/ Threat Abatement Plans	Assessments of the activity against the following species have been undertaken and presented earlier, and the control measures adopted ensure the activity will be conducted in a manner that is not inconsistent with each plan: • The conservation advice for humpback whales (TSSC, 2015b) - Table 8.2. • Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Wildlife of Australia's coasts and oceans (DoEE, 2018) - Table 8.3. • Recovery Plan for Marine Turtles 2017-2017 (DoEE, 2017c) - Table 8.4. • The Sawfish and River Shark Multispecies Recovery Plan (DoE, 2015c) - Table 8.5.
ESD principles	The EIA presented throughout this EP demonstrates that ESD principles (a), (b), (c) and (d) are met (noting that principle (e) is not relevant).	
Statement of acceptability	EOG considers the risk of accidental discharge of waste to the ocean to be acceptable because: • It will adhere to the company's Safety & Environmental Policy; • The residual risk rating is negligible; • An Implementation Strategy (described in Chapter 9) is in place to ensure the EPS are achieved. • Input from engagement with relevant persons has been considered and incorporated into the design of the activity; • Relevant legislation and industry best practice will be complied with; • Accidentally discharged wastes will not have long-term or significant impacts on MNES; • The management of wastes is not inconsistent with the aims of recovery plans/conservation plans/advice that are in force for EPBC Act-listed threatened and migratory species; • The management of wastes is not inconsistent with the aims of relevant marine reserve management plans; and • The management of wastes is not inconsistent with ESD principles.	
Environmental Monitoring		
• Waste tracking.		

Record Keeping	
• Contractor pre-qualification reports. • GMPs. • Garbage Record Books. • Crew induction and attendance records.	• Inspection records/checklists. • Shore-based waste contract. • Incident reports.

8.2 RISK 2 – Vessel Collision with Megafauna

8.2.1 Hazard

The movement of the drilling support vessels throughout the operational area on a 24-hr basis has the potential to result in collision with megafauna, this being marine mammals (whales, dolphins, dugong), whale sharks and turtles.

The MODU legs will not present a strike hazard to megafauna as they are stationary and readily detected and avoided by megafauna. In petroleum production provinces around Australia, marine mammals such as whales, dolphins and seals swim around platform jackets without any apparent risk of injury.

8.2.2 Potential Environmental Risks

The risks of vessel strike with megafauna are:

- Injury; and
- Death.

8.2.3 EMBA

The EMBA for vessel strike with megafauna is the immediate area around the support vessel.

8.2.4 Evaluation of Environmental Risks

Cetaceans

Cetaceans are naturally inquisitive marine mammals that are often attracted to offshore vessels, and dolphins commonly 'bow ride' with offshore vessels. The reaction of whales to the approach of a vessel is quite variable. Some species remain motionless when in the vicinity of a vessel while others are known to be curious and often approach ships that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster moving ships (Richardson et al., 1995).

Peel et al (2016) reviewed vessel strike data (2000-2015) for marine species in Australian waters and identified the following:

- Whales including the humpback, pygmy blue, fin, Bryde's, pygmy, sperm, and pygmy sperm were identified as having interacted with vessels. The humpback whale exhibited the highest incidence of interaction. A number of these species may migrate through the waters of the activity area (see Section 5.4.5).
- Dolphins including the Australian humpback, common bottlenose and Risso's dolphin species were also identified as interacting with vessels. The common bottlenose dolphin exhibited the highest incidence of interaction. A number of these species may reside in or pass through the waters of the activity area (see Section 5.4.5).
- All turtle species present in Australian waters are identified as interacting with vessels. The green and loggerhead species exhibited the highest incident of

interaction. The presence of turtles in the activity area and EMBA is considered likely (see Section 5.4.6).

Collisions between vessels and cetaceans occur more frequently where high vessel traffic and cetacean habitat coincide (WDCS, 2006). There have been recorded instances of cetacean deaths in Australian waters (e.g., a Bryde's whale in Bass Strait in 1992), though the data indicates this is more likely to be associated with container ships and fast ferries (WDCS, 2006). Some cetacean species, such as humpback whales, can detect and change course to avoid a vessel (WDCS, 2006). The Australian National Marine Safety Committee (NMSC) reports that during 2009, there was one report of a vessel collision with an animal (species not defined) (NMSC, 2010).

The DoE (2015b) reports that there were two blue whale strandings in the Bonney Upwelling (western Victoria) with suspected ship strike injuries visible. When the vessels are stationary or slow moving, the risk of collision with cetaceans is extremely low, as the vessel sizes and underwater noise 'footprint' will alert cetaceans to its presence and thus elicit avoidance. Laist et al (2001) identifies that larger vessels moving in excess of 10 knots may cause fatal or severe injuries to cetaceans with the most severe injuries caused by vessels travelling faster than 14 knots. When the support vessels are operating within the operational area, they will be travelling very slowly or will be stationery, so the risk associated with fast moving vessels is eliminated for this activity.

The Conservation Management Plan for the Blue Whale (DoE, 2015b) lists 'vessel disturbance in the form of collisions' to be a threat that may inhibit the recovery of the species. An assessment of the relevant management actions listed in the Conservation Management Plan against the activity is provided in Table 8.7.

Table 8.7. Assessment of relevant management actions of the Conservation Management Plan for the Blue Whale with the activity

Management Action	Assessment
Relevant Interim Recovery Objectives	
4. Anthropogenic threats are demonstrably minimised.	Vessel disturbance in the form of collision is a threat to blue whales. The EPS listed in Table 8.13 will reduce the likelihood of vessel strike with blue whales to ALARP. Therefore, the activity will be managed in a manner that is not inconsistent with this interim recovery objective.
Relevant Interim Recovery Objective Targets	
Target 4.1: robust and adaptive management regimes leading to a reduction in anthropogenic threats to Australian blue whales are in place.	The EPS listed in Table 8.13 represent a robust and adaptive management regime for the activity with regard to blue whales. This results in a significant reduction in anthropogenic threats generated by the activity on blue whales. Therefore, the activity will be managed in a manner that is not inconsistent with this interim objective target.
Target 4.2: management decisions are supported by high quality information and high priority research projects identified in this plan are achieved or underway.	The information presented throughout this section and the subsequent EIA presented in Table 8.13 is based on high quality information, scientific literature and research projects. This in turn has informed the management decisions relevant to the activity. Therefore, the activity will be managed in a manner that is not inconsistent with this interim objective target.

Management Action	Assessment
Relevant Action Areas	
A.4. Minimising vessel collisions	The control measures adopted and associated EPS listed in Table 8.13 will reduce the likelihood of vessel strike with blue whales to ALARP. With control measures implemented, the activity will be managed in a manner that is not inconsistent with this management action.
Relevant Actions	
2. Ensure all vessel strike incidents are reported in the National Ship Strike Database.	Reporting of vessel strike incidents has been adopted for this activity and an appropriate EPS developed in Table 8.13. Therefore, the activity will be consistent with this action.
3. 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.	This section of the EP provides an assessment of vessel strike risk and EPS have been adopted for the activity in Table 8.13. Therefore, the activity will be consistent with this action.

DoE (2015b).

The Approved Conservation Advices for the Sei Whale (TSSC, 2015b) and the Fin Whale (TSSC, 2015c) list vessel strike as a threat with a minor consequence rating. An assessment of the listed management actions with the activity is provided in Table 8.8.

Table 8.8. Assessment of relevant management actions of the Approved Conservation Advice for the Sei Whale and Fin Whale with the activity

Management Action	Assessment
Ensure all vessel strike incidents are reported in the National Vessel Strike Database.	Reporting of vessel strike incidents has been adopted as a control measure for this activity and an appropriate EPS developed in Table 8.13. Therefore, the activity will be consistent with this action.

TSSC (2015b;c).

The Approved Conservation Advice for the Humpback Whale (TSSC, 2015a) lists vessel strike as a threat to the species. An assessment of the listed management actions with the activity is provided in Table 8.9.

Table 8.9. Assessment of relevant management actions of the Approved Conservation Advice for the Humpback Whale with the activity

Management Action	Assessment
Maximise the likelihood that all vessel strike incidents are reported in the National Ship Strike Database. All cetaceans are protected in Commonwealth waters and, the EPBC Act requires that all collisions with whales in Commonwealth waters are reported. Vessel collisions can be submitted to the National Ship Strike Database at https://data.marinemammals.gov.au/report/shipstrike	Reporting of vessel strike incidents has been adopted for this activity as a control measure with an appropriate EPS developed in Table 8.13. Therefore, the activity will be consistent with this action.

Management Action	Assessment
Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike.	This section of the EP provides an assessment of vessel strike risk and EPS have been adopted for the activity in Table 8.13. Therefore, the activity will be consistent with this action.

TSSC (2015a).

There is a CMP in place for the southern right whale, but given it is unlikely to occur in the activity area, an assessment of the activity against this plan is not presented.

Table 8.10 provides an assessment of the objectives and relevant management actions of the National Strategy for Reducing Vessel Strike on Cetaceans and Other Marine Megafauna (DoEE, 2017a) with the activity.

Table 8.10. Assessment of the objectives and relevant management actions of the National Strategy for Reducing Vessel Strike on Cetaceans and Other Marine Megafauna with the activity

Relevant Objectives and Management Actions	Assessment
Relevant objectives	
Reduce the likelihood and severity of megafauna vessel collision.	The adopted EPS listed in Table 8.12 are aligned with best-practice mitigation measures, which will reduce the likelihood of vessel strike with megafauna to ALARP. Therefore, the activity will be consistent with this objective.
Identify and adopt best-practice mitigation measures and emerging technologies, and encourage the development of new mitigation measures.	
Management actions	
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.	The adopted EPS listed in Table 8.12 will reduce the likelihood of vessel strike with cetaceans to ALARP. Therefore, the activity will be consistent with these actions.
Develop and implement vessel strike management plans which identify appropriate mitigation measures in locations where the relative risk of vessel strike is higher, as determined by a risk assessment.	
Adaptive management principles, including the use of regular reviews are used during the implementation of mitigation measures.	

DoEE (2017a).

Turtles

The operational EMBA overlaps the following turtle BIAs (Figure 7.2):

- Green turtle – foraging;
- Flatback turtle – inter-nesting; and
- Olive Ridley turtle – foraging.

When these turtles are migrating through or foraging in the operational area , they may be at risk of colliding with support vessels when they surface to breathe and rest. However, only a small portion of their time is spent at the surface, as they typically spend more than 90% of their time underwater (Lutcavage and Lutz, 1997; Hochscheid *et al*., 2010).

The Recovery Plan for Marine Turtles in Australia lists vessel strike as a threat to marine turtles (DoEE, 2017c). Table 8.11 presents an assessment of the relevant objectives and targets of the Recovery Plan for Marine Turtles in Australia with the activity.

Table 8.11. Assessment of the relevant interim recovery objectives and targets of the Recovery Plan for Marine Turtles 2017-2027 with the activity

Interim Objective or Target	Assessment
Interim Objective 3: Anthropogenic threats are demonstrably minimised.	
Target 3.1: Robust and adaptive management regimes that lead to a reduction in anthropogenic threats to marine turtles and their habitats are in place	The EPS listed in Table 8.12 will reduce the likelihood of vessel strike with cetaceans to ALARP and ensure the activity is conducted in a manner that is not inconsistent with this recovery target.
Target 3.2: Threat mitigation strategies are supported by high quality information	The activity will not have any impacts on this recovery target.

DoEE (2017c).

Whale sharks

The whale shark may occur in the operational area and are known to seasonally aggregate in shallow tropical waters off the North West Cape in WA in March and April (DCCEEW, 2022b). Given there is little spatial overlap between this species' known migration routes, and it's unlikely to be a temporal overlap with the drilling window, vessel collisions with whale sharks and the support vessels has a low risk of occurring.

Nevertheless, whale sharks do spend considerable time close to the surface. Whale sharks tagged off the WA coast (Wilson *et al*., 2006; Gleiss *et al*., 2013) spent approximately 25% of their time less than 2 m from the sea surface, which increases their vulnerability to vessel strike (DoEE, 2017b).

The Approved Conservation Advice (TSSC, 2015d) notes that the threat to the recovery of the species includes strikes from vessels.

Table 8.12. Assessment of the relevant conservation actions of the Conservation Advice for whale sharks with the activity

Interim Objective or Target	Assessment
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 WA coastline along the 200 m isobath.	The activity is 300 km from the whale shark BIA, 1,700 km from known aggregation areas (Ningaloo Reef) and 450 km south of the 200 m isobath. The EPS listed in Table 8.13 will reduce the likelihood of vessel strike with whale sharks to ALARP.
Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient	The EIA presented in Chapter 7 of the EP indicates the emissions and discharges associated with this activity will have a negligible impact on marine fauna.

Interim Objective or Target	Assessment
levels) on whale sharks and mitigation options for these impacts.	
Conduct further research into the impacts of boat strike on whale sharks to determine the significance of the threat. Consider possible mitigation actions (collision avoidance systems) if required.	The activity will have no impacts on this research priority

TSSC (2015).

8.2.5 Risk Assessment

Table 8.13 presents the risk assessment for vessel collision or entanglement with megafauna.

Table 8.13. Risk assessment for vessel collision with megafauna

Summary			
Summary of risks	Injury or death of megafauna.		
Extent of risks	Localised – limited to individuals coming into contact with a support vessel.		
Duration of risks	Temporary (if individual animal dies or has a minor injury) to long-term (if there is a serious injury).		
Level of certainty of risk	HIGH – injury may result in the reduced ability to swim and forage. Serious injury may result in death.		
Risk decision framework context	Decision type	A - good industry practice required.	
	Activity	Nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.	
	Risk & uncertainty	Risks are well understood, uncertainty is minimal.	
	Stakeholder influence	No conflict with company values, no partner interest, no significant media interest.	
Defined acceptable level	No collision with megafauna.		

Risk Assessment (inherent)		
Likelihood	Consequence	Risk rating
Occasional	Minor	Low

Assessment of Proposed Control Measures			
Control measure	Control type	Adopt	Justification
Eliminate the use of support vessels.	Eliminate	No	**EB:** Eliminates the potential collision hazard. **C:** The activity could not proceed. **Ev:** The use of support vessels is the only way in which the activity can proceed. The cost of not using them is the cost of not fulfilling exploration obligations associated with the exploration permit and potential future lost hydrocarbon production.

No night-time/low visibility operations.	Eliminate	No	**EB:** Reduces the likelihood of collision with megafauna. **C:** Doubles the length of time required to complete the activity and subsequent costs, resulting in increased impacts and risks in other areas such as routine discharges, greater collision risk due to additional time spent on-water, etc). **Ev:** Cost outweighs the environmental benefit given the low residual risk to marine megafauna populations.
Restrict support vessel speed to no greater than 6 knots in the activity area.	Administrative	No	**EB:** Reduces the risk of collision with megafauna. **C:** In the event of an emergency, the support vessels may need to travel at speeds >6 knots. There may be a human health or safety cost of not being able to do so. **Ev:** Preventing vessels from travelling at speed in the event of an emergency is not commensurate with the negligible risk rating for this hazard.
Dedicated marine fauna observer (MFO) onboard the support vessels.	Administrative	No	**EB:** Improves the ability to spot megafauna by allowing vessel Masters to focus on navigation duties, thereby reducing the risk of collision. **C:** Tens of thousands of dollars over the duration of the drilling program, increasing if sourcing MFOs and/or logistics issues means that MFOs cannot be sourced in time for the scheduled start date. **Ev:** The cost of dedicated MFOs on the support vessels is grossly disproportionate to the negligible residual risk associated with this hazard and in light of the low likelihood of high numbers of megafauna in the operational area.
Australian National Guidelines for Whale and Dolphin Watching (2017) (giving effect to the 'interacting with cetaceans and whale watching' in EPBC Regulations Part 8) **(RSK-02: EPS-01).**	Administrative	Yes	**EB:** Observation for megafauna reduces likelihood for potential collision or entanglement through directing the Vessel Master to slow down or move away to avoid megafauna. **C:** No additional cost for vessel crew to implement this control measure. **Ev:** Environmental benefits outweigh the costs.
Environmental induction **(RSK-02: EPS-02).**	Administrative	Yes	**EB:** Ensures vessel personnel are aware of obligations, which in turn reduces the risk of interactions with megafauna. **C:** Negligible; it is a standard on-water requirement. Minor administrative cost to prepare induction and present to crew. **E:** Environmental benefit outweighs cost.

Notification and reporting of collisions with megafauna **(RSK-02: EPS-03, -04).**	Administrative	Yes	**EB:** Reduces risk of physical impacts to cetaceans from the activity vessels. **C:** No additional costs. **Ev:** Environmental benefit can be achieved without costs.

Environmental Controls and Performance Measurement		
EPO	EPS	Measurement criteria
No collision with megafauna.	**(RSK-02: EPS-01)** Through constant bridge watch, vessels comply with the *Australian National Guidelines for Whale and Dolphin Watching for Vessels* (DoEE, 2017b) when working within the activity area. This means: • Caution zone (300 m either side of whales and 150 m either side of dolphins) – vessels must operate at no wake speed in this zone. • No approach zone (100 m either side of whales and 50 m either side of dolphins) – vessels should not enter this zone and should not wait in front of the direction of travel or an animal or pod/group. • Do not encourage bow riding. • If animals are bow riding, do not change course or speed suddenly. • If there is a need to stop, reduce speed gradually. • Recording all interactions.	Daily operations reports note marine megafauna interactions.
	(RSK-03: EPS-02) Vessel crew has completed an environmental induction covering the above-listed requirements for vessel and megafauna interactions.	Induction and attendance records verify that all crews have completed an environmental induction.
Vessel strike is reported to regulatory authorities.	**(RSK-02: EPS-03)** Vessel strike causing injury to or death of a cetacean is reported to the DCCEEW via the online National Ship Strike Database (https://data.marinemammals.gov.au/report/shipstrike) within 72 hours of the incident.	Electronic record of report submittal is available.
		Incident report is available within the OMS.
	(RSK-02: EPS-04) Injured megafauna is reported to the Wildcare Helpline on (08) 9474 9055 (for cetaceans travelling towards WA) or the Marine Wild Watch Hotline on 1800 453 941 (for cetaceans travelling towards the NT) as soon as possible. No attempts to disentangle megafauna should be made by vessel crew.	Incident report verifies contact was made with the Wildcare Helpline or Marine Wild Watch Hotline.

Risk Assessment (residual)		
Likelihood	Consequence	Risk rating
Rare	Minor	Negligible

The risk of vessel strike with megafauna is assessed as negligible because:

- The activity is temporary in nature;
- The movement of the drilling support vessels throughout the operational area on a 24-hr basis and
- Implementation of the EPS will reduce the likelihood of vessel collision or entanglement with megafauna to ALARP.

Demonstration of ALARP		
A 'negligible' residual risk rating is considered to be ALARP and a 'lower order' risk. The adopted controls and associated EPS have lowered the risk to the point that any additional or alternative control measures either fail to lower the residual risk rating any further or are grossly disproportionate to the residual risk rating.		
Demonstration of Acceptability		
Policy compliance	EOG's Safety & Environmental Policy objectives are met.	
EMS compliance	Chapter 10 outlines the EP implementation strategy to be employed for this activity.	
Risk matrix standard compliance	The residual risk is negligible, which is considered acceptable.	
External context	No objections or claims have been raised by relevant persons regarding vessel strike with megafauna.	

Legislative context	The EPS align with the requirements of:
	• *EPBC Act* 1999 (Cth):
	  ○ Section 199 (failing to notify taking of listed species or listed ecological community).
	• EPBC Regulations 2000 (Cth):
	  ○ Part 8 (Interacting with cetaceans and whale watching).
	  ○ AMSA Marine Notice 2016/15 – Minimising the risk of collisions with cetaceans.	

Industry practice	The consideration and alignment of EPS with the mitigation measures outlined in the below-listed codes of practice and guidelines demonstrates that BPEM will be implemented for this activity	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS developed for this activity are in line with the management measures listed for collision with marine fauna in Section 4.7.5 of the guidelines: • Monitoring for the presence and movement of large cetaceans and pinnipeds so that avoidance can be taken when marine fauna is observed to be on a collision course with vessels **(RSK-02: EPS-01)**.
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	There are no guidelines for offshore activities with regard to minimising the risk of collisions with megafauna.

	Health, Safety and Environmental Case Guidelines for Mobile Offshore Drilling Units (IADC, 2015)	There is no specific guidance regarding minimising the risk of megafauna collisions. Section 2.3.6.1 (environmental protection) states that location- and well-specific environmental protection plans should be prepared. The EP satisfies this requirement.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	There are no guidelines regarding minimising the risk of vessel strike or entanglement with megafauna.
	AEP CoEP (APPEA 2008)	The EPS for this activity meet the code's following objectives for offshore drilling operations: • To reduce the risks to the abundance, diversity, geographical spread and productivity of marine species to ALARP and to an acceptable level (all **RSK-02 EPS**).
	Megafauna collision-specific	
	The Australian Guidelines for Whale and Dolphin Watching (DoEE, 2017b)	The EPS listed in this table are aligned with the requirements of these guidelines **(RSK-02: EPS-01).**
	National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (DoEE, 2017a).	The EPS listed in this table are aligned with objective 3 of this strategy, which is to reduce the likelihood and severity of megafauna vessel collisions **(RSK-02: EPS-01)**.
Environmental context	MNES	
	AMPs	The risk of collisions with megafauna will not have any effect on nearby AMPs.
	Ramsar wetlands	The risk of collisions with megafauna will not have any effect on Ramsar wetlands.
	TECs	The risk of collisions with megafauna will not have any effect on TECs.
	Nationally threatened and migratory species	The low speed or stationary nature of the support vessels, along with the temporary nature of the activity, makes it unlikely that vessel strike with megafauna will occur. This section provides an assessment of the relevant management actions of the: • Conservation Management Plan for the Blue Whale (DoE, 2015b); • Approved Conservation Advice for the Sei Whale (TSSC, 2015b); • Approved Conservation Advice for the Fin Whale (TSSC, 2015c); • Conservation advice for the humpback whale (TSSC, 2015a);

		• Recovery Plan for Marine Turtles in Australia, DoEE, 2017c); and • National Strategy for Reducing Vessel Strike on Cetaceans and Other Marine Megafauna (DoEE, 2017a). The EPS adopted for the activity will reduce the likelihood of vessel collision or entanglement to ALARP, thereby enabling the activity to be conducted in a manner that is not inconsistent with these plans.
	Other matters	
	KEFs	The risk of collisions with megafauna will not have any effect on KEFs.
	NIWs	The risk of collisions with megafauna will not have any effect on NIWs.
	State marine parks	The risk of collisions with megafauna will not have any effect on state marine parks.
	Species Conservation Advice/ Recovery Plans/ Threat Abatement Plans	Vessel collisions are listed as a threat to cetaceans in the: • Conservation Management Plan for the Blue Whale (DoE, 2015b); • Conservation advice for the sei whale (TSSC, 2015b); • Conservation advice for the fin whale (TSSC, 2015c); and • Conservation advice for the humpback whale (TSSC, 2015a). The EPS listed in this table aim to minimise the risk of vessel strike with megafauna. This section provides an assessment of the activity against the management actions relevant to vessel strike and demonstrate that the activity will be managed in a manner such that it is not inconsistent with the relevant management actions of these plans.
ESD principles	The EIA presented throughout this EP demonstrates that ESD principles (a), (b), (c) and (d) are met (noting that principle (e) is not relevant).	
Defined acceptable level	EOG considers the risks of collision and entanglement with megafauna to be acceptable because: • It will adhere to the company's Safety & Environmental Policy; • The residual risk rating is negligible; • An Implementation Strategy (described in Chapter 9) is in place to ensure the EPS are achieved. • Input from engagement with relevant persons has been considered and incorporated into the design of the activity; • Relevant legislation and industry best practice will be complied with; • Collisions with megafauna will not have long-term or significant impacts on MNES;	

	• Control measures in place to prevent collisions with megafauna are not inconsistent with the aims of recovery plans/conservation plans/advice that are in force for EPBC Act-listed threatened and migratory species; • Control measures in place to prevent collisions with megafauna are not inconsistent with the aims of relevant marine reserve management plans; and • The control measures are not inconsistent with ESD principles.
Environmental Monitoring	
• Constant bridge watch on support vessels.	
Record Keeping	
• Vessel crew induction presentation and attendance records. • Megafauna sighting records. • Incident reports.	

8.3 RISK 3 – Introduction and Establishment of Invasive Marine Species

8.3.1 Hazard

The DAWR (2018) defines marine pests (referred to in this EP as invasive marine species, IMS) as:

- Non-native marine plants or animals that harm Australia's marine environment, social amenity or industries that use the marine environment, or have the potential to do so if they were to be introduced, established (that is, forming self-sustaining populations) or spread in Australia's marine environment.

The following activities have the potential to result in the introduction of IMS in the activity area:

- Discharge of ballast water from the support vessels and MODU hull containing foreign species; and
- Translocation of foreign species through biofouling on support vessel hulls and niches (e.g., thruster tunnels, sea chests) and the MODU hull and legs.

Biofouling is the accumulation of aquatic microorganisms, algae, plants and animals on vessel hulls and submerged surfaces. More than 250 non-indigenous marine species have established in Australian waters, with research indicating that biofouling has been responsible for more foreign marine introductions than ballast water (DAWR, 2018).

Ballast water is estimated to be responsible for 30% of all marine pest incursions into Australian waters (DAWR, 2018). The DAWR declares that all saltwater from ports or coastal waters outside Australia's territorial seas presents a high risk of introducing foreign marine pests into Australia (AQIS, 2011), while DAWR (2018) notes that the movement of vessels and marine infrastructure is the primary pathway for the introduction of IMS.

The MODU

As a jack-up, the key IMS risks from the MODU come from the legs, as they are immersed in the water column for long periods, along with the spud cans that are immersed in seabed sediments. Ballast water is taken up from the jack-up MODU in the hull when it leaves a location (to assist with ballasting during the tow) and then discharged when it reaches a location.

The IMS risk for jack-up MODUs is lower when compared to semi-submersible MODUs because the legs are raised out of the water when towed between drilling locations, meaning that any

biofouling generally dehydrates and dies (and may dislodge) between locations and is therefore less likely to survive in a new location once the MODU is jacked down.

Support Vessels

Support vessels ballast and de-ballast to improve stability, even out vessel stresses and adjust vessel draft, list and trim, with regard to the weight of equipment on board at any one time.

8.3.2 Potential Environmental Risks

The risks of IMS introduction (assuming their survival, colonisation and spread) include:

- Reduction in native marine species diversity and abundance;
- Displacement of native marine species;
- Depletion of commercial fish stocks (and associated socio-economic effects); and
- Changes to conservation values of protected areas.

8.3.3 EMBA

The EMBA for IMS introduction is anywhere within the operational area (wherever vessel movements occur), though if IMS survive the introduction and go on to colonise and spread, this EMBA could extend to large parts of the JBG.

Receptors most at risk within this EMBA, either as residents or migrants, are:

- Benthic fauna (because of their limited ability to move to other suitable areas);
- Benthic habitat; and
- Pelagic fish.

8.3.4 Evaluation of Environmental Risks

Successful IMS invasion requires the following three steps:

1. Colonisation and establishment of the marine pest on a vector (e.g., vessel hull) in a donor region (e.g., home port).
2. Survival of the settled marine species on the vector during the voyage from the donor to the recipient region (e.g., operational area).
3. Colonisation (e.g., dislodgement or reproduction) of the marine species in the recipient region, followed by successful establishment of a viable new local population.

If successful invasion takes place, the IMS is likely to have little or no natural competition or predation, thus potentially outcompeting native species for food or space, preying on native species or changing the nature of the environment. It is estimated that approximately one in six introduced marine species becomes pests (AMSA, n.d). Because the eradication of IMS populations is innately extremely difficult, it is necessary that preventing their introduction (or failing this, early detection) is the key to managing this risk.

Marine pest species can also deplete fishing grounds and aquaculture stock, with between 10% and 40% of Australia's fishing industry being potentially vulnerable to marine pest incursion (AMSA, n.d). For example, the introduction of the Northern Pacific seastar (*Asterias amurensis*) in Victorian and Tasmanian waters was linked to a decline in scallop fisheries. Similarly, the ability of the New Zealand screw shell (*Maoricolpus roseus*) to reach densities of thousands of shells per square metre has presented problems for commercial scallop fishers (MESA, 2022). The ABC

(2000) reported that the New Zealand screw shell is likely to displace similar related species of screw shells, several of which occupy the same depth range and sediment profile.

Marine pests can also damage marine and industrial infrastructure, such as encrusting jetties and marinas or blocking industrial water intake pipes. By building up on vessel hulls, they can slow the vessels down and increase fuel consumption.

Activity-specific risk assessment

The Interactive Map for Marine Pests in Australia (DAFF, 2021) does not identify any known pests within the Port of Darwin. Given that this is the largest port in the region and the most likely port of call for the support vessels, the likelihood of IMS introduction from this port is therefore low.

The jack-up MODU to be used for drilling is likely to be currently or soon-to-be operating in northern Australian waters, with steps already taken by previous operator(s) to reduce the risk of introducing IMS. This would lower the risk of introducing IMS to the JBG compared to the MODU coming directly from non-Australian waters (because any fouling species or IMS present in ballast waters are likely to have come from the region and therefore present a lower risk of being invasive species). In the unlikely event that Beehive-1 uses a MODU which is coming from outside the Northwest Marine Region or outside Australia, EOG would take the appropriate steps as adopted per the risk assessment to keep the risk of IMS introduction ALARP.

The unconsolidated sandy sediments of the activity area and surrounds (see Section 5.2.3), combined with its water depth (40 m) and distance from shore (80 km), reduce the risk of IMS establishment because IMS generally require hard substrate to attach to in the photic zone. Colonisation and spread is more likely in shallow, highly disturbed nearshore waters (such as ports and marinas) than open waters further offshore (Geiling, 2014) where the rate of dilution and the degree of dispersal are high (Paulay *et al*,. 2002).

The National Strategic Plan for Marine Pest Biosecurity (2018-2023) (DAWR, 2018) has five objectives and associated management activities. An assessment of the objectives and management activities of the National Strategic Plan for Marine Pest Biosecurity (2018-2023) against the activity is provided in Table 8.14.

Table 8.14. Assessment of the objectives and management activities of the National Strategic Plan for Marine Pest Biosecurity (2018-2023) against the activity

Objectives and Activities	Assessment
Objective 1: Minimise the risk of marine pest introductions, establishment and spread	The adopted EPS listed in Table 8.15 are aligned with best-practice mitigation measures, which will reduce the likelihood of introduction of IMS to ALARP. Therefore, the activity will be consistent with this objective.
1.1. Implement nationally consistent domestic ballast water regulations under the Biosecurity Act 2015 (Cwlth).	The adopted EPS listed in Table 8.15 are aligned with best-practice mitigation measures, which will reduce the likelihood of introduction of IMS to ALARP. Therefore, the activity will be consistent with these management activities.
1.2. Ensure the use of ballast water management systems in Australian waters meets accepted environmental standards.	
1.3. Investigate regulatory options to manage biosecurity risks associated with biofouling on vessels.	The activity will not have any impact on this management activity.

Objectives and Activities	Assessment
1.4. Review the National Biofouling Management Guidelines for marine sectors and update as required.	The activity will not have any impact on this management activity.
1.5. Investigate the benefits of an intelligence-gathering framework to monitor marine pest risk pathways and expand the International Biosecurity Intelligence System as appropriate.	The activity will not have any impact on this management activity.
Objective 2: Strengthen the national marine pest surveillance system	The activity will not have any impact on this objective.
2.1. Develop a national marine pest surveillance strategy.	The activity will not have any impact on this management activity.
2.2. Investigate Australia's current passive surveillance capability for marine pests and recommend possible improvements.	The activity will not have any impact on this management activity.
2.3. Promote tailored education and awareness materials to engage marine pest observer groups in passive surveillance activities.	The activity will not have any impact on this management activity.
2.4. Develop validation guidelines for marine pest molecular detection methods.	The activity will not have any impact on this management activity.
2.5. Validate molecular detection methods (including sampling methodology) for selected high-priority marine pest species.	The activity will not have any impact on this management activity.
2.6. Audit, maintain and share a database of marine pest identification capability.	The activity will not have any impact on this management activity.
2.7. Review surveillance information management needs and ensure an appropriate information system is in place.	The activity will not have any impact on this management activity.
2.8. Perform an audit of marine pest surveillance activities and data sets relevant to Australia.	The activity will not have any impact on this management activity.
Objective 3: Enhance Australia's preparedness and response capability for marine pest introductions	The activity will not have any impact on this objective.
3.1. Plan and implement a national program of marine pest emergency response exercises.	The activity will not have any impact on this management activity.
3.2. Develop a benefit–cost analysis framework to guide response efforts in the event of a nationally significant marine pest incursion.	The activity will not have any impact on this management activity.
3.3. Identify marine pest emergency response training needs.	The activity will not have any impact on this management activity.

Objectives and Activities	Assessment
3.4. Review the national Emergency Marine Pest Plan (EMP Plan) framework.	The activity will not have any impact on this management activity.
3.5. Plan and implement procedures to develop and update the EMP Plan rapid response manuals and related guidance materials.	The activity will not have any impact on this management activity.
Objective 4: Support marine pest biosecurity research and development	The activity will not have any impact on this objective.
4.1. Periodically review the national marine pest biosecurity research and development priorities.	The activity will not have any impact on this management activity.
4.2. Promote research coordination through the national marine pest research network.	The activity will not have any impact on this management activity.
4.3. Review the economic, environmental and social impacts of marine pests in Australia.	The activity will not have any impact on this management activity.
4.4. Conduct risk analyses of marine pest vectors and pathways, and make recommendations for improved management.	The activity will not have any impact on this management activity.
4.5. Assess the effectiveness of current management options for biofouling in niche areas.	The activity will not have any impact on this management activity.
Objective 5: Engage stakeholders to better manage marine pest biosecurity	The activity will not have any impact on this objective.
5.1. Identify and build a profile of marine pest biosecurity stakeholders.	The activity will not have any impact on this management activity.
5.2 Develop a national stakeholder engagement strategy for Marine Pest Plan 2018–2023 and the Marine Pest Sectoral Committee.	The activity will not have any impact on this management activity.
5.3. Design a targeted national campaign to improve awareness of marine pest biosecurity risks, management actions and shared responsibilities.	The activity will not have any impact on this management activity.
5.4. Review, update and maintain the www.marinepests.gov.au website.	The activity will not have any impact on this management activity.
5.5. Establish an independent national marine pest network.	The activity will not have any impact on this management activity.

8.3.5 Risk Assessment

Table 8.15 presents the risk assessment for the introduction of IMS.

Table 8.15. Risk assessment for the introduction of IMS

Summary		
Summary of risks	Reduction in native marine species diversity and abundance, displacement of native marine species, socio-economic impacts on commercial fisheries and changes to conservation values of protected areas.	
Extent of risk	Localised (isolated locations if there is no spread) to widespread (if colonisation and spread occurs).	
Duration of risk	Short-term (IMS is detected and eradicated, or IMS does not survive long enough to colonise and spread) to long-term (IMS colonises and spreads).	
Level of certainty of risk	HIGH – the impacts associated with IMS introduction are well known and the vectors of introduction are known. Regulatory guidelines controlling these vectors have been established.	
Risk decision framework context	Decision type	A - good industry practice required.
	Activity	Nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
	Risk & uncertainty	Risks are well understood, uncertainty is minimal.
	Stakeholder influence	No conflict with company values, no partner interest, no significant media interest.
Defined acceptable level	No introduction of IMS.	

Risk Assessment (inherent)		
Likelihood	Consequence	Risk rating
Occasional	Moderate	Medium

Assessment of Proposed Control Measures			
Control measure	Control type	Adopt	Justification
Use only locally/ regionally sourced support vessels.	Elimination	Likely	**EB:** Eliminates the potential for introduction of IMS from non-Australian waters. **C:** This is not standard industry practice. This is a significant limitation on the activity, as there are very few if any drilling support vessels permanently based in Australia, so vessels must be sourced opportunistically if they are in-country when required, or else internationally (e.g., southeast Asia). There is no cost to the project in adopting this approach. However, this cannot be guaranteed. **Ev:** There are significant schedule and capability implications for the activity by restricting the choice of vessels. On balance, the cost to implement this control is disproportionate to the risk if other controls are adopted.
Do not exchange or discharge ballast water in the operational area.	Elimination	No	**EB:** Eliminates the potential for introduction of IMS. **C:** It is not feasible to implement this from a structural integrity or safety perspective, as

			ballast water exchange is required to ensure the stability of vessels as they load and unload goods. **Ev:** The high risk to human safety outweighs any environmental benefits.
International Anti-fouling System (IAFS) Certificate **(RSK-03: EPS-02).**	Engineering	Yes	**EB:** Ensures that the MODU and support vessels have an anti-fouling coating and associated certificate to reduce the likelihood of transfer of IMS from their hulls to the activity area. **C:** Significant cost to the contractors to have the MODU and vessels inspected and anti-fouling paint applied (generally every 5 years). This is a legislated requirement. **Ev:** Environmental benefit outweighs the cost.
Biofouling Management Plan and Biofouling Record Book **(RSK-03: EPS-01, -03).**	Administrative	Yes	**EB:** Provides for operational guidance to vessels for planning and actions required to manage vessel biofouling, in addition to outlining measures for the control and management of vessel biofouling in accordance with IMO Guidelines. Thereby reducing the likelihood of IMS transfer and establishment in the activity area. **C:** Small cost involved with personnel undertaking inspections and audits. **Ev:** Environmental benefit outweighs the cost.
Cleaning of immersible equipment **(RSK-03: EPS-04).**	Administrative	Yes	**EB:** Reduces the likelihood of introducing IMS. **C:** Small cost involved in cleaning and verification during inspection. **Ev:** Environmental benefit outweighs cost.
Ballast water management plan. **(RSK-03: EPS-05, -06).**	Administrative	Yes	**EB:** Reduces likelihood of introducing IMS. **C:** Small costs associated with preparing and implementing the ballast water management plan and with maintaining record books and logs. This is a legislated requirement. **Ev:** Environmental benefit outweighs cost.
Incident reporting **(RSK-04: EPS-07).**	Administrative	Yes	**EB:** Alerts authorities to the known or potential introduction of IMS, thereby allowing authorities to deal with (or remove) the threat early so as to minimise environmental impacts. **C:** No cost. **Ev:** Environmental benefit outweighs the cost.

Environmental Controls and Performance Measurement		
EPO	EPS	Measurement criteria
Biofouling		
No introduction of IMS through hull fouling.	**(RSK-03: EPS-01)** The MODU and support vessels are managed in accordance with the *National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry* (CoA, 2009) to ensure they present a low biofouling risk. This means:	Biofouling assessment reports prior to mobilising to site confirms acceptability to enter the operational area.

	• Biofouling risk assessment is conducted to ensure there is a low risk of IMS introduction. • Conducting in-water inspection by divers or inspection in drydock if deemed necessary (based on risk assessment). • Cleaning of hull and internal seawater systems, if deemed necessary. • Anti-fouling coating status taken into account, with antifouling renewal undertaken if deemed necessary.	
	(RSK-03: EPS-02) The MODU and support vessels >400 gross tonnes carry a current IAFS Certificate that is complaint with Marine Order Part 98 (Anti-fouling Systems).	IAFS Certificates are available and current.
	(RSK-03: EPS-03) The MODU and support vessels are managed in accordance with *The Australian Biofouling Management Requirements* (Version 1, 2022), which involves submitting information to the DCCEEW in its Pre-Arrival Report (PAR) specifying whether the MODU and vessel: • Maintain an effective Biofouling Management Plan (includes the plan, biofouling record book and supporting evidence); • Have been cleaned of biofouling within 30 days of arriving in Australia; • Have an alternative biofouling management method that has been pre-approved by the DCCEEW (includes approval document); • Will be subject to in-water cleaning in Australia (if required, includes permissioning document from the relevant state or NT government). EOG will only contract a MODU and support vessels that can demonstrate they have met these requirements.	The following documentation is current: • Accepted PAR; • Biofouling Management Plan; • Biofouling Record Book; • Cleaning report and supporting photos or video; and • Pre-approved alternative biofouling management method (if required).
Immersible equipment does not introduce IMS to the activity area.	**(RSK-03: EPS-04)** Immersible equipment (e.g., VSP equipment, ROV) is cleaned (e.g., biofouling is removed) prior to initial use on the MODU.	Records are available to verify that immersible equipment was cleaned prior to use.
Ballast water		
No introduction of IMS through ballast water.	**(RSK-03: EPS-05)** Vessels fulfil the requirements of the *Australian Ballast Water Management Requirements* (DAWR, 2020, v8). This includes requirements to: • Carry a valid Ballast Water Management Plan (BWMP).	BWMP is available and current.
		BWR (or exemption) is submitted prior to entry to the activity area.
		A valid BWMC is in place.

	• Submit a Ballast Water Report (BWR) through the Maritime Arrivals Reporting System (MARS).
	  ○ If intending to discharge internationally-sourced ballast water, submit BWR through MARS at least 12 hours prior to arrival.
	  ○ If intending to discharge Australian-sourced ballast water, seek a low-risk exemption through MARS.
	• Hold a Ballast Water Management Certificate (BWMC).
	• Ensure all ballast water exchange operations are recorded in a Ballast Water Record System (BWRS).
		An up-to-date BWRS is in place.
		
		An electronic Pre-Arrival Report (ePAR) is available and signed off by DAWR.

	(RSK-03: EPS-06) As above, except a BWR is not required for domestic journeys (i.e., when moving between Australian ports and 200 nm of the coastline). *Note: ballast water management is not required between Australian ports if:* • *Ballast water is taken up and discharged in the same place.* • *Potable water is used as ballast.* • *Ballast water was taken up on the high seas only.* • *The vessel receives a risk-based exemption from ballast water management.*	As above, except for the BWR.
Reporting		
Known or suspected non-compliance with biosecurity measures are reported to regulatory agencies.	**(RSK-03: EPS-07)** Non-compliant discharges of domestic ballast water are to be reported to the DAWR immediately (contact details in Section 9.7.2).	Incident report notes that contact was made with the DAWR regarding non-compliant ballast water discharges.

Risk Assessment (residual)		
Likelihood	Consequence	Risk rating
Remote	Moderate	Low

The risk of the introduction and establishment of IMS is assessed as low because:

- The control measures adopted are effective in reducing the risk to ALARP.

Demonstration of ALARP
A 'low' residual risk rating is considered to be ALARP and a 'lower order' risk. The adopted EPS have lowered the risk to the point that any additional or alternative control measures either fail to lower the residual risk rating any further or are grossly disproportionate to the residual risk rating.

Demonstration of Acceptability	
Policy compliance	EOG's Safety and Environmental Policy objectives are met.
OEMS compliance	Chapter 10 outlines the EP implementation strategy to be employed for this activity.

Risk matrix standard compliance	The residual risk is low, which is considered acceptable.	
External context	No objections or claims have been raised by relevant persons regarding the introduction and establishment of IMS.	

Legislative context	The EPS align with the requirements of:
	• *Biosecurity Act* 2015 (Cth):
	  ○ Chapter 4 (Managing biosecurity risk).
	  ○ Chapter 5, Part 3 (Management of discharge of ballast water).
	  ○ Biosecurity Regulations 2016.
	  ○ Biosecurity Amendment (Biofouling Management) Regulations 2021.
	• *Protection of the Sea (Harmful Anti-fouling Systems) Act* 2006 (Cth):
	  ○ Part 2 (Application or use of harmful anti-fouling systems).
	  ○ Part 3 (Anti-fouling certificates and anti-fouling declarations).
	  ○ Marine Order 98 (Marine pollution – anti-fouling systems).
	• Ballast Water Management Convention and Resolution 127 (53) (Marine Environmental Protection Committee of the IMO) 2005.
	• Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 (IMO).	

Industry practice	The consideration and alignment of EPS to the mitigation measures outlined in the below-listed codes of practice and guidelines demonstrates that BPEM is being implemented.	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS developed for this activity are in line with the management measures listed for the introduction of IMS in Section 4.7.6 of the guidelines: • Complying with the International Convention on the Control of Harmful Anti-fouling Systems on Ships **(RSK-03: EPS-02)**. • Ensuring vessels of appropriate class have IAFS certificates **(RSK-03: EPS-02)**. • Ensuring compliance with local regulatory guidelines.
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	There are no guidelines for offshore activities with regard to minimising the risk of introducing IMS.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	There are no guidelines regarding preventing the introduction of IMS.
	AEP CoEP (APPEA 2008)	The EPS for this activity meet the code's following objectives for offshore drilling operations: • To reduce the risk of introduction of marine pests to ALARP and to an acceptable level (**All RSK-03 EPS**).

		• To reduce the impacts to benthic communities to ALARP and to an acceptable level.
	IMS-specific	
	Australian Biofouling Management Requirements (Version 1, 2022)	The EPS in this table reflect the guidance regarding biofouling management **(RSK-03: EPS-03)**.
	Australian Ballast Water Management Requirements (DAWR, 2020, v8)	The EPS in this table reflect the guidance regarding ballast water management in the DAWR guide **(RSK-03: EPS-05)**.
	Offshore Installations – Biosecurity Guide (DAWE, 2020, v1.4)	The EPS in this table reflect the guidance provided in the DAWE guide, which largely references other guidelines listed here.
	Anti-Fouling and In-Water Cleaning Guidelines (DoA/DoE, 2015).	The EPS in this table reflect the general guidance regarding managing fouling in the DoA/DoE guidelines, which have since been updated in the aforementioned DAWR (2020) quarantine guide.
	Guidelines for the Control and Management of Ships' Biofouling to Minimise the Transfer of Invasive Aquatic Species (IMO, 2011)	The EPS in this table reflect the guidance regarding minimising the transfer of IMS from biofouling.
	National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (DAFF, 2009)	The EPS in this table reflect the guidance regarding biofouling management in the DAFF guide **(RSK-03: EPS-01)**.
Environmental context	MNES	
	AMPs	The North Marine Parks Network Management Plan 2018 (DNP, 2018) identifies invasive species introduction via ballast water in shipping, fishing vessels and other vessels as a potential biosecurity pressure to the AMP network. The implementation of the EPS make it unlikely that IMS will be introduced to the activity area and spread to nearby AMPs.
	Ramsar wetlands	The risk of introducing IMS is highly unlikely to affect Ramsar wetlands.
	TECs	The risk of introducing IMS is highly unlikely to affect TECs.
	Nationally threatened and migratory species	The threatened and migratory species within the spill EMBA are all highly mobile species. There are no EPBC Act-listed benthic species listed as occurring in the operational area; these are

		generally more susceptible to the effects of IMS than mobile fauna.
	Other matters	
	KEFs	The risk of introducing IMS is highly unlikely to affect KEFs.
	NIWs	The risk of introducing IMS is highly unlikely to affect NIWs.
	State marine parks	This hazard does not intersect any state marine parks.
	Species Conservation Advice/ Recovery Plans/ Threat Abatement Plans	The National Strategic Plan for Marine Pest Biosecurity (2018-2023) (DAWR, 2018) has five objectives. The EPS listed in this table are aligned with the plan's objective to minimise the risk of marine pest introductions, establishment and spread (noting that the other four objectives do not apply to the activity).
ESD principles	The EIA presented throughout this EP demonstrates that ESD principles (a), (b), (c) and (d) are met (noting that principle (e) is not relevant).	
	Is there a threat of serious or irreversible environmental damage?	Possibly, but the EPS aim to avoid this.
	Is there scientific uncertainty as to the environmental damage?	Yes. Individual species fill different ecological niches and understanding how one or more species are likely to behave outside their native habitat is generally unknown until it occurs.
Statement of acceptability	EOG considers the risks of introducing IMS to be acceptable because: • It will adhere to the company's Safety & Environmental Policy; • The residual risk rating is low; • An Implementation Strategy (described in Chapter 9) is in place to ensure the EPS are achieved; • Input from engagement with relevant persons has been considered and incorporated into the design of the activity; • Relevant legislation and industry best practice will be complied with; • The management of IMS is not inconsistent with the aims of the National Strategic Plan for Marine Pest Biosecurity; and • The management of IMS is not inconsistent with ESD principles.	
Environmental Monitoring		
• None required.		
Record Keeping		
• Vessel contractor pre-qualification reports. • Biofouling risk assessment. • Ballast water risk assessments. • BWMP. • BWR.	• BWMC. • BWRS. • IAFS Certificates. • DAWR-signed ePARs.	

8.4 RISK 4 – Interference with Other Marine Users

8.4.1 Hazard

The presence of the MODU and support vessels may result in unplanned interference with other marine users and equipment, such as commercial fishing gear and merchant shipping.

8.4.2 Known and potential environmental impacts

The known and potential impacts of interference with other marine users are:

- Collision potential with third-party vessels (and damage in the case of collision); and
- Damage to or loss of fishing equipment and/or loss of commercial fish catches.

8.4.3 EMBA

The EMBA for interference with other marine users is anywhere within the operational area (wherever vessel movements occur), and more specifically the immediate area around the two intersecting vessels or equipment.

Receptors in the EMBA include:

- Commercial fishing vessels; and
- Merchant vessels.

8.4.4 Evaluation of Environmental Risks

Collision with other marine users

Interference from the MODU and support vessels undertaking the activity with other marine users is highly unlikely because:

- There is low shipping traffic in and around the activity area (see Section 5.7.7);
- The MODU will be highly visible from long distances;
- The support vessels are highly visible and move slowly around the MODU;
- Large vessels use sophisticated navigation aids;
- Navigational warnings and a PSZ will be in place; and
- Consultation has been undertaken with relevant persons prior to the activity.

In the event of interference with other marine users that results in a vessel-to-vessel collision, health and safety impacts are more likely than environmental impacts. Should the force of a collision be enough to breach a vessel hull (which is unlikely due to the generally low speed), an MDO spill may eventuate (the environmental consequences of which are addressed in Section 8.6).

Damage to or loss of fishing equipment

There is the remote possibility that fishing gear (e.g., NPF otter trawl nets) may get caught by the MODU legs if third-party commercial fishing vessels breach the 500-m radius PSZ with their gear deployed. This would likely result in the gear becoming detached from the fishing vessel and the loss of any associated catch. In addition to the cost of repairing or replacing this equipment, it could also result in the loss of income from caught fish during that fishing expedition. This is highly unlikely to occur because the size of the MODU ensures it is visible from long distances, meaning that fishers will not deploy trawl nets nearby.

The only fishery likely to be active in the activity area is the NPF. The NPF primarily operates from April to June and August to November. If the activity occurs commences in the first half of 2023, it will overlap with the NPF fishing season. Although there is a temporal overlap with the NPF fishing season, for the reasons outlined above, it will be unlikely to result in damage to or loss of fishing equipment.

Interference from the support vessels with commercial fishing vessels is unlikely, for the same reasons stated above.

8.4.5 Risk Assessment

Table 8.16 presents the impact assessment for interference with other marine users.

Table 8.16. Risk assessment for interference with other marine users

Summary		
Summary of risks	Presence of MODU and support vessels, resulting in the risk of vessel-to-vessel collision, damage to or loss of fishing equipment and loss of commercial fish catches.	
Extent of risks	Highly localised (within the activity area).	
Duration of risks	Short-term (minutes for a third-party vessel detour) to long-term (vessel collision).	
Level of certainty of risks	HIGH – the impacts associated with interference with other marine users is well understood.	
Risk decision framework context	Decision type	A - good industry practice required.
	Activity	Nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
	Risk & uncertainty	Risks are well understood, uncertainty is minimal.
	Stakeholder influence	No conflict with company values, no partner interest, no significant media interest.
Defined acceptable level	No interference with other marine users.	

Impact Consequence (inherent)		
Likelihood	Consequence	Risk rating
Occasional	Minor	Low

Assessment of Proposed Control Measures			
Control measure	Control type	Adopt	Justification
PSZ **(RSK-04: EPS-01)**.	Engineering	Yes	**EB:** Minimises collision risk with the MODU, support vessels and third-party equipment through increased awareness. **C:** Minimal cost to prepare and issue notices to marine users. **Ev:** Benefits to safety for all parties outweighs the minimal costs.

Navigation equipment and procedures **(RSK-04: EPS-03, -04, -06, -09)**.	Engineering	Yes	**EB:** Reduces the risk of collisions with other marine users. **C:** While the costs of navigation equipment are significant, it is standard on vessels and the costs of maintaining it are minimal. It is a legislative requirement. **Ev:** The safety benefits of having navigation equipment and procedures outweighs the cost.
Relevant person notifications **(RSK-04: EPS-01, -02, -10)**.	Administrative	Yes	**EB:** Ensures other marine users are aware of the activity and thus reduces likelihood of collision and interference. **C:** Minimal costs associated with EOG personnel preparing and issuing notifications and responding to stakeholders. **Ev:** Benefits outweigh the minimal cost.
Continuous bridge watch **(RSK-04: EPS-04)**.	Administrative	Yes	**EB:** Reduces the risk of collisions with other marine users or their equipment (e.g., marker buoys). **C:** No additional cost. It is routine maritime practice that the vessel master and mates maintain bridge watch at all times. **Ev:** Environmental benefits are achieved with no additional cost.
Crew qualifications. **(RSK-04: EPS-05)**.	Administrative	Yes	**EB:** Reduces the risk of vessel collision by ensuring crew possess appropriate qualifications to operate the vessels. **C:** Negligible; it is a standard maritime requirement that crew possess such qualifications. **Ev:** Environmental benefits can be achieved with negligible additional cost.
No fishing from MODU or support vessels. **(RSK-04: EPS-07)**.	Administrative	Yes	**EB:** Keeps all fishing stock available to commercial fishers. **C:** No cost involved. MODU and vessel crews are well supplied with fresh food and there is no need for fishing. **Ev:** Environmental benefits can be achieved with no cost.
Avoid drilling between 1st August to 1st December (4-month period) in any year in line with the request from the NPF.	Administrative	No	**EB:** Reduces the risk of interfering with NPF trawl fishing operations during a key fishing period. **C:** Extremely high (tens of millions of dollars), if MODU availability aligns with the requested exclusion period. The costs are associated with 'warm-stacking' the MODU, paying a termination fee to the MODU operator for breach of contract and/or lost opportunity costs.

			Ev: The cost of this control measures is grossly disproportionate to low inherent risk to third-party marine users. Trawling will not be impacted outside of the 500-m radius PSZ around the MODU.
Environmental Controls and Performance Measurement			
EPO	EPS		Measurement criteria
The EPS listed in 'displacement of other marine users' (Impact 2, Section 7.2) also apply to this risk. Additional controls are provided here.			
No incidents or complaints of spatial conflict with third-party vessels or fishing equipment.	**(RSK-04: EPS-01)** The AHO will be notified of the activity no less than three weeks prior to the activity commencing to enable the promulgation of a Notice to Mariners (NTM) that communicates the 500-m PSZ and 4.6 km (2.5 nm) cautionary area around the MODU for the duration of the activity.		NTM is issued via the AHO prior to the activity and includes details of the PSZ and cautionary area.
	(RSK-04: EPS-02) EOG notifies relevant persons ahead of the activity so that third-party marine users are aware of the MODU location and activity timing.		Stakeholder correspondence verifies that EOG contacted relevant persons about the timing and location of the activity.
	(RSK-04: EPS-03) The MODU and support vessels are readily identifiable to third-party vessels with lights, signals, AIS transponders and communication equipment.		Visual inspection and/or Offshore Vessel Inspection Database (OVID)/Common Marine Inspection Document (CMID) verify that the anti-collision monitoring equipment (e.g., 24-hour radar watch, Global Maritime Distress and Safety System (GMDSS) and Automatic Identification System [AIS]) is functional and in use.
	(RSK-04: EPS-04) The support vessels monitor the PSZ and cautionary area at all times using safe continuous watch.		Daily drilling reports/vessel bridge logbooks verify constant monitoring of the PSZ and cautionary area.
	(RSK-04: EPS-05) The support vessel masters and deck officers have valid SCTW certificates in accordance with AMSA Marine Order 70 (seafarer certification) (or equivalent) to operate radio equipment to warn of potential third party spatial conflicts (e.g., International Convention on Standards of Training, Certification and Watch-keeping for Sea-farers [STCW95], GDMSS proficiency).		Appropriate qualifications are available.
	(RSK-04: EPS-06) The support vessel masters issue warnings (e.g., radio warning, flares, lights/horns) to third-party vessels		Radio operations communications log verifies that warnings to third-party vessels approaching the PSZ have been issued when necessary.

	approaching the PSZ in order to prevent a collision with the MODU.	
	(RSK-04: EPS-07) Fishing is prohibited from the MODU and support vessels.	Induction and attendance records verify that all crew members are aware of the commitment.
	(RSK-04: EPS-08) All incidents of spatial conflict with other marine users will be reported in the EOG incident register.	The incident register is current.
Vessel-to-vessel collisions are managed in accordance with vessel-specific emergency procedures.	**(RSK-04: EPS-09)** The support vessel masters will sound the general alarm, manoeuvre the vessel to minimise the effects of the collision with the MODU and implement all other measures as outlined in the vessel or structure collision procedure (or equivalent).	Incident report verifies that the relevant safety procedure was implemented.
	(RSK-04: EPS-10) Vessel collisions will be reported to AMSA if that collision has or is likely to affect the safety, operation or seaworthiness of the vessel or involves serious injury to personnel.	Incident report verifies that AMSA were notified of a vessel collision.

Impact Consequence (residual)		
Likelihood	Consequence	Risk rating
Rare	Minor	Negligible

The risk of interference with other marine users is assessed as negligible because:

- The activity will be temporary in nature;
- There is low commercial shipping and fishing activity in and around the activity area;
- Thorough consultation has been undertaken with relevant persons to understand the risks and avoid potential interference; and
- The control measures adopted significantly reduce the likelihood of an incident of interference.

Demonstration of ALARP

A 'negligible' residual risk rating is considered to be ALARP and a 'lower order' risk. The adopted controls and associated EPS have lowered the risk to the point that any additional or alternative control measures either fail to lower the residual risk rating any further or are grossly disproportionate to the residual risk rating.

Demonstration of Acceptability

Policy compliance	EOG's Safety and Environmental Policy objectives are met through implementation of this EP.
EMS compliance	Chapter 9 outlines the EP implementation strategy to be employed for this activity.
Risk matrix standard compliance	The residual risk is negligible, which is considered acceptable.
External context	No objections or claims have been raised by relevant persons regarding interference with other marine users.

Legislative context	The EPS outlined in this table align with the requirements of:
	• *OPGGS Act* 2006 (Cth).
	  ○ Section 280 – requires that a person carrying on activities in an offshore area under the permit, lease, licence, authority or consent must carry on those activities in a manner that does not interfere with navigation or fishing (among others).
	• *Navigation Act* 2012 (Cth).
	  ○ Chapter 6 (Safety of navigation), particularly Part 3 (Prevention of collisions).
	  ○ AMSA Marine Orders Part 21 (Safety of Navigation and Emergency Procedures).
	  ○ AMSA Marine Orders Part 27 (Safety of Navigation and Radio Equipment).
	  ○ AMSA Marine Order Part 30 (Prevention of Collisions).	

Industry practice	The consideration and alignment of EPS with the mitigation measures outlined in the below-listed guidelines and codes of practice demonstrates that BPEM will be implemented for this activity	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS developed for this hazard are in line with the management measures listed for offshore physical presence in Section 4.3.1 of the guidelines, which include: • Develop exclusion zones in consultation with key stakeholders, including local fishing communities; raise awareness of exclusion zones with all stakeholders **(RSK-04: EPS-01, -07)**. • Issue a NTM through the relevant government agencies, detailing the area of operations **(RSK-04: EPS-01)**. • Ensure all vessels adhere to International Regulations for Preventing Collisions at Sea (COLREGS), which set out the navigation rules to be followed to prevent collisions between two or more vessels **(RSK-04: EPS-02, 04, -05)**. • Optimise vessel use to ensure the number of vessels required and length of time that vessels are on site is as low as practicable.
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	There is no specific guidance regarding collision avoidance and navigational lighting.
	Health, Safety and Environmental Case Guidelines for Mobile Offshore Drilling Units (IADC, 2015)	There is no specific guidance regarding collision avoidance and navigational lighting. Section 2.3.6.1 (environmental protection) states that location- and well-specific environmental protection plans should be prepared. The EP satisfies this requirement.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas	There is no specific guidance regarding collision avoidance and navigational lighting.

	Development (World Bank Group, 2015)	
	AEP CoEP (APPEA 2008)	The EPS for this activity meets the code's following objectives for offshore drilling operations: • To reduce the impact on other marine resource users to ALARP and to an acceptable level **(RSK-04: All EPS)**. • To reduce risks to public safety to ALARP and an acceptable level **(RSK-04: All EPS)**.
Environmental context	MNES	
	AMPs	This hazard will not affect nearby AMPs.
	Ramsar wetlands	This hazard will not affect any Ramsar wetlands.
	TECs	This hazard will not affect any TECs.
	Nationally threatened and migratory species	This hazard will not affect threatened or migratory species.
	Other matters	
	KEFs	This hazard will not affect any KEFs.
	NIWs	This hazard will not affect any NIWs.
	State marine parks	This hazard will not affect any state marine parks.
	Species Conservation Advice/ Recovery Plans/ Threat Abatement Plans	None triggered by this hazard.
ESD principles	The EIA presented throughout this EP demonstrates that ESD principles (a), (b), (c) and (d) are met (noting that principle (e) is not relevant).	
Statement of acceptability	EOG considers the risk of interference with other marine users to be acceptable because: • It will adhere to the company's Safety & Environmental Policy; • The residual consequence rating is negligible; • An Implementation Strategy (described in Chapter 9) is in place to ensure the EPS are achieved. • Input from engagement with relevant persons has been considered and incorporated into the design of the activity; and • Relevant legislation and industry best practice will be complied with.	

Environmental Monitoring
• Continuous bridge and radar monitoring.

Record Keeping	
• Stakeholder communication records. • NTM. • PSZ gazettal. • Crew qualifications.	• Radio communication logs. • Crew qualifications. • Incident reports. • Daily drilling reports.

8.5 RISK 5 – Unplanned Discharge of Drilling Fluids, Chemicals or Hydrocarbons

8.5.1 Hazard

The following activities have the potential to result in unplanned discharges of small volumes (typically no greater than 5-10 m^3) of drilling fluids, chemicals and hydrocarbons:

- MODU operations – crane transfers and bunkering operations;
- Well testing – liquid drop-out from incomplete combustion or discharge of oily water;
- Support vessel operations – cane transfers and bunkering operations; and
- Aviation operations – refuelling of the helicopter on the MODU.

Crane transfers or bunkering operations between support vessels and the MODU may result in accidental discharges of various products overboard or to deck, such as:

- Drilling muds;
- Bulk drilling chemicals (e.g., barite, bentonite);
- Bulk chemicals (e.g., pipe dope, BOP hydraulic fluids);
- Hydraulic oil from the cranes' electric prime movers;
- Helicopter aviation fuel (avgas [aviation gasoline] or diesel [Jet-A1]); and
- Assorted pumps, winches, power packs and generators.

Spills overboard may be caused by:

- Hose or connection failure (due to equipment condition or failure of a support vessel to keep station);
- Failure to align valves correctly during transfer to tanks;
- Overfilling of tanks on MODU or support vessel;
- Overfilling of aviation fuel tank on fuel unit or bulk storage tank of the MODU;
- Overfilling of helicopter on the MODU helideck;
- Dropped objects from crane transfers; and
- Accidental or emergency disconnection of the riser.

Fluids stored in tanks (or pits) are pumped between tanks or to mixing equipment using transport pumps. The pipes through which they are pumped are under pressure. Possible causes of spills during these transfers include:

- Leaks due to the condition of pipes, connections, flanges and valves;
- Leaks from pump packers;
- Leaks from blocked mixing hoppers;
- Loss of storage tank integrity; and
- Failure to align valves correctly during transfer to tanks.

Jet A1 fuel used for helicopter refuelling has been excluded from spill modelling and this assessment as only small volumes will be stored on the MODU (~6 m^3), and spills of this fuel evaporate quickly due to the very high levels of light ends.

8.5.2 Potential Environmental Risks

The known and potential environmental risks of the unplanned discharge of small volumes of drilling muds, chemicals and hydrocarbons are:

- Temporary and localised reduction of water quality; and
- Acute toxicity to marine fauna through ingestion or absorption.

8.5.3 EMBA

The EMBA for the risk of discharge of drilling muds, chemicals and fuel is likely to range from tens to hundreds of metres depending on the product and volume spilled, so a precise EMBA cannot be calculated.

Receptors most at risk within this EMBA are:

- Water quality;
- Plankton;
- Pelagic fish;
- Seabirds;
- Marine mammals; and
- Marine reptiles.

8.5.4 Evaluation of Environmental Risks

The impact of the discharge of drilling muds is addressed in Section 7.6.2. The impacts of a small unplanned discharge of drilling muds will not vary significantly from the EIA presented in Section 7.6.5.

The risks associated with the discharge of chemicals in drilling muds is addressed in Section 7.6.4. The risks of an unplanned discharge of chemicals will not vary significantly, though the increased release volume means it will take longer to dilute and disperse through the water column.

The risks associated with the discharge of MDO is addressed in Section 8.6.2. The risks of a discharge of aviation fuel will be less than that resulting from a vessel collision due to the much smaller volumes involved, so the extent of spread will be less, and the high volatility of aviation fuel means a greater proportion of fuel will evaporate much faster than MDO.

Flaring associated with well testing may be interrupted by pressure drops, incomplete combustion, or higher than anticipated drilling fluid content in the flaring system. Efficient combustion in the flame depends on achieving good mixing between the fuel gas and air and on the absence of liquids. Where liquids are present (i.e., formation fluids) and not completely 'knocked out' upstream of the flare boom, minor quantities (in the order of litres) of formation fluids may accidentally reach the ocean. Hydrocarbon volumes released due to drop out from flaring are difficult to estimate. Given the automatic and manual systems in place during flaring, the accidental release of hydrocarbon is expected to be low (less than 2 m^3) in the event of flare dropout. The risks from flaring of oil, gas or condensate are considered so minor that the OSPAR Commission concluded that there is no need to develop a background document (i.e., guideline) on the flaring of oil, gas or condensate (OSPAR, 2005).

Near the sea surface, fish are able to detect and avoid contact with surface slicks and as a result, fish mortalities rarely occur in open waters from surface spills (Volkman *et al*., 2004). This, combined with their high mobility (that allows them to avoid exposure to toxic components for long periods), means that pelagic fish are generally not susceptible to impacts from hydrocarbon spills (Volkman *et al*., 2004).

The WCP for seabirds (2020) identifies chronic pollution as an existing threat to seabirds. Chemical contamination has been described within the WCP as contributing to the decline of many seabirds by impairing their ability to reproduce successfully. Eggshell thinning, embryo viability and offspring deformities are noted as reproductive issues caused by chemical contamination (Commonwealth of Australia, 20202). The WCP also notes that organochlorines and heavy metals degrade very slowly in the environment and therefore, is retained by organisms, and passed throughout the food chain.

In general, the small potential release volumes mean that such releases would be confined to a small area around the drill site and result in rapid dilution in the open ocean environment, meaning that the risk of toxic effects to marine fauna are low. The low commercial fishing activity and absence of fish BIAs and sensitive habitats in the operational area means the risks to the biological and socio-economic environments are low.

8.5.5 Risk Assessment

Table 8.17 presents the impact assessment for the unplanned discharge of small volumes of drilling muds, chemicals and hydrocarbons.

Table 8.17. Risk assessment for the unplanned discharge of drilling muds, chemicals and hydrocarbons

Summary		
Summary of risks	Temporary and localised reduction of water quality and acute toxicity to marine fauna through ingestion or absorption of small volumes of drilling muds, chemicals and hydrocarbons.	
Extent of risks	Highly localised – small mixing zone around the MODU	
Duration of risks	Temporary and short-term (several minutes for small deck spills or longer for larger spill)	
Level of certainty of risks	HIGH – the impacts associated with drilling fluid, chemical and hydrocarbon spills at sea are well known and documented.	
Risk decision framework context	Decision type	A - good industry practice required.
	Activity	Nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
	Risk & uncertainty	Risks are well understood, uncertainty is minimal.
	Stakeholder influence	No conflict with company values, no partner interest, no significant media interest.
Defined acceptable level	No unplanned release of drilling muds, chemicals and hydrocarbons.	

Impact Consequence (inherent)			
Likelihood	Consequence		Risk rating
Occasional	Minor		Low
Assessment of Proposed Control Measures			
Control measure	Control type	Adopt	Justification
Pre-acceptance inspection of MODU **(RSK-05: EPS-01).**	Administrative	Yes	**EB:** Ensures the storage tanks, equipment and bunding are in good working condition prior to the activity commencing, thereby reducing the likelihood of drilling fluid, chemical and hydrocarbon spills. **C:** Negligible; it is a standard maritime requirement. Minor administrative cost to produce documents and educate personnel. **Ev:** Benefits outweighs the low costs.
Hydrocarbon and chemical storage and loading **(RSK-05: EPS-02, 03 & 04).**	Engineering	Yes	**EB:** Reduces the likelihood that hydrocarbon and chemical storage will be accidentally lost overboard. **C:** Negligible; it is a standard maritime requirement. Minor administrative cost to produce documents and educate personnel. **Ev:** Environmental benefit outweighs the negligible costs.
PTW system **(RSK-05: EPS-05)**.	Administrative	Yes	**EB:** Reduces the likelihood that hydrocarbon and chemical storage will be accidentally lost overboard by ensuring operations is undertaken via a PTW. **C:** Negligible; it is a standard maritime requirement. Minor administrative costs associated with maintaining the PTW. **Ev:** Environmental benefit outweighs the negligible costs.
PMS **(RSK-05: EPS-06)**.	Administrative	Yes	**EB:** The maintenance of MODU storage systems and associated fittings minimises the likelihood of chemical and hydrocarbon lost overboard. **C:** Negligible; it is a standard maritime requirement. Minor administrative costs associated with maintaining the PMS. **Ev:** Environmental benefit outweighs the negligible costs.
SMPEP **(RSK-05: EPS-07, 08, 10 & 11)**.	Administrative	Yes	**EB:** Ensures crew are well prepared to quickly respond to a spill, thereby minimising the volume spilled and the extent of sea affected. **C:** SMPEP should already be in place. Low costs to stock vessel with equipment and maintain it. This is standard maritime practice.

			Ev: Environmental benefit outweighs the low costs.
Well Test Plan **(RSK-05: EPS-09)**	Administrative Engineering	Yes	**EB:** Ensures well test crew follow set procedures, thereby minimising the likelihood of liquid dropouts. **C:** The preparation of a Well Test Plan is standard practice for well testing contractors, whereby the cost is factored into the contract and not an extra cost per se. **Ev:** Environmental benefits outweigh the low costs.

Environmental Controls and Performance Measurement		
EPO	EPS	Measurement criteria
A pre-acceptance inspection of the MODU takes place.	**(RSK-05: EPS-01)** EOG's pre-acceptance inspection of the MODU confirms that storage tanks, equipment, bunding and machinery spaces are free of defects.	MODU pre-acceptance inspection records verify good condition of all equipment.
Hydrocarbons and chemicals stored on the MODU are stored in a manner that prevents bulk release.	**(RSK-05: EPS-02)** All hydrocarbons and chemicals are stored within secure receptacles within bunded areas or dedicated chemical lockers that drain to bilge tanks.	Visual inspection verifies that hydrocarbons and chemicals are stored within secure receptacles within bunded areas or dedicated chemical lockers that drain to bilge tanks.
	(RSK-05: EPS-03) Where hydrocarbons and chemicals are stored within open draining decks, receptacles are stored on/in temporary bunds.	Visual inspection verifies that where hydrocarbons and chemicals are stored within open draining decks, receptacles are stored on/in temporary bunds.
Hydrocarbons and chemicals are transferred to and from the MODU in a manner that prevents bulk release.	**(RSK-05: EPS-04)** Bulk dry and liquid transfers are undertaken in accordance with the MODU procedures for bulk transfers and lifting to reduce the risk of an unintentional release to the sea. The procedure typically includes the following (which also links to checklists that need to be completed as part of the procedure): • Approval for the supply vessel involved in the bulk transfer operations to enter the PSZ. • Ensuring that no other vessels are within the PSZ during the transfer operations. • Reviewing work instructions prior to undertaking the	MODU bulk transfer/lifting procedure is available. Completed Job Safety Analysis, PTW and transfer checklists will be in place prior to the commencement of bulk transfers.

	transfer, including the issue of a Permit to Work (PTW) (if required). • Visual contact and proper communication will be maintained with the vessel performing the transfer to the MODU at all times. • Checks on wind direction, transfer volume, tank and line contents, tank sounding, hose type and condition, status of vent valves and valve alignments will be undertaken ahead of the transfer. • Personnel will remain at both ends of the transfer to monitor pressure, transfer volumes and so forth, and they will remain in radio contact with each other. • At completion of transfer, the volume of bulk material transferred will be recorded and all equipment and tools will be returned to a dedicated storage area.	
The operation of the dump valve/s for the mud tanks will be managed under a PTW system.	**(RSK-05: EPS-05)** The mud dump valve/s are locked, with the keys remaining secure in a key locker. A PTW will be required to unlock the dump valve/s, which involves an assessment by the OIM regarding the need for a specific operation.	Visual inspection of key locker and dump valve/s verify its integrity. Daily Fluids Report allow for material balance assessment to determine discharge volume of weighted brine. PTW records verify that a PTW was prepared prior to unlocking the dump valve/s.
Planned maintenance will be undertaken on all MODU storage systems (bunds, hoppers), hose fittings and so forth.	**(RSK-05: EPS-06)** Planned maintenance is undertaken to the PMS schedule.	PMS records verify that maintenance work (and repairs where necessary) is undertaken.
The MODU management and crew are well prepared to respond to deck spills.	**(RSK-05: EPS-07)** The MODU OIM ensures that crew undertake spill response drills every three months in accordance with the SMPEP and drills and exercises matrix.	Records show that relevant crew have conducted quarterly spill response drills.

	(RSK-05: EPS-08) In accordance with the SMPEP, oil spill response kits are available in relevant locations around the MODU, are fully stocked and are used in the event of hydrocarbon or chemical spills to deck.	Inspection/audit confirms that SMPEP kits are readily available on deck.
		Incident reports for MDO spills to deck record that the spill is cleaned up using SMPEP resources.
Release of oil and oily water during well testing is avoided.	**(RSK-05: EPS-09)** A Well Testing Plan will be in place and implemented so the following is achieved: • Separator tanks are installed upstream of the flare boom in order to remove liquids (formation water, completion fluids and/or oil) prior to flaring and thus reduce the chance of liquid dropouts.	Well test daily report verifies the presence of separator tanks.
	• A high-efficiency burner (e.g., 'Evergreen' burner) is installed on the flare boom to reduce the likelihood of liquid dropout.	Well test daily report verifies that a high-efficiency burner was in use during well testing.
	• Burner pilots remain ignited during the well test to minimise the likelihood of liquid dropouts.	Well test daily report verifies that burner pilot remained ignited during the well test.
	• Dedicated MODU deck crew are in place to watch for liquid dropouts, who then notify the Well Test Supervisor as soon as liquid dropout is observed so that the well test process can be quickly shut down and corrected before re-commencing.	Well test daily report includes details of flare watch for liquid dropouts.
	• Liquids stored in the separator tanks are treated through an oily water filtration system (to <30 ppm) prior to overboard discharge or shipped to shore for disposal.	Well test daily report verifies that discharged fluids were treated to <30 ppm or shipped to shore for disposal.
	• Oily water filtration equipment will be calibrated prior to use.	Calibration results verify that the system is calibrated to <30 ppm.
	• In the event of a flare drop-out or hydrocarbons being observed on the sea surface, then flaring (and if applicable, the well test), will cease and the event will be investigated and corrected before re-commencing.	Incident report of flare drop-out or unplanned hydrocarbon release.
Reporting		

A bulk spill of chemicals or hydrocarbons at surface will be promptly reported internally and externally, and appropriately managed.	**(RSK-05: EPS-10)** The MODU OIM will report a bulk spill to the DSV and lead the onboard response in line with the SMPEP.	Incident reports and logs confirm that internal notifications were made in a timely fashion.
A bulk spill of chemicals or hydrocarbons at surface will be promptly reported to external regulatory agencies.	**(RSK-05: EPS-11)** The Drilling Incident Management Team (DIMT) Incident Controller will report to AMSA and NOPSEMA within 2 hours of EOG becoming aware of the spill (see Section 9.7.2).	Incident reports and logs confirm that regulatory authorities were notified within 2 hours of EOG becoming aware of the spill.

Impact Consequence (residual)		
Likelihood	Consequence	Risk rating
Rare	Minor	Negligible

The risk of the unplanned discharge of bulk drilling muds, chemicals and hydrocarbons is assessed as negligible because:

- The volumes of chemicals and hydrocarbons on the MODU will be small;
- Helicopter refuelling is unlikely to take place on the MODU; and
- The control measures adopted significantly reduce the likelihood of an unplanned discharge of bulk drilling fluids, chemicals and hydrocarbons.

Demonstration of ALARP

A 'negligible' residual risk rating is considered to be ALARP and a 'lower order' risk. The adopted controls and associated EPS have lowered the risk to the point that any additional or alternative control measures either fail to lower the residual risk rating any further or are grossly disproportionate to the residual risk rating.

Demonstration of Acceptability

Policy compliance	EOG's Safety and Environmental Policy objectives are met through implementation of this EP.	
EMS compliance	Chapter 10 outlines the EP implementation strategy to be employed for this activity.	
Risk matrix standard compliance	The residual risk is negligible, which is considered acceptable.	
External context	No objections or claims have been raised by relevant persons regarding accidental discharge of drilling fluids, chemicals and hydrocarbons.	
Legislative context	The performance standards outlined in this EP align with the requirements of: • Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Cth): ○ Section 9 (Prohibition of discharge of oil or oily mixture to sea).	
Industry practice	The consideration and adoption of the controls outlined in the below-listed codes of practice and guidelines demonstrates that BPEM is being implemented for this activity.	
	Environmental management in the upstream oil and gas	As per the impact assessment table in Section 7.6 and Section 7.11.

	industry (IOGP-IPIECA, 2020)	
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	As per the impact assessment table in Section 7.6 and Section 7.11.
	Health, Safety and Environmental Case Guidelines for Mobile Offshore Drilling Units (IADC, 2015)	As per the impact assessment table in Section 7.6 and Section 7.11.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	As per the impact assessment table in Section 7.6 and Section 7.11.
	AEP CoEP (APPEA 2008)	As per the impact assessment table in Section 7.6 and Section 7.11.
Environmental context	MNES	
	AMPs	This hazard will not affect nearby AMPs.
	Ramsar wetlands	This hazard will not affect any Ramsar wetlands.
	TECs	This hazard will not affect any TECs.
	Nationally threatened and migratory species	This hazard is unlikely to have acute or chronic toxicity effects on threatened or migratory species.
	Other matters	
	KEFs	This hazard will not affect any KEFs.
	NIWs	This hazard will not affect any NIWs.
	State marine parks	This hazard will not affect any state marine parks.
	Species Conservation Advice/ Recovery Plans/ Threat Abatement Plans	The EPS outlined within this table assist in mitigating the threat of chemical pollution on seabirds identified by the WCP for seabirds (2020).
ESD principles	The EIA presented throughout this EP demonstrates that ESD principles (a), (b), (c) and (d) are met (noting that principle (e) is not relevant).	
Statement of acceptability	EOG considers the risk of unplanned small discharges of drilling fluids, chemicals and hydrocarbons to be acceptable because: • It will adhere to the company's Safety & Environmental Policy;	

	• The residual consequence rating is negligible; • An Implementation Strategy (described in Chapter 9) is in place to ensure the EPS are achieved. • Input from engagement with relevant persons has been considered and incorporated into the design of the activity; and • Relevant legislation and industry best practice will be complied with.
Environmental Monitoring	
• Not applicable.	
Record Keeping	
• Pre-acceptance MODU inspection records. • Inspection records. • Drill records. • Daily fluids reports.	• PMS records. • PTWs and Job safety analysis (JSAs). • Incident reports.

8.6 RISK 6 - Marine Diesel Oil Release

8.6.1 Hazard

A release of MDO may occur from the support vessels as a result of refuelling, a vessel-to-vessel collision or a support vessel colliding with the MODU legs. The waters of the activity area and its surrounds are deep and bathymetry mapping indicates there are no sub-surface features (such as reefs or shoals) that present a risk of vessel grounding (see Figure 5.9), so this risk has been discounted for this risk assessment.

Only the vessel-to-vessel collision scenario has been taken forward for Oil Spill Trajectory Modelling (OSTM). The other scenarios are dismissed as having negligible risks or as non-credible, as discussed herein.

MODU refuelling

MODU refuelling is a closely supervised activity on board a MODU with strict controls on the transfer of fuel from support vessels to the MODU. The fuel transfer hoses are supplied by the MODU and generally have a capacity of 47 m^3 (based on a re-fuelling hose 10 cm in diameter and 60 m long). The fuel transfer pump for jack-up MODUs is typically capable of supplying up to 33 m^3/hr.

AMSA's guidance (AMSA, 2015) of using the fuel transfer rate multiplied by 15 minutes of flow (for supervised operations) to estimate the volume of MDO for spill modelling significantly over-estimates how long it would take to shut down re-fuelling operations and it is more likely to be around 5 minutes maximum based on industry experience. Fifteen minutes of flow from the pumps represents a potential loss of 8.25 m^3 based on the maximum transfer pump rate. A spill of this volume in the operational area would rapidly evaporate and dilute with seawater, and would not reach shorelines, causing negligible environmental impacts (NOAA, 2006). Therefore, spill modelling for this scenario has not been undertaken.

Vessel collision with MODU

An errant vessel collision with the MODU is not a credible scenario for the loss of MDO from the MODU for the following reasons, and is therefore not modelled and assessed:

- A temporary PSZ will be gazetted around the MODU;

- One support vessel is present on location at all times to maintain guard and intercept any errant vessel;
- Jack-up MODU hulls are raised high above the water line (generally with an air gap of about 20 m), meaning that the tanks would not be pierced in the event of a collision with a large vessel; and
- The MDO tanks are located inboard and double-skinned (with mud, pre-load and potable tanks typically located on the outer edge of the hull), further ensuring that piercing of the MDO tanks (and fuel loss) is even more unlikely.

8.6.2 Potential Environmental Risks, EMBA and Evaluation of Environmental Risks

In line with OPGGS(E) Regulation 56 and Section 2.6 of NOPSEMA's *Environment Plan content requirement guidance note* (September 2020), EOG refers the reader to Sections 7.16.2, 7.16.3 and 7.16.4 of its PDSA EP (996161-2022-Beehive#1_PDSA-EP-Rev2, available here) that describes the environmental risks, EMBA and evaluation of environmental risks for an MDO spill. The volume chosen for that spill scenario took into account the typical fuel tank sizes on drilling support vessels (as well as vessels used to undertake geophysical and geotechnical investigations).

8.6.3 Risk Assessment

The risk assessment for an MDO release during the activity is provided in Table 8.19. The key difference with the PDSA activity is that refuelling of the MODU is likely to be required, so refuelling controls are included in this risk assessment.

Table 8.19. Risk assessment for an MDO spill

Summary				
Summary of risks	Temporary reduction in water quality. Potential toxicity impacts to marine life. Temporary fisheries closures.			
Extent of risks	EMBA is defined in Figure 7.10 to Figure 7.26 of the PDSA EP.			
Duration of risks	Short-term (several days, depending on level of contact, location and receptor).			
Level of certainty of risks	HIGH – the environmental impacts of spilled hydrocarbons are well understood.			
Risk decision framework context	Decision type	A - good industry practice required.		
	Activity	Nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.		
	Risk & uncertainty	Risks are well understood, uncertainty is minimal.		
	Stakeholder influence	No conflict with company values, no partner interest, no significant media interest.		
Defined acceptable level	No release of MDO to sea.			
Risk Assessment (inherent)				
Receptor		Consequence	Likelihood	Risk rating
Benthic fauna		Negligible	Rare	Negligible
Macroalgal communities		Negligible	Rare	Negligible

Plankton	Negligible	Rare	Negligible
Pelagic fish	Negligible	Rare	Negligible
Cetaceans	Negligible	Rare	Negligible
Marine reptiles	Minor	Rare	Negligible
Seabirds	Negligible	Rare	Negligible
Shorebirds	Negligible	Rare	Negligible
Sandy beaches	Negligible	Rare	Negligible
Rocky shores	Negligible	Rare	Negligible
Commercial fisheries	Negligible	Rare	Negligible

Assessment of Proposed Control Measures

Control measures listed in 'displacement of other marine users' (Impact 2, Section 7.2), 'Interference with other marine users' (Risk 4, Section 8.4) and 'Routine emissions – light' (Impact 3, Section 7.3) are not repeated here.

Only additional control measures are provided here.

Control measure	Control type	Adopt	Justification
No fuel bunkering	Elimination	No	**EB**: Avoids the potential for a spill. **C:** The MODU has a finite storage volume that must be topped up in order to continue functioning. Without refuelling, the activity cannot continue and the objectives of the campaign cannot be met. At-sea bunkering of MODUs is a routine industry activity. **Ev**: The negligible environmental risk posed by this hazard does not justify banning bunkering at sea. This measure cannot be adopted.
Support vessels refuel in port only **(RSK-06:EPS-01)**	Substitution	Yes	**EB**: Reduces the risk of an at-sea spill. **C:** No additional cost. Vessels return to port regularly throughout the activity and therefore have the ability to refuel outside the operational area. **Ev**: Environmental benefits can be achieved without additional cost.
MODU refuels in port only	Substitution	No	**EB**: Reduces the risk of an at-sea spill. **C:** significant additional cost (and air emissions) associated with towing the MODU back to port for each bunkering event. Increases the duration of the campaign. **Ev**: The negligible environmental risk posed by at-sea bunkering does not justify this very expensive control measure.
Refuelling procedure **(RSK-06:EPS-02)**	Engineering	Yes	**EB:** Reduces the risk of hydrocarbon release to the sea.

			C: The costs of installing and maintaining the equipment, systems and processes for refuelling on the MODU and support vessels is factored into day hire rates. Developing and implementing an refuelling procedure is routine industry practice. **Ev:** The benefits of having the procedure outweigh the costs.
SMPEP **(RSK-06:EPS-08)**	Administrative	Yes	**EB:** Ensures crew are well prepared to quickly respond to a spill, thereby minimising the volume spilled and the extent of sea affected. **C:** SMPEP should already be in place. Low costs to stock vessel with equipment and maintain it. This is standard maritime practice. **Ev:** Benefits outweighs the low costs.
OPEP **(RSK-06:EPS-03, -05, -06)**	Administrative	Yes	**EB:** Ensures EOG is well prepared to quickly respond to a spill, thereby minimising the extent of sea affected. **C:** Minimal cost to prepare OPEP and roll out training. This is standard industry practice. Significant costs for implementing response strategies and arranging call-off (standby) contracts for response resources. **Ev:** Environmental benefits outweigh the significant costs.
OSMP **(RSK-06:EPS-07)**	Administrative	Yes	**EB:** Ensures EOG is well prepared to quickly undertake operational and scientific studies, thereby supporting the future assessment of impacts resulting from the spill. **C:** High cost to prepare OSMP, detailed implementation plans and roll out training. This is standard industry practice. Low cost for putting call-off contracts in place and significant costs to implement the OSMP. **Ev:** Environmental benefits outweigh the significant costs.

Environmental Controls and Performance Measurement		
EPO	EPS	Measurement criteria
The EPS listed in 'displacement of other marine users' (Impact 2, Section 7.2), 'Interference with other marine users' (Risk 4, Section 8.4) and 'Routine emissions – light' (Impact 3, Section 7.3) also apply here. *Only additional controls are provided here.*		
Preparedness (additional preparedness EPS are provided in Appendix B of the OPEP)		
No MDO is spilled at sea.	**(RSK-06:EPS-01)** No support vessel refuelling is undertaken at sea (this will be done in port).	Bunker log verifies that support vessel refuelling was undertaken in port.

	(RSK-06:EPS-02) The MODU bunkering Procedure will be implemented in order to prevent an MDO spill. This will include (but is not limited to):	
	• A JSA and/or PTW is signed off for each bunkering event, taking into account spill response considerations.	JSA and/or PTW records verify that spill response was taken into consideration.
	• Ensuring that the dry-break refuelling hose couplings assembly is in order to minimise the risk of a spill and hose floats are installed on the refuelling hose so that a hose leak is easily visible.	Completed refuelling checklist verifies that dry-break hose couplings and floats are installed on the refuelling hose assembly.
	• Ensuring that communications (visual and/or radio) between the MODU and the vessel will be tested by the MODU Chief Mate and Vessel Master prior to the commencement of bunkering.	PTW indicates that communications were tested between the MODU and vessel.
	• Ensuring that fuel transfer hoses are replaced in accordance with the PMS or when they are visibly degraded.	Hose register and PMS indicates regular replacement of fuel hoses.
	• The bunkering operation is supervised at all times.	Completed bunkering checklist verifies that bunkering was supervised.
	• Ensuring that bunkering only commences during daylight hours and in calm sea conditions.	Completed bunkering checklist verifies that bunkering commenced in daylight hours and in calm sea conditions.
	• Ensuring that tank level indicators and level alarms are provided in the control room for the bunkering tanks.	Completed bunkering checklist verifies that the tank level alarms are functional.
Emergency response		
MODU and/or support vessel crews promptly respond to a spill.	**(RSK-06:EPS-03)** A Beehive-1 OPEP and ERP are in place and tested in a desktop exercise by nominated Drilling Incident Management Team (DIMT) members.	The OPEP and ERP are current.
		OPEP and ERP training schedule is available and remains live.
		The training matrix is maintained as a live document and verifies that DIMT members are up to date with their training.
		OPEP and ERP exercise reports verify that exercises have been undertaken.
	(RSK-06:EPS-04) The MODU OIM and/or Vessel Master will authorise actions in accordance with the SMPEP (or equivalent according to class).	Incident reports verify that the SMPEP was implemented.

	(RSK-06:EPS-05) The Beehive-1 OPEP is implemented to limit the release of a Level 2 or 3 MDO spill.	Daily operations reports verify that the OPEP was implemented.
Compensation		
Compensate for economic loss due to an MDO spill.	As per **IMP-02:EPS-04** and **IMP-02:EPS-05.**	As per **IMP-02:EPS-04** and **IMP-02:EPS-05.**
Recording & reporting		
EOG and regulatory authorities are promptly made of aware of near-misses and spills.	**(RSK-06:EPS-06)** EOG will report the MDO spill to regulatory authorities within 2 hours of the spill or becoming aware of the spill.	Incident report verifies that contact with regulatory agencies was made within 2 hours.
Monitoring		
Characterise environmental impacts of a Level 2 or 3 spill.	**(RSK-06:EPS-07)** EOG will undertake operational and scientific monitoring in accordance with the OSMP.	Daily operations reports and overall study reports verify that the OSMP was implemented.

Risk Assessment (residual)			
Receptor	Consequence	Likelihood	Risk rating
Benthic fauna	Negligible	Remote	Negligible
Macroalgal communities	Moderate	Remote	Negligible
Plankton	Moderate	Remote	Negligible
Pelagic fish	Moderate	Remote	Negligible
Cetaceans	Moderate	Remote	Negligible
Marine reptiles	Moderate	Remote	Negligible
Seabirds	Moderate	Remote	Negligible
Shorebirds	Moderate	Remote	Negligible
Sandy beaches	Moderate	Remote	Negligible
Commercial fisheries	Moderate	Remote	Negligible

The risk of an unplanned MDO release is assessed as negligible for all receptors because:

- The control measures adopted are effective at reducing the likelihood of an unplanned MDO release to remote.

Demonstration of ALARP

A ‘negligible’ residual risk rating is considered to be ALARP and a ‘lower order’ impact. The adopted controls and associated EPS have lowered the risk to the point that any additional or alternative control measures either fail to lower the residual risk rating any further or are grossly disproportionate to the residual risk rating.

Demonstration of Acceptability

Policy compliance	EOG's Safety and Environmental Policy objectives are met.	
EMS compliance	Chapter 8 outlines the EP implementation strategy to be employed for this activity.	
Risk matrix standard compliance	The residual risk for each receptor is negligible, which is considered acceptable.	
Engagement	No concerns have been raised with regards to MDO spills for this activity.	

Legislative context	The EPS align with the requirements of:
	• *Navigation Act* 2012 (Cth):
	  ○ Chapter 4 (Prevention of Pollution).
	• OPGGS Act 2006 (Cth):
	  ○ Section 572A-F (Polluter pays for escape of petroleum).
	• OPGGS(E):
	  ○ Part 5 (Incidents, reports and records).
	• *Protection of the Sea (Prevention of Pollution by Ships) Act* 1983 (Cth):
	  ○ Section 11A (SOPEP).	

Industry practice	The consideration and alignment of EPS with the mitigation measures in the below-listed codes of practice and guidelines demonstrates that BPEM will be implemented in this activity	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS developed for this activity are in line with the management measures listed for spills from vessels in Section 4.7.2 of the guidelines: • Vessels having a SMPEP. • Vessels having radar fitted and maintaining appropriate lighting and navigation systems • Having safety exclusion zones around facilities.
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	No guidance is provided regarding preventing or managing an offshore MDO spill, other than having a spill contingency plan in place. An OPEP is in place for the Beehive-1 PDSA.
	Effective planning strategies for managing environmental risk associated with geophysical and other imaging surveys (Nowacek & Southall, 2016)	The four practices outlined in this document have been considered (and adopted where practicable) in the development of performance standards for this EP and the survey design in general.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development	Guidelines met with regard to: • Section 75 (Spills): Conducting a spill risk assessment, implementing personnel training and field exercises, ensuring spill response equipment is available **(OPEP)**.

	(World Bank Group, 2015)	• Sections 76-79 (Spill response planning): A spill response plan should be prepared **(OPEP)**.
	Environmental Manual for Worldwide Geophysical Operations (IAGC, 2013)	Guidelines met with regard to: • Section 8.6 (Hazardous materials): Ensuring that vessels carry a SMPEP, that spills are reported to local authorities and that oil spill response drills are conducted at regular intervals **(OPEP)**. • Section 8.8 (Vessel operations): Vessels must have oil absorbent materials available to respond to spills, and oil spills must be reported to local authorities **(OPEP)**.
	AEP CoEP (APPEA 2008)	The EPS for this activity meet the code's following objectives for offshore geophysical surveys: • To reduce the risk of any unplanned release of material into the marine environment to ALARP and an acceptable level.
Environmental context	MNES	
	AMPs	The MDO EMBA intersects the JBG AMP. The AMP has the following relevant conservation value: - Carbonate banks and shoals. As addressed in Table 7.54 to Table 7.63, the consequence of an MDO spill on these conservation values is negligible and unlikely to result in long-term ecological impacts.
	Ramsar wetlands	There are no Ramsar wetlands intersected by the spill EMBA.
	TECs	There are no TECs identified in the spill EMBA.
	Nationally threatened and migratory species	Some nationally threatened species and migratory species have the potential to be present in the MDO spill EMBA, however as evaluated in the previous tables in this section, the consequence to individuals or populations of threatened and migratory species are considered negligible.
	Other matters	
	KEFs	The MDO EMBA intersects the Carbonate bank and terrace system of the Sahul Shelf KEF. The conservation values of this KEF are related to its benthic environment (diverse corals, sponges and demersal fish), and as such are unlikely to be affected by MDO because MDO is unlikely to occur at anything other than low thresholds near the seabed.

	NIWs	There are no NIWs that are intersected by the activity area or the spill EMBA.
	State marine parks	The MDO EMBA intersects the North Kimberley MP, which has the following environmental values: • River estuaries; • Turtle nesting beaches; • Fringing reefs; • Seabird and shorebird breeding sites; • Marine mammal foraging habitat; • Presence of pelagic finfish; and • Mangrove and intertidal mudflats. Given that these values and sensitivities will not be exposed to hydrocarbon concentration that are likely to cause ecological impact, it is anticipated that the impact to these values will be negligible.
	Species Conservation Advice / Recovery Plans / Threat Abatement Plans	Marine pollution is a threat identified for the Australian lesser noddy, Abbott's booby, red knot, curlew sandpiper, great knot, greater sand plover, lessor sand plover, Nunivak bar-tailed godwit, Northern Siberian bar-tailed godwit and eastern curlew. In general, population monitoring is the suggested action to deal with marine pollution. Table 7.60 outlines the potential risks of an MDO spill to these species. The conservation advice and management plans for blue, humpback, sei and fin whales identify hydrocarbon spill as threats, though there are no specific aims to address this. Table 7.58 outlines the potential risks of an MDO spill to these species. The WCP for seabirds (2020) identifies acute pollution (oil spills) as a moderate threat to seabirds. The EPS outlined within this table mitigate the chance of an oil spill, and therefore, reduce the probability of acute pollution impacts on seabirds.
ESD principles	The EIA presented throughout this EP demonstrates that ESD principles (a), (b), (c) and (d) are met (noting that principle (e) is not relevant).	
Statement of acceptability	EOG considers the risk of an MDO release to be acceptable because: • It will adhere to the company's Safety & Environmental Policy; • The residual risk ratings are negligible; • An Implementation Strategy (described in Chapter 8) is in place to ensure the EPS are achieved. • Input from engagement with relevant persons has been considered and incorporated into the design of the survey; • Relevant legislation and industry best practice will be complied with; • An MDO release will not have long-term or significant impacts on MNES; • The management of an MDO release is not inconsistent with the aims of recovery plans/conservation plans/advice that are in force for EPBC Act-listed threatened and migratory species;	

	• The management of an MDO release is not inconsistent with the aims of relevant marine reserve management plans; and • The management of an MDO release is not inconsistent with ESD principles.
Environmental Monitoring	
• As per the OPEP and OSMP.	
Record Keeping	
• Vessel assurance reports. • Notices to Mariners. • Stakeholder consultation records. • SMPEPs. • OPEP. • ERP.	• Crew training records. • Bunkering procedure. • Bunkering PTWs, JSAs, inspection checklists. • Oil spill response exercise records. • Inspection/audit reports. • Incident reports.

8.7 RISK 7 – Loss of Well Control and Major Oil Spill

8.7.1 Hazard

A LoWC may occur in the highly unlikely event of all barriers on the well failing, which could result in a large-scale oil spill. As outlined in Section 2.10, the most credible worst-case release of light crude oil (using Jabiru crude as an analogue) is for an average daily release of 10,219 m^3 over 77 days (the maximum time required to source a MODU, drill a relief well and kill the well). This would result in a maximum worst-case spill volume of approximately 786,794 m^3.

Based on data from the Gulf of Mexico, UK and Norway from 1980-2004, it was estimated that for wells with a BOP installed, including shear rams and following the two-barrier principle, the frequency of a blowout was 3.1 x 10^{-4} (0.00031, or 0.031%) per exploration well drilled (OGP, 2010 in DNV, 2011).

In this section, the risk assessment is based on a worst-case scenario assuming that the flow of oil has not stopped until day 77 and in the absence of spill response measures. Oil spill response actions that would reduce the impact in the event of a spill are discussed in Section 8.8.

8.7.2 Potential Environmental Risks

The known and potential risks of a LoWC are:

- A temporary to long-term and widespread reduction in water quality;
- Injury or death of exposed marine fauna and seabirds;
- Habitat damage, especially where the spill reaches shorelines; and
- Changes to the functions, interests or activities of other users (e.g., commercial fisheries).

8.7.3 EMBA

The outer boundary of the environment that may be affected (EMBA) by a LoWC event during the Beehive-1 drilling activity was determined using the combined stochastic results of oil spill

trajectory modelling (OSTM) (RPS, 2022b) from 100 simulations per season (summer, winter, transitional) and applying the following thresholds:

- 1 g/m^2 floating oil thickness, which is considered to be below levels which would cause environmental harm and is more indicative of the areas perceived to be affected due to its visibility on the sea-surface
- 10 g/m^2 for accumulated (shoreline) oil, which represents the area visibly contacted by the spill
- 10 ppb for dissolved hydrocarbons corresponds generally with potential for exceedance of water quality triggers
- 10 ppb entrained hydrocarbons represents the low exposure zone and corresponds generally with potential for exceedance of water quality triggers.

The EMBA for a LoWC (sea surface, shoreline, entrained and dissolved hydrocarbons) is illustrated in Figure 8.4 to Figure 8.19. Receptors most at risk within this EMBA are those within the water column, whether resident or migratory, are:

- Water quality;
- Seabed sediments;
- Plankton;
- Invertebrates;
- Fish;
- Marine mammals;
- Marine reptiles;
- Seabirds and shorebirds;
- Shoreline habitats (sandy beaches, mangroves, tidal flats, mud flats, rocky shores);
- Values of protected areas; and
- Socio-economic values (e.g., commercial fisheries).

8.7.4 Oil Spill Trajectory Modelling

To understand the risks posed by a LoWC, EOG commissioned RPS to undertake OSTM for a worst-case spill of 786,858 m^3 over 77 days (RPS, 2022b). The spill was tracked for 98 days for each of the three distinct seasons in the region:

- Summer – October to February;
- Transitional – March and September; and
- Winter – April to August.

The adopted exposure values are based primarily on the exposure values defined in NOPSEMA *Bulletin #1 Oil Spill Modelling* (April 2019), as listed in Table 5.2 of Chapter 5. Exposure values applied for surface, entrained, dissolved and shoreline accumulated hydrocarbons used in the modelling study are summarised in Table 8.21.

Stochastic modelling overlays the results of each of the 100 simulations per season to give the widest possible area that may be affected by a spill. This is used to determine the EMBA and

support risk assessments. It should be noted that no individual spill would cover the entire EMBA. For response planning purposes, the worst-case deterministic results of the modelling are used. The deterministic results are selected from the individual simulations which show the maximum volume of oil ashore and maximum length of shoreline affected.

The modelling included scenarios with and without the application of dispersants. The modelling showed that dispersant application decreased oil loads on shorelines and on the sea surface (see Appendix 13). As such, the maximum extent of the EMBA is based on a worst-case LoWC without dispersant use. The risk assessment presented in this section does include potential impacts from dispersant use, where applicable.

The OSTM report is provided in **Appendix 13.**

Modelling inputs

The modelling was undertaken using the crude oil properties outlined in Table 2.3. The boiling point ranges for the Jabiru analogue oil are presented in Table 8.19, and Table 8.20 presents the key physical properties of the oil.

Table 8.19. Boiling points and persistence of Jabiru crude

	Volatiles	Semi-volatiles	Low Volatiles	Residual Oil
Boiling Point (°C)	< 180	180-160	160-380	> 380
Carbon range	C_4 to C_{10}	C_{11} to C_{15}	C_{16} to C_{20}	>C_{20}
Jabiru crude	24.2%	20.9%	33.9%	21.0%
Evaporation times	Up to 12 hrs	Up to 24 hrs	Several days	Slow
Persistence	Non-persistent			Persistent

Table 8.20. Key physical characteristics of Jabiru crude

Characteristic	Details
Density (kg/m^3)	813.9 at 15°C
API	42.3
Dynamic viscosity (cP)	3.0 at 20°C
Pour point (°C)	18
Oil property category	Group II
Oil persistence classification	Light persistent oil

Modelling of the fate of oil was performed using the Spill Impact Mapping Analysis Program (SIMAP). SIMAP is designed to simulate the fate and effects of spilled hydrocarbons for both the surface and subsurface releases and has been used to predict the weathering and fate of oil spills during and after major incidents including Montara (Australia), Macondo (USA) Bohai Bay (China) oil spill and the pipeline oil spill July 2013 in the Gulf of Thailand. The SIMAP model calculates the transport, spreading, entrainment, evaporation and decay of surface hydrocarbon slicks as well as the entrained and dissolved oil components in the water column, whether spilled at surface or discharged subsea.

The movement and weathering of the spilled oil is calculated for specific oil types. Input specifications for oil mixtures include the density, viscosity, pour point, distillation curve (volume lost versus temperature) and the aromatic/aliphatic component ratios within given boiling point ranges.

SIMAP is a three-dimensional model that allows for various response actions to be modelled including oil removal from skimming, burning, or collection booms, and surface and subsurface dispersant application. The SIMAP oil spill model includes advanced weathering algorithms, specifically focused on unique oils that tend to form emulsions and/or tar balls. The weathering algorithms are based on five years of extensive research conducted in response to the Deepwater Horizon oil spill in the Gulf of Mexico.

Biodegradation is included in the oil spill model. In SIMAP, degradation is calculated for the surface slick, deposited oil on the shore, the entrained oil and dissolved constituents in the water column, and oil in the sediments. For surface oil, water column oil and sedimented oil, a first order degradation rate is specified. Biodegradation rates are relatively high for hydrocarbons in dissolved state or in dispersed small droplets.

Table 8.21 outlines the key OSTM inputs.

Table 8.21. Summary of the OSTM inputs

Parameter	Details
Oil Type	Jabiru crude
Total spill volume	4,949,192 bbl (~786,858 m^3)
Release rate	Average of 64,275 bbl (10,219 m^3) per day
Release type	Sea surface
Release duration	77 days
Simulation duration	98 days
Number of simulations	100 per season (300 in total)
Surface oil concentration thresholds (g/m^2)	1 g/m^2 – low exposure 10 g/m^2 – moderate exposure 50 g/m^2 – high exposure
Shoreline load threshold (g/m^2)	10 g/m^2 – low exposure 100 g/m^2 – moderate exposure 1,000 g/m^2 – high exposure
Dissolved aromatic dosages to assess potential exposure (ppb)	10 ppb – low exposure 50 ppb – moderate exposure 400 ppb – high exposure
Entrained oil dosages to assess potential exposure (ppb)	10 ppb – low exposure 100 ppb – high exposure

Weathering

RPS conducted a series of model weather tests to illustrate the potential behaviour of the Jabiru crude oil when exposed to idealised and representative environmental conditions:

- A 1-hour release onto the water surface at a discharge rate of 25 m^3/hr under calm wind conditions (constant 5 knots), assuming low seasonal water temperature (25°C) and average air temperature (29°C). The slick was also subject to ambient tidal and drift currents.
- A 1-hour release onto the water surface at a discharge rate of 50 m^3/hr under variable wind conditions (1-12 knots), assuming low seasonal water temperature (25°C) and average air temperature (29°C). The slick was also subject to ambient tidal and drift currents.

The first case is indicative of cumulative weathering rates under calm conditions that would not generate entrainment, while the second case may represent conditions that could cause a minor degree of entrainment. Both scenarios provide examples of potential behaviour during periods of a spill event once the oil reaches the surface.

The mass balance forecast for the constant-wind case (Figure 8.2) shows that 45.3% of the oil is predicted to evaporate within 24 hours. Under calm conditions, the majority of the remaining oil on the water surface will weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation of the residual compounds will slow significantly, and they will then be subject to more gradual decay through biological and photochemical processes.

Under the variable-wind case (Figure 8.3), where the winds are of greater strength on average, entrainment of the crude oil into the water column is predicted to increase. Approximately 24 hours after the spill, 54.1% of the oil mass is forecast to have entrained and a further 42.8% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<1%). The residual compounds will tend to remain entrained beneath the surface under conditions that generate wind waves (approximately >6 m/s).The increased level of entrainment in the variable-wind case will result in a higher percentage of biological and photochemical degradation, where the decay of the floating slicks and oil droplets in the water column occurs at an approximate rate of ~1.3% per day with an accumulated total of ~9.1% after 7 days, in comparison to a rate of ~0.3% per day and an accumulated total of ~2.4% after 7 days in the constant-wind case.

Table 8.22 summarises the mass balance for the calm wind and variable wind case at day 7. Given the proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay over several weeks.

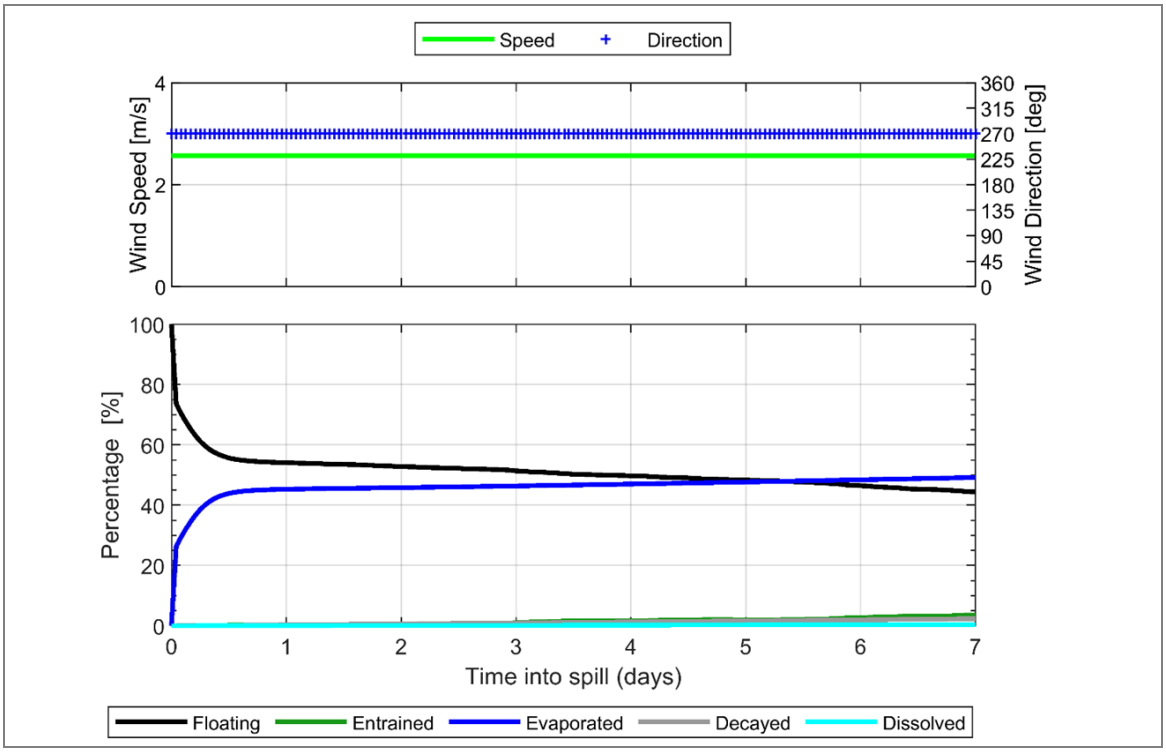


Figure 8.2. Proportional mass balance plot representing the weathering of crude oil spilled onto the water surface over 1 hour and subject to a constant 5 knots (2.6 m/s) wind speed at 25°C water temperature and 29°C air temperature

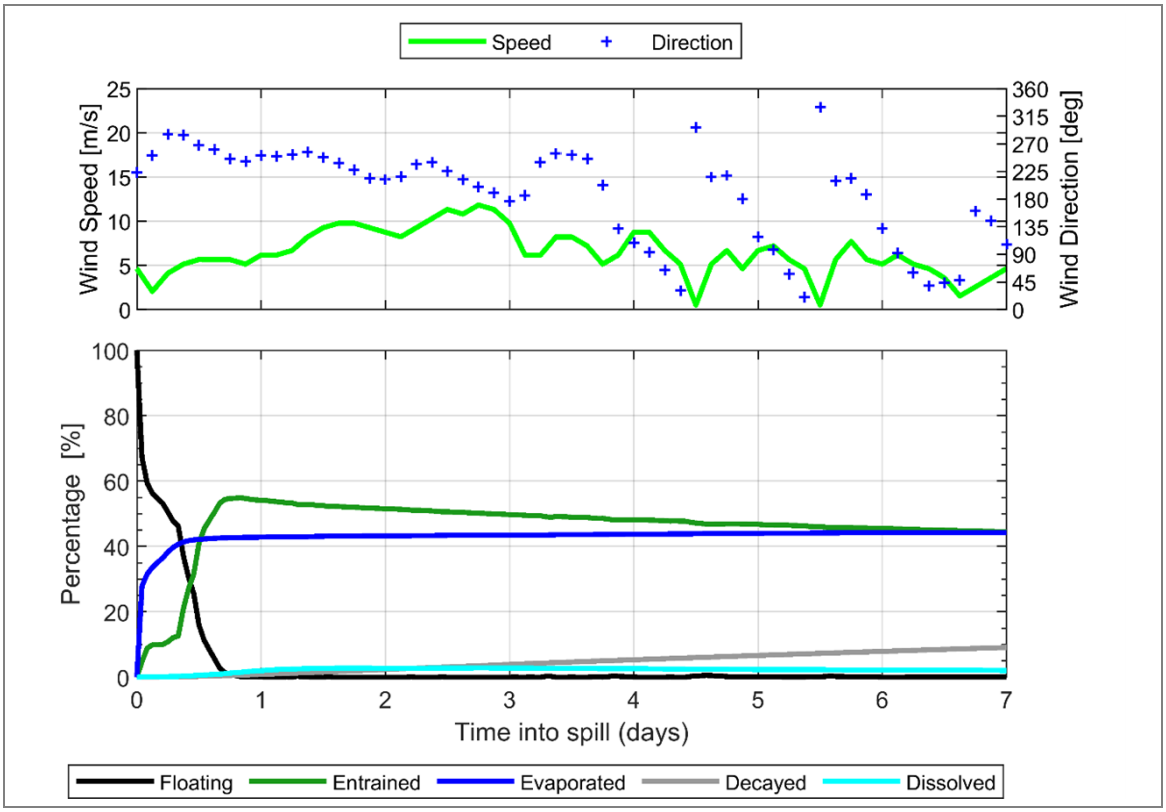


Figure 8.3. Proportional mass balance plot representing the weathering of crude oil spilled onto the water surface over 1 hour and subject to variable wind speeds (1-12 knots) at 25°C water temperature and 29°C air temperature

Table 8.22. Summary of the mass balance at day 7

Exposure metric	Calm wind conditions	Variable wind conditions
Surface/floating oil (%)	44.4	0
Shoreline (%)	0	0
Entrained (%)	3.6	44.5
Evaporated (%)	49.2	44.2
Decay (%)	2.4	9.1

Results are based on a 25 m^3 surface release of crude oil over 1 hour, tracked for 7 days.

Exposure thresholds

The outputs of the OSTM are used to assess the environmental risk if a credible hydrocarbon spill scenario occurred, by defining which areas of the marine environment could be exposed to hydrocarbon concentrations that exceed exposure values that may result in impact to sensitive receptors.

The degree of impact will depend on the sensitivity of the biota contacted, the duration of the exposure and the toxicity of the hydrocarbon mixture making the contact. The toxicity of a hydrocarbon will change over time, due to weathering processes altering the composition of the hydrocarbon.

The OSTM considered four key physical or chemical phases of hydrocarbons that pose differing environmental and socio-economic risks:

- Surface hydrocarbons;
- Entrained hydrocarbons;
- Dissolved hydrocarbons; and
- Shoreline accumulated hydrocarbons.

The modelling used defined hydrocarbon exposure values (see Table 8.21), as relevant for risk assessment and oil spill planning, for the various hydrocarbon phases. To ensure conservatism in the environmental assessment process, the exposure values applied to the model are selected to adopt the most sensitive receptors that may be exposed, the longest likely exposure times and the more toxic hydrocarbons.

Modelling Results

This section presents the stochastic OSTM results. These are presented for the different hydrocarbon phases (surface, entrained, dissolved and shoreline) for each of the three modelling seasons (summer, winter and transition).

The results are calculated based on 100 simulations per season of a volume of 786,858 m^3 over 77 days and tracked for 98 days. Section 10.1 of Appendix 13 presents the detailed tabulated results of the stochastic analysis, with the associated maps presented here:

- Surface/floating oil – Figures 8.4, 8.5 and 8.6, and zones of floating oil for the deterministic trajectory with the largest swept area above 1 g/m^2 in Figure 8.7;

- Shoreline oil - Figures 8.8, 8.9 and 8.10, and the deterministic trajectory with the largest volume of oil ashore in Figure 8.11;
- Dissolved hydrocarbons (0-10 m below the sea surface) – Figures 8.12, 8.13 and 8.14, and the deterministic trajectory with the largest area of dissolved hydrocarbons above 10 ppb in Figure 8.15; and
- Entrained hydrocarbons (0-10 m below the sea surface) – Figures 8.16, 8.17 and 8.18, and the deterministic trajectory with the largest area of entrained hydrocarbons above 10 ppb in Figure 8.19.

Note that the stochastic results shown in the following figures represent the cumulative results of 100 individual spill scenarios, not the result of an individual spill.

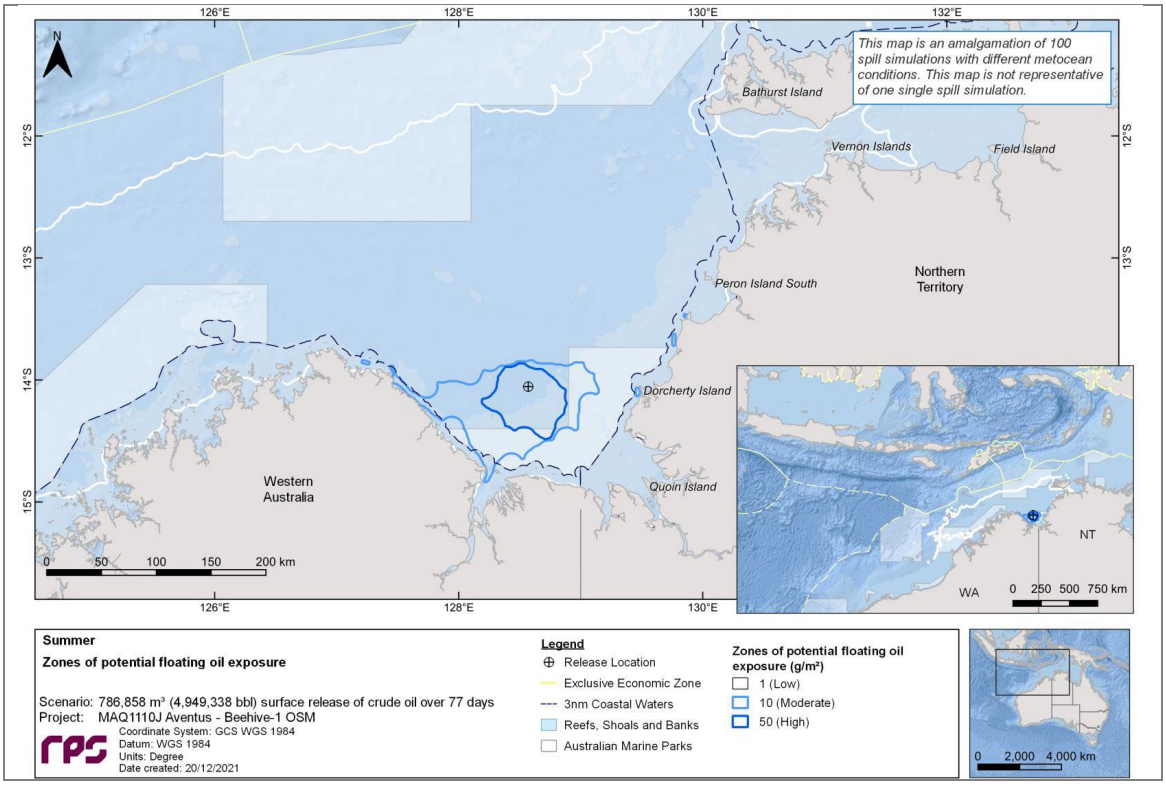


Figure 8.4. Zones of potential floating oil exposure during summer conditions

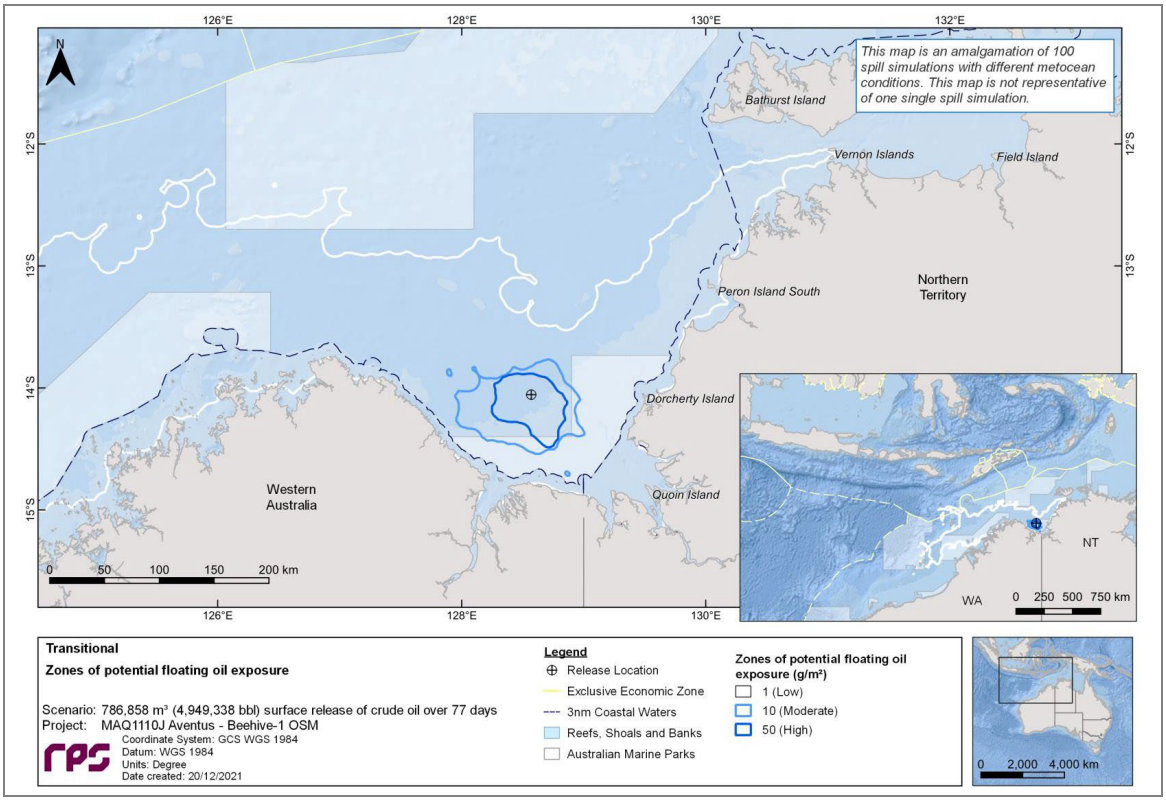


Figure 8.5. Zones of potential floating oil exposure during transitional conditions

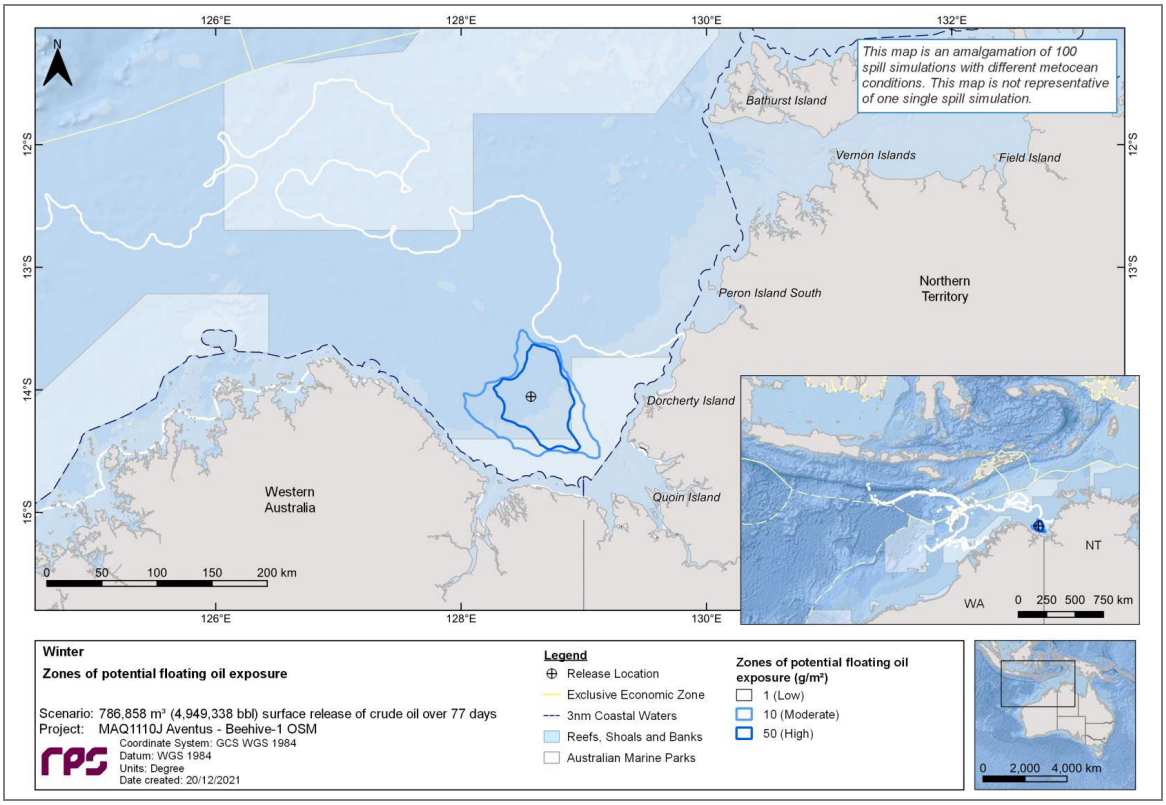


Figure 8.6. Zones of potential floating oil exposure during winter conditions

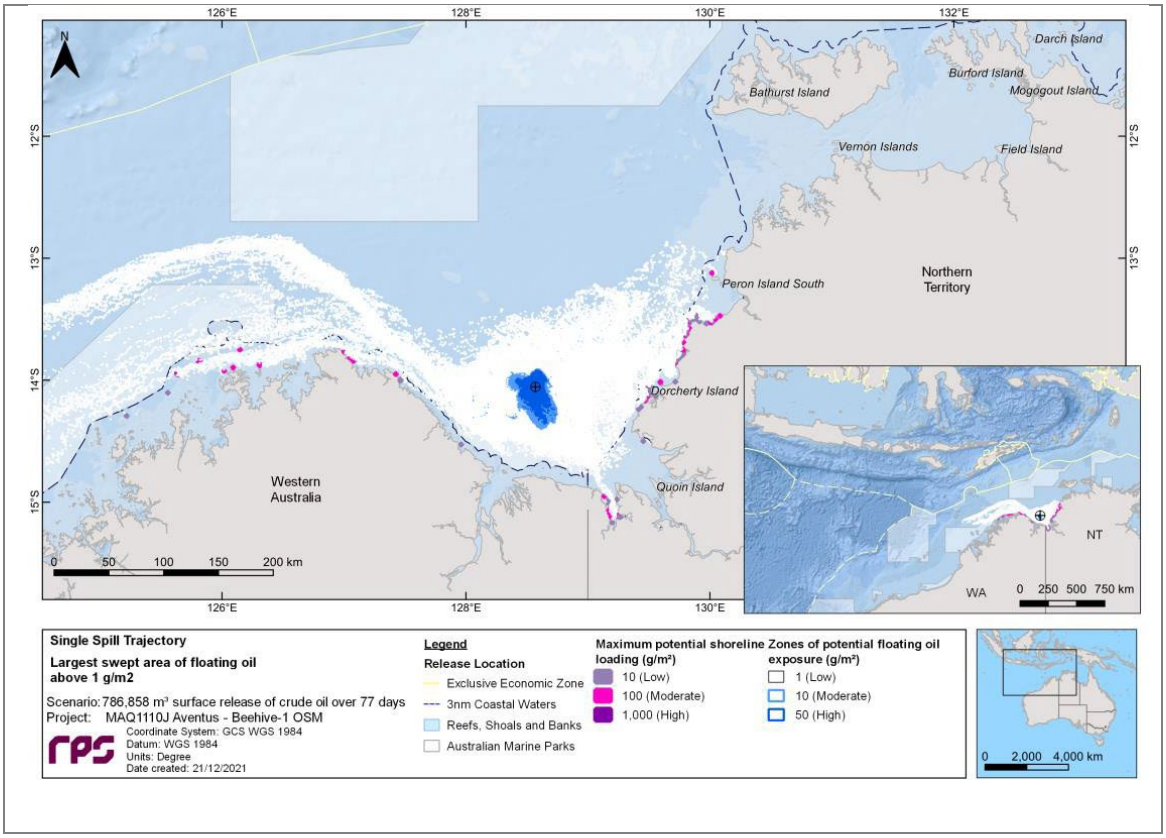


Figure 8.7. Zones of potential floating oil exposure and shoreline accumulation, for the trajectory with the largest swept area of floating oil above 1 g/m²

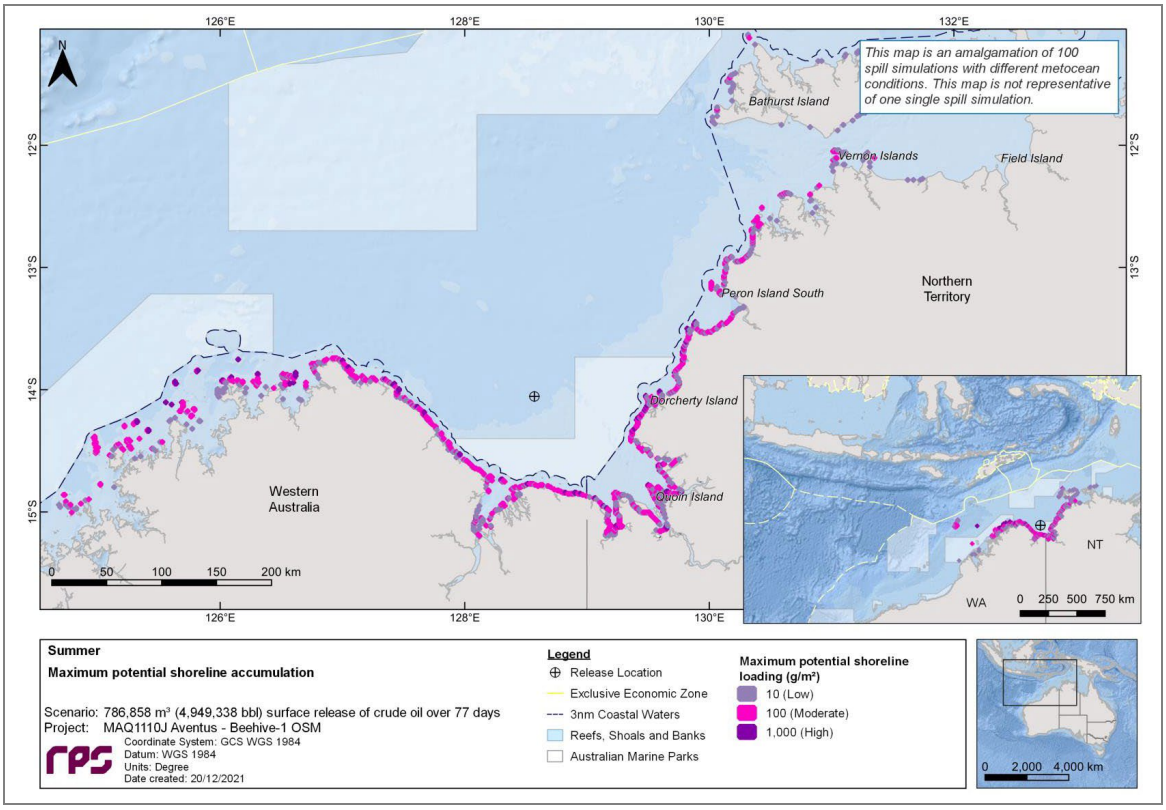


Figure 8.8. Maximum potential shoreline loading during summer conditions

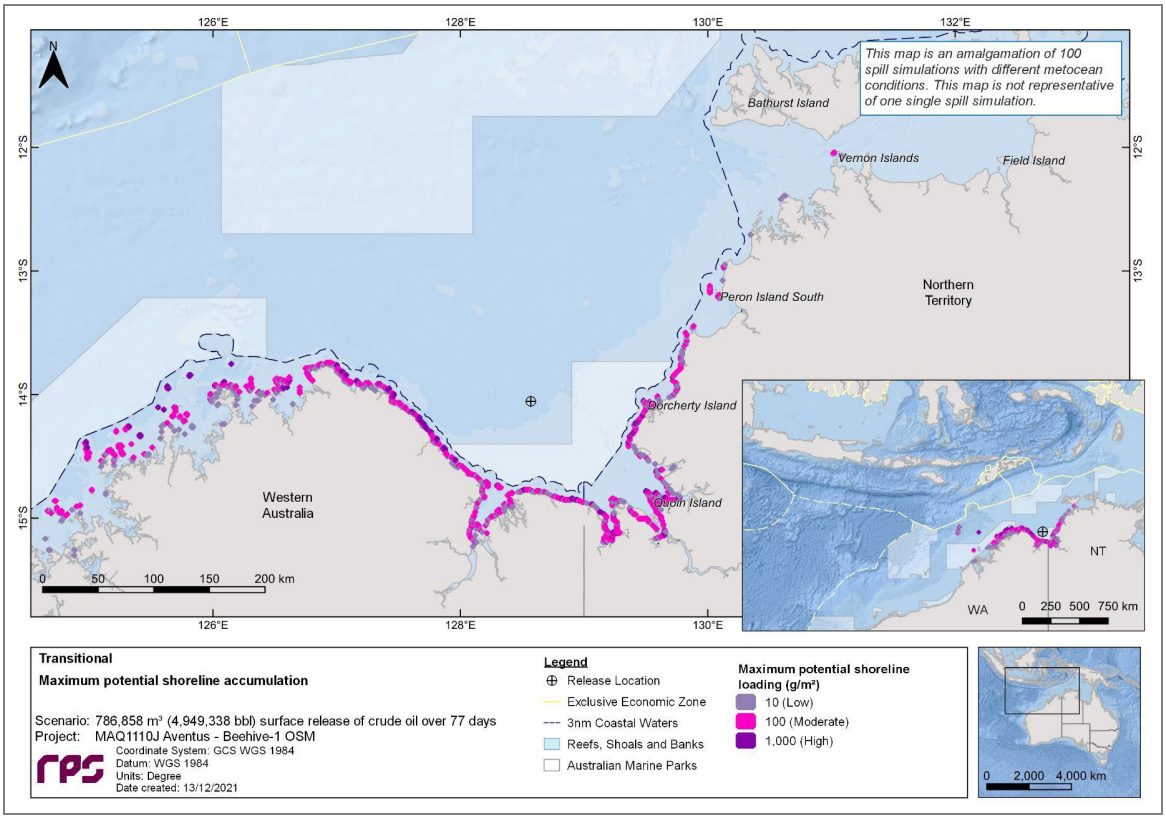


Figure 8.9. Maximum potential shoreline loading during transitional conditions

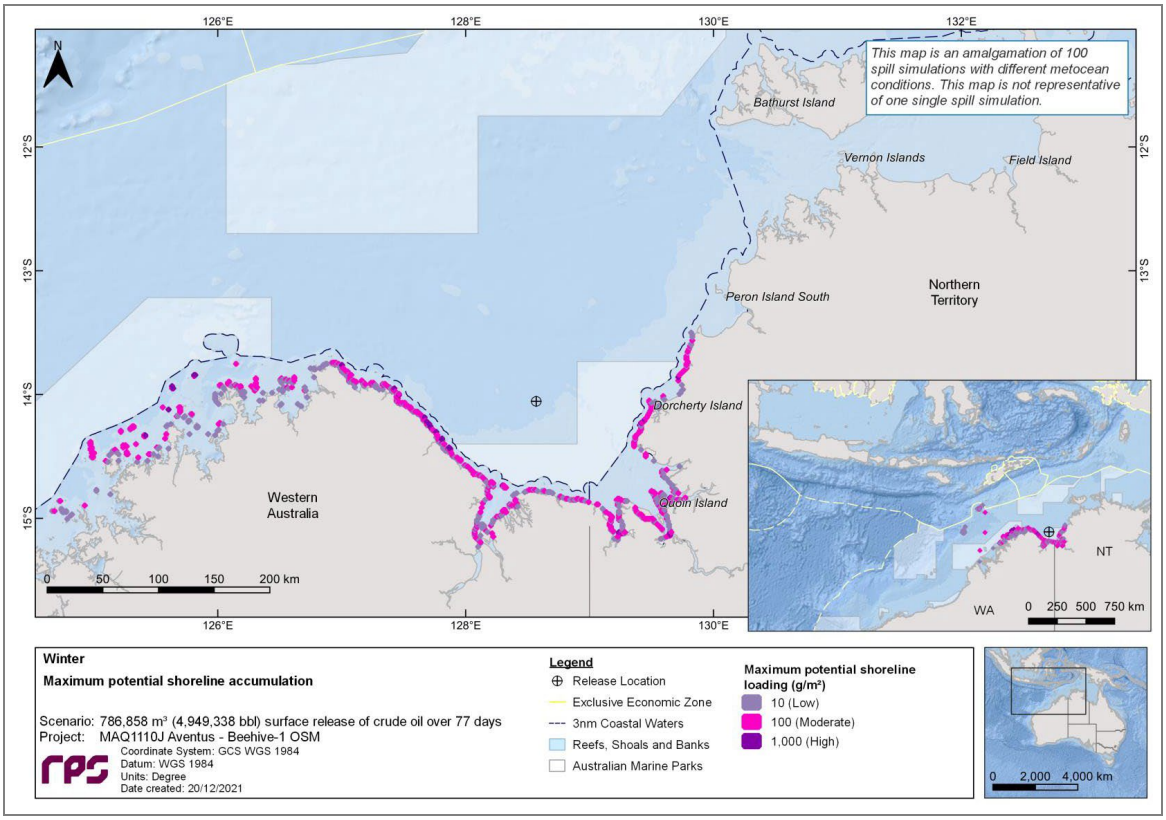


Figure 8.10. Maximum potential shoreline loading during winter conditions

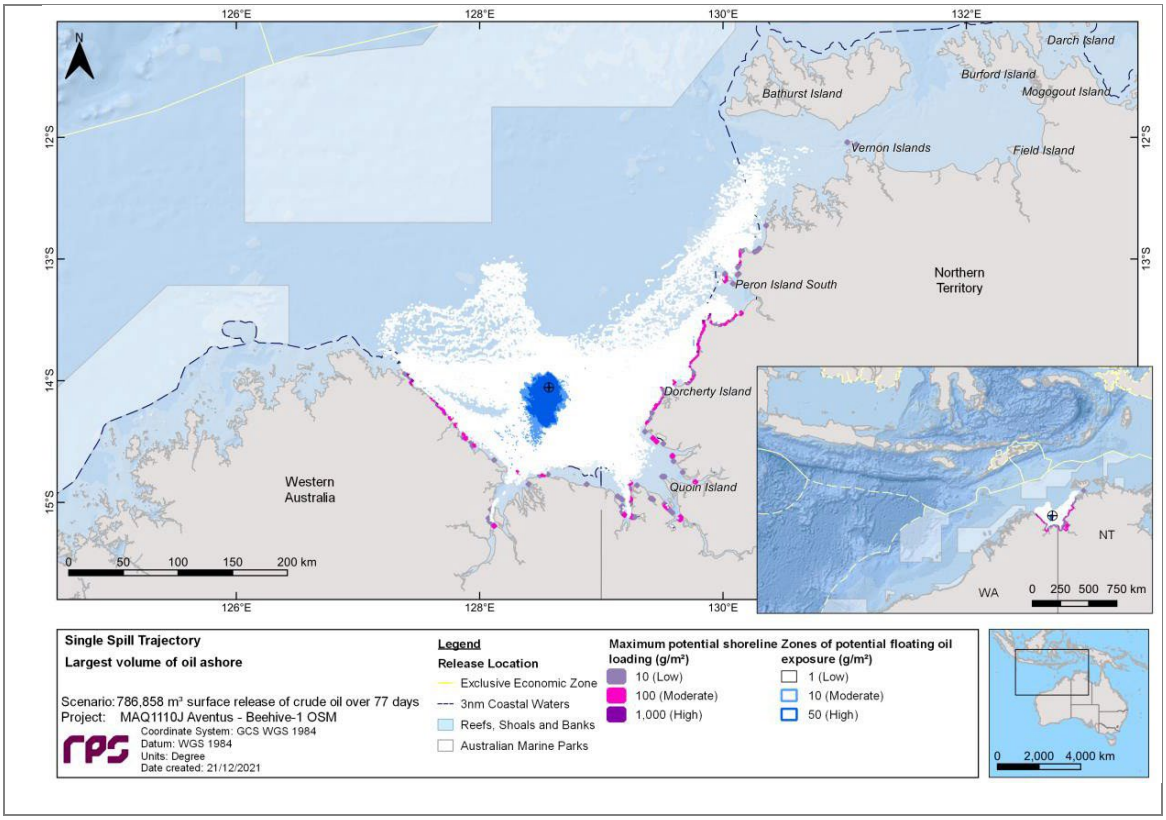


Figure 8.11. Zones of potential floating oil exposure and shoreline accumulation, for the trajectory with the largest volume of oil ashore

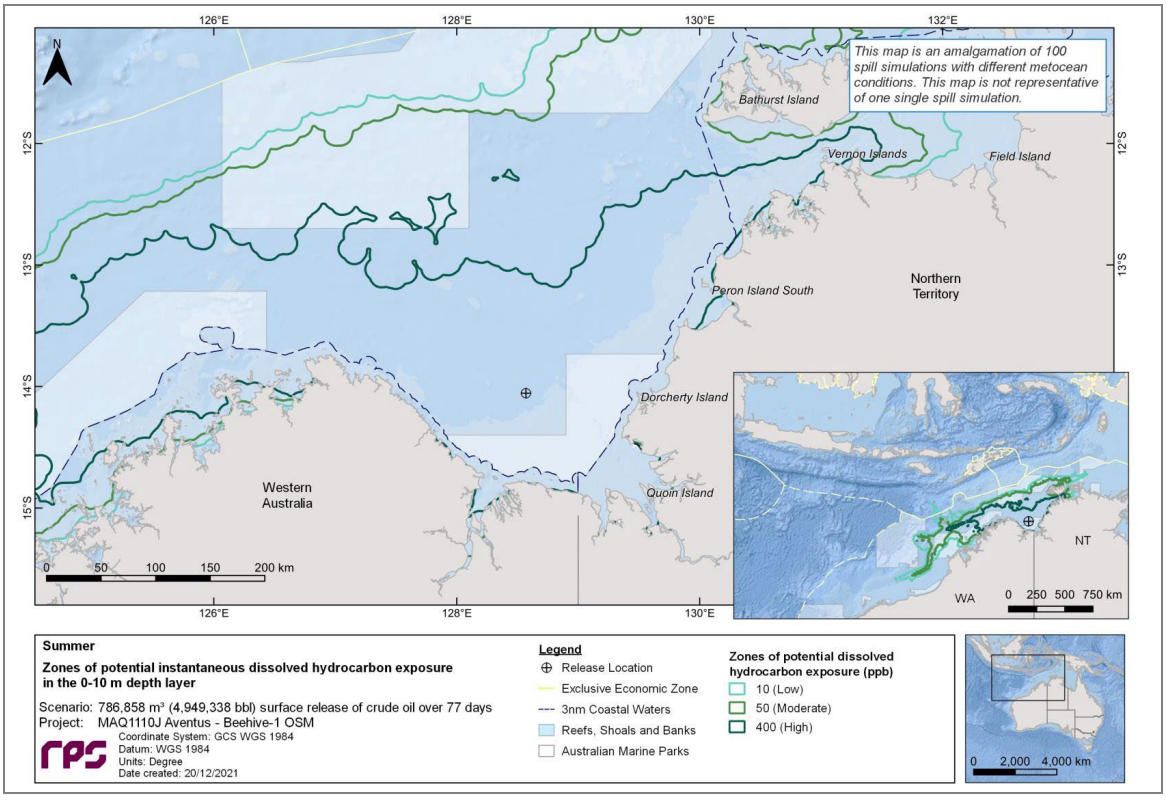


Figure 8.12. Zones of potential dissolved hydrocarbon exposure during summer conditions

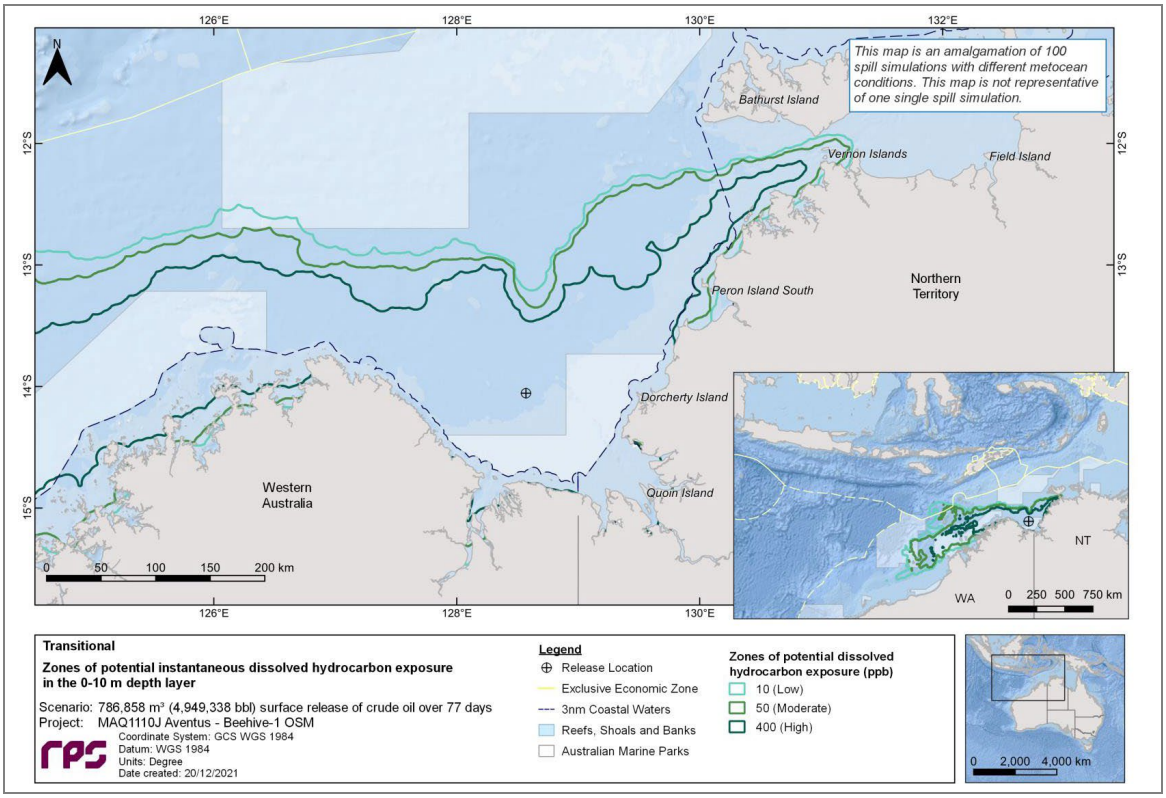


Figure 8.13. Zones of potential dissolved hydrocarbon during transitional conditions

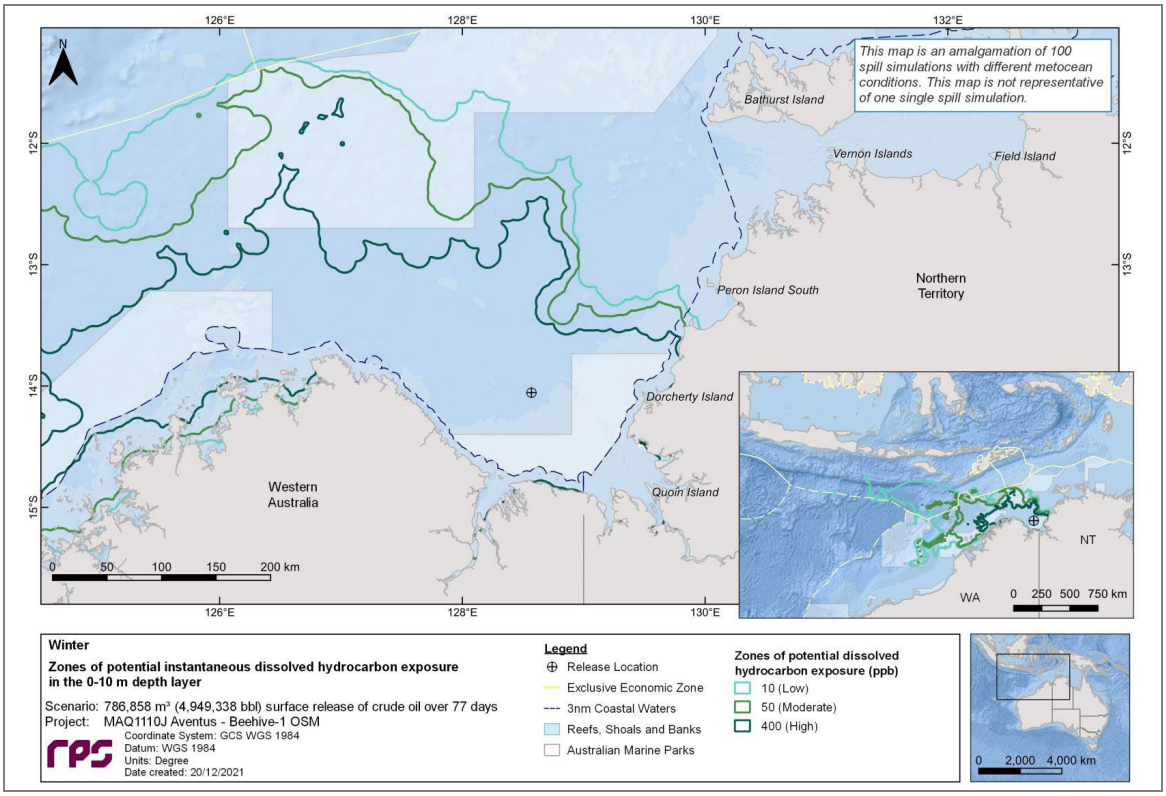


Figure 8.14. Zones of potential dissolved hydrocarbon exposure during winter conditions

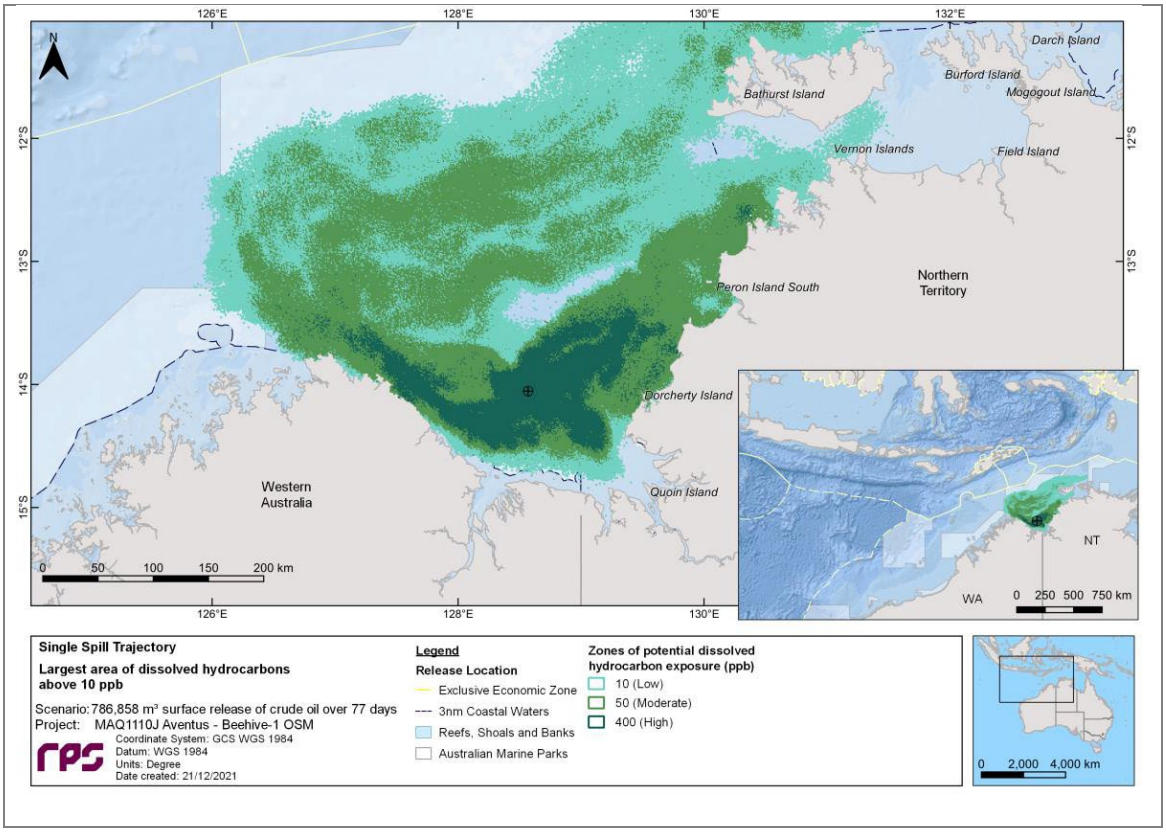


Figure 8.15. Zones of potential dissolved hydrocarbon exposure, for the trajectory with the largest area of dissolved hydrocarbons above 10 ppb

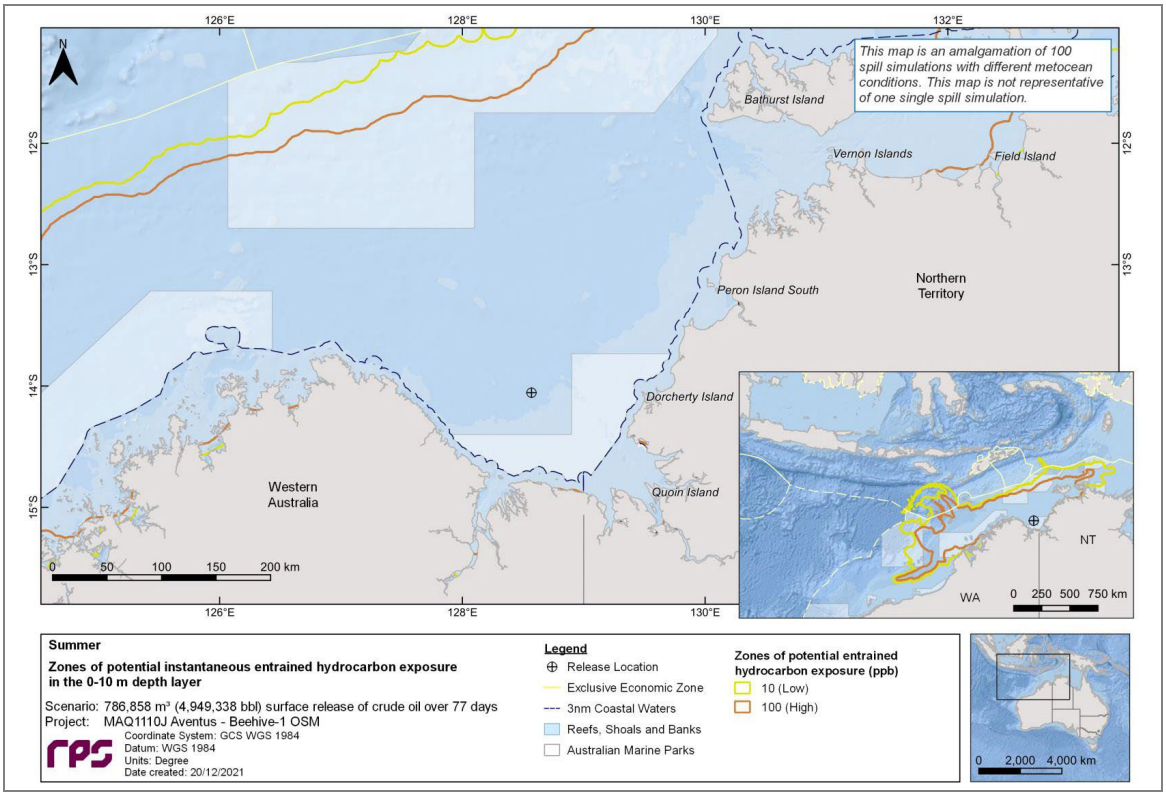


Figure 8.16. Zones of potential entrained hydrocarbon exposure during summer conditions

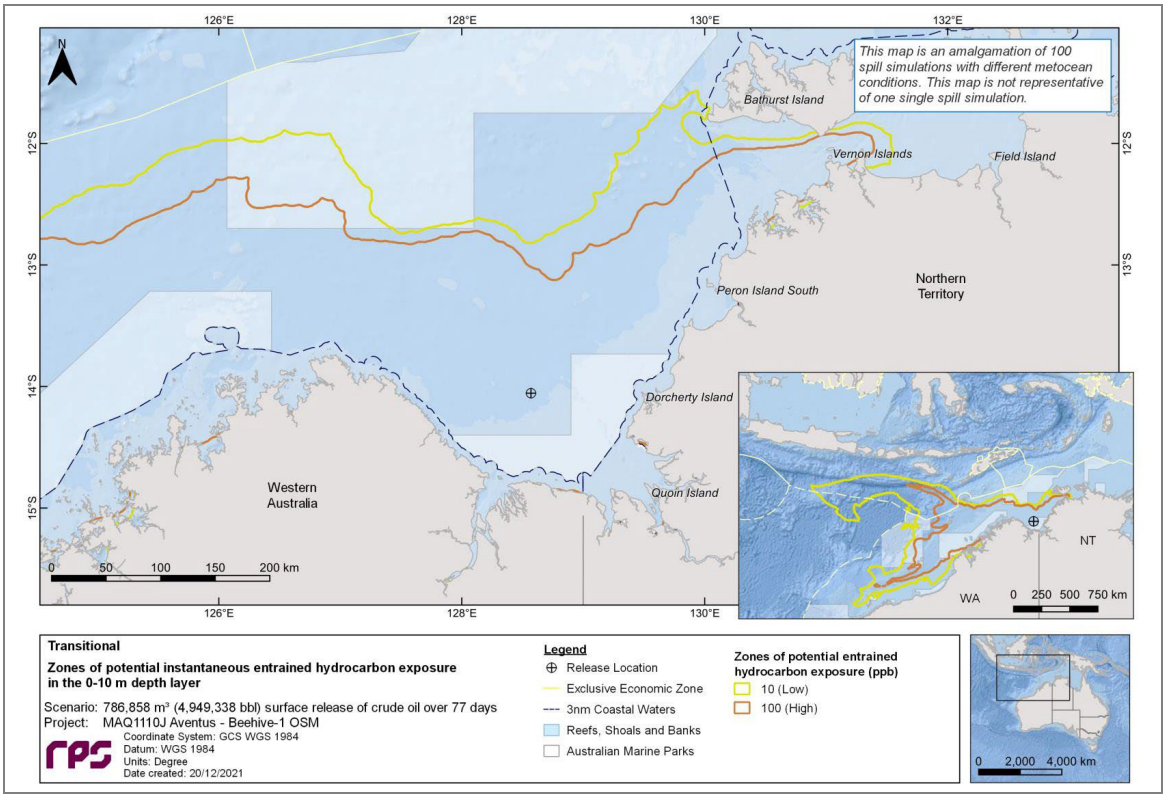


Figure 8.17. Zones of potential entrained hydrocarbon exposure during transitional conditions

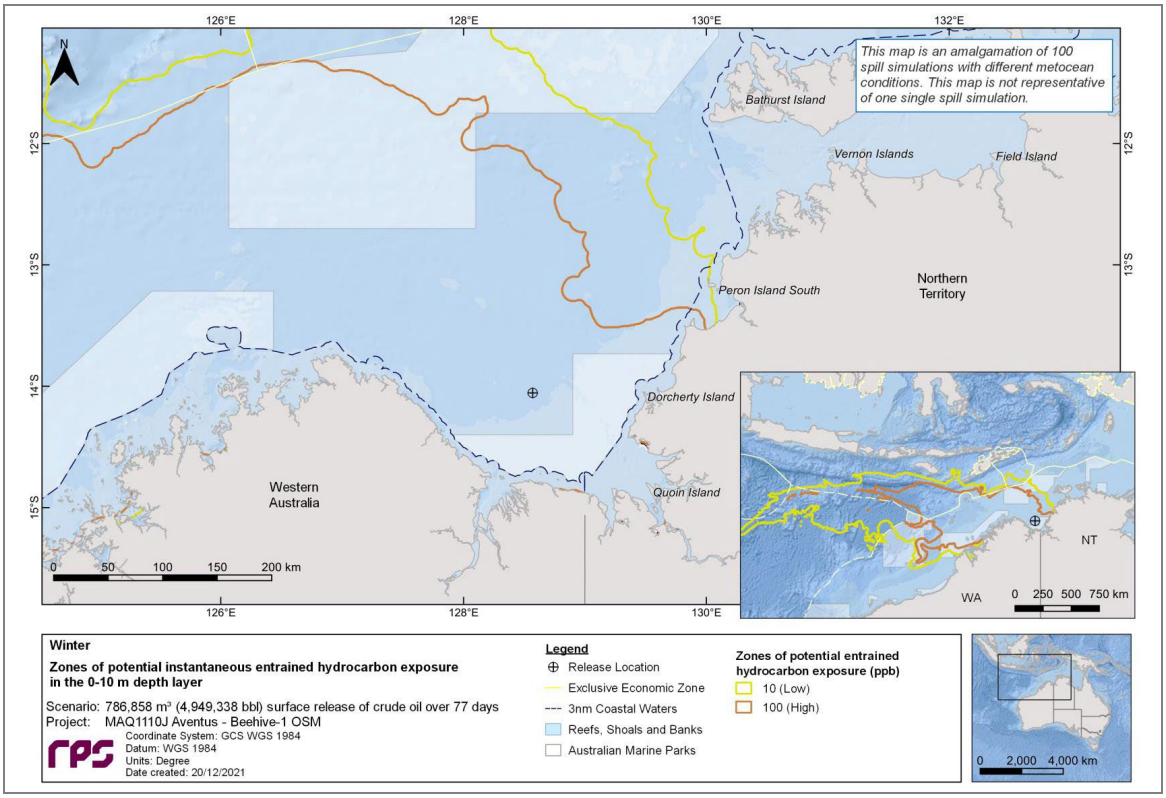


Figure 8.18. Zones of potential entrained hydrocarbon exposure during winter conditions

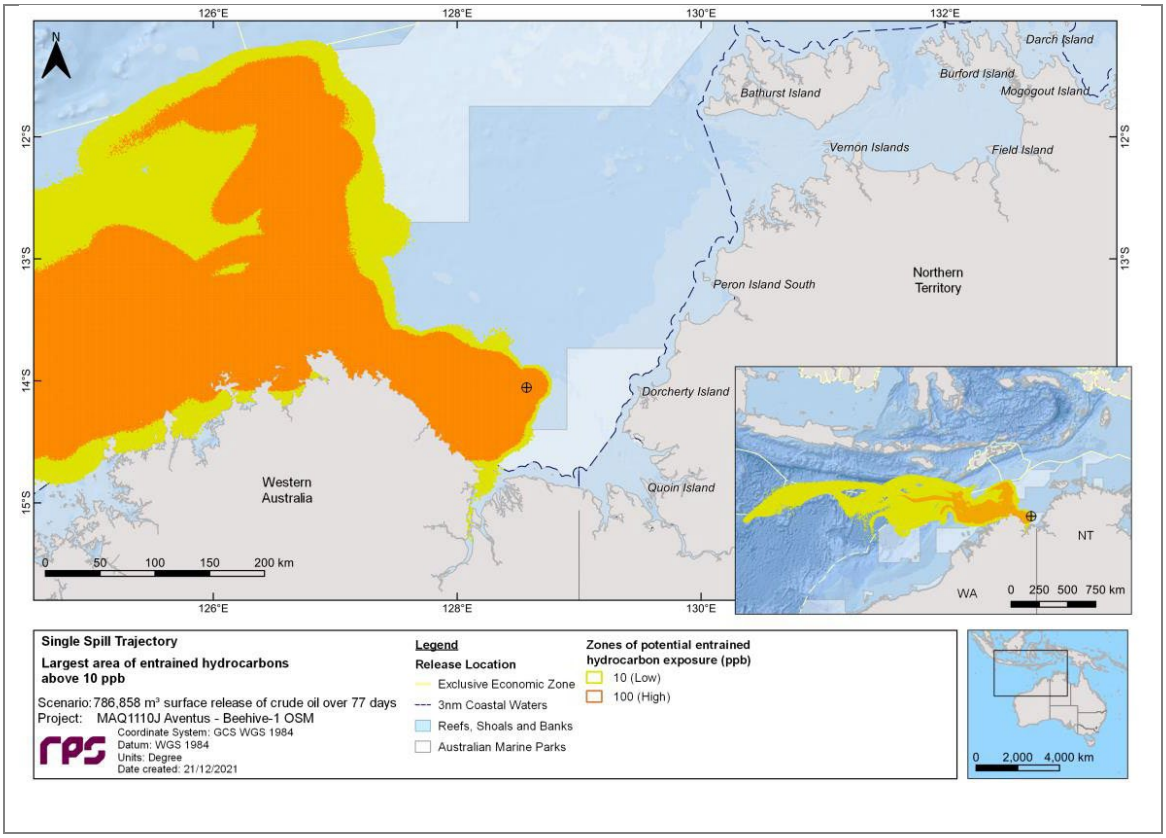


Figure 8.19. Zones of potential entrained hydrocarbon exposure, for the trajectory with the largest area of entrained hydrocarbons above 10 ppb

8.7.5 Evaluation of Environmental Risks

An environmental risk assessment for the receptors at risk from a LoWC at Beehive-1 is provided in this section, based on a literature review of the sensitivities of the receptors to oil. The defined spill EMBA is highly conservative as the stochastic modelling does not consider response actions to reduce the extent or impacts of a LoWC.

The criteria used to classify the sensitivity of receptors that may be affected by an oil spill, and thereby identify protection priorities, are presented in Table 8.23. These categoris reflect environmental values in NatPlan (AMSA, 2020), the WA Oil Spill Contingency Plan (WA DoT, 2015) and the NT Oil Spill Contingency Plan (Dept of Transport Marine Safety, 2014).

The impacts of the LoWC on environmental and socio-economic receptors in the spill EMBA, and their sensitivity criteria, are described in Table 8.24 to Table 8.37. The assessment is divided into subtidal habitat, intertidal habitat and water column segments.

A summary of the sensitivity and location of these environmental receptors is provided in Table 8.23.

Table 8.23. Criteria used to determine receptor sensitivity in the spill EMBA

Environmental value	Low sensitivity	Medium sensitivity	High sensitivity	Very high sensitivity
Protected fauna	• Normal range for threatened migratory or marine species. Species present occasionally or as vagrants – no intersection with BIAs • Populations known to recover rapidly from disturbance • Benthic flora/fauna	• Likely foraging, migration area for threatened species (reptiles, mammals) • Fish - Known breeding/pupping, congregation, aggregation area/habitat for threatened species • Known breeding/aggregation/foraging areas for listed migratory/marine species. • Species may be present at time of activity • Some susceptibility to oiling • Population has medium-term recovery times • Some intersection with BIAs	• Known breeding/ aggregation, inter-nesting area for threatened species (reptiles, mammals) • Known breeding, nesting, aggregation areas for threatened species (birds) including important bird areas (IBA) • Known to be present at the time of activity • Known susceptible to oiling • Significant intersection of BIAs • Long population recovery times	• Critical Habitat* to a species as defined in Protected Species Recovery Plans or on the EPBC Register of Critical Habitat
Protected areas/habitats	• Exposed rocky shores, man-made structures, rocky cliffs, wave-cut platforms in bedrock; exposed scarps and steep slopes in clay, sand and gravel beaches, exposed rip-rap structures (rapid recovery from oiling (~1 year or less) • Identified sites of importance but no protected status (e.g., sites of conservation significance)	• Exposed tidal flats, sheltered scarps and rocky shores; Sheltered Tidal Flats • Seagrass • Subtidal reefs • Fish habitat protection area • AMP (Multiple Use Zone) • Marine National Park (General Use) (State)	• Salt and brackish water marshes & mangroves • Corals • Intertidal reef • NIW • AMP (Habitat Protection) • Marine National Park (Special purpose) (State)	• Ramsar Wetlands • AMP (Sanctuary) • Marine National Park/Sanctuary Area (State)

Environmental value	Low sensitivity	Medium sensitivity	High sensitivity	Very high sensitivity
Economic/ Commercial	• Very low economic significance for the region (<$150K/km of coast) • Tourism region key population centre (> 5% of state income from tourism) • Port throughput <10 M tonnes/annum • Salt works seawater intakes, aquaculture seawater intakes and LNG seawater intake facilities • State or Commonwealth-managed Commercial Fishery: <$100M	• Low economic significance for the region ($150-$500K/km of coast) • Port throughput 11-100 M tonnes/annum • Cooling water intakes for power stations • Tourism region key population centre (> 10% of state income from tourism) • Pearling Leases • State or Commonwealth-managed Commercial Fishery: $101-$500M	• Some economic significance for the region $500K - $1.5M/km of coast) • Port throughput 101-400 M tonnes/annum • State or Commonwealth-managed Commercial Fishery: $500M-$1B	• High economic significance for the region >$1.5M/km of coast) • Reverse osmosis potable water intakes • Port throughput >401M tonnes/annum • State or Commonwealth-managed commercial fishery: >$1B
Cultural Heritage	• Local indigenous significance (Joint Management of Parks by Traditional Owners) • Protected shipwrecks and maritime archaeology	• Commonwealth Heritage Places: indigenous, historic and natural heritage places • Commonwealth maritime cultural heritage • State protected heritage places	• National heritage places: indigenous, historic and natural heritage places	• World Heritage Areas
Social, amenity and recreation	• Low to moderate local recreational use, community or amenity values	• Regionally significant seasonal recreational use, community or amenity values	• Regionally significant year-round recreational use, community or amenity values	• Nationally significant seasonal and year-round recreational use, community or amenity values

** Habitat critical to a species for survival – areas necessary for foraging, breeding or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; for the reintroduction of populations or recovery of the species (EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance)*

Table 8.24. Sensitivity and consequence evaluation of hydrocarbon exposure to subtidal communities - benthic assemblages

General sensitivity to oiling – benthic assemblages	
Sensitivity rating of benthic species and communities:	Low
A description of benthic fauna in the spill EMBA is provided in:	Appendix 11, Section 11.3.1

Surface hydrocarbons

Benthic species are generally protected from exposure to surface hydrocarbon. The primary modes of exposure for benthic communities in oil spills include:

- Direct exposure to dispersed oil (e.g., physical smothering) where bottom hydrocarbons stay at the ocean bottom;
- Direct exposure to dispersed and non-dispersed oil (e.g., physical smothering) where oil sinks to seabed from higher depths of the ocean;
- Direct exposure to dispersed and non-dispersed oil dissolved in sea water and/or partitioned onto sediment particles; and
- Indirect exposure to dispersed and non-dispersed oil through the food web (e.g., uptake of oiled plankton, detritus, prey, etc.) (NRDA, 2012).

Adult marine invertebrates and larvae usually reside within benthic substrates and pelagic waters, rarely reaching the water's surface in their life cycle (to breed, breathe and feed). Therefore, surface hydrocarbons are not considered to pose a high risk to marine invertebrates except at locations where surface oil reaches shorelines.

Acute or chronic exposure, through surface contact, and/or ingestion can result in toxicological risks. However, the presence of an exoskeleton (e.g., crustaceans) reduces the impact of hydrocarbon absorption through the surface membrane. Other invertebrates with no exoskeleton and larval forms may be more prone to impacts from hydrocarbons.

Water column/seabed hydrocarbons

Entrained and dissolved hydrocarbons can have negative impacts on marine invertebrates and associated larval forms, while impacts to adult species is reduced as a result of the presence of an exoskeleton. Localised impacts to larval stages may occur which could impact on population recruitment that year. If invertebrates are contaminated by hydrocarbons, tissue taint can remain for several months, although taint may eventually be lost. For example, it has been demonstrated that it took 2-5 months for lobsters to lose their taint when exposed to a light hydrocarbon (NOAA, 2002).

Exposure to microscopic oil droplets may also impact aquatic biota either mechanically (especially filter feeders) or act as a conduit for exposure to semi-soluble hydrocarbons (that might be taken up by the gills or digestive tract) (McCay-French, 2009). Toxicity is primarily attributed to water soluble PAHs, specifically the substituted naphthalene (C_2 and C_3) as the higher C-ring compounds become insoluble and are not bioavailable. ANZECC/ARMCANZ (2000) identifies the following 96-hr LC_{50} concentrations for naphthalene (a key primary PAH dissolved phase toxicant in crude oils):

- For the bivalve mollusc, *Katelysia opima*, a concentration of 57,000 ppb; and
- For six species of marine crustaceans, a concentration between 850 and 5,700 ppb.

Other possible impacts from the presence of dispersed and non-dispersed oil include effects of oxygen depletion in bottom waters due to bacterial metabolism of oil (and/or dispersants), and light deprivation under surface oil (NRDA, 2012).

Surveys undertaken after the Montara well blowout in the Timor Sea in 2009 found no obvious visual signs of major disturbance at Barracouta and Vulcan shoals (Heyward *et al*., 2010), which occur about 20-30 m below the water line in otherwise deep waters (generally >150 m water depth). Later sampling indicated the presence of low-level severely degraded oil at some shoals, though in the absence of pre-impact data, this could not be directly linked to the Montara spill. Levels of hydrocarbons in the sediments were, in any case, several orders of magnitude lower than levels at which biological effects become possible (Heyward *et al*., 2010; Gagnon & Rawson, 2011).

Studies undertaken since the Macondo well blowout in the Gulf of Mexico (GoM) in 2010 have shown that fewer than 2% of the more than 8,000 sediment samples collected exceeded the EPA sediment toxicity benchmark for aquatic life, and these were largely limited to the area close to the wellhead (Felder *et al*., 2014).

Studies of offshore benthic seaweeds in the northwest GoM prior to and after the Macondo well blowout at Sackett and Ewing banks (in water depths of 55-75 m) found a dramatic die-off of seaweeds after the spill (60 species pre-spill compared with 10 species post-spill) (Felder *et al*., 2014). Benthic decapod assemblages (crabs, lobsters, prawns) associated with the seaweeds and benthic substrate also showed a strong decline in abundance at both banks post-spill (species richness on Ewing Bank reduced by 42% and on Sackett Bank by 29%), though it is noted that these banks are exposed to influences from Mississippi River discharges that vary year to year, so definitive links to the oil spill are not possible. It is noted, however, that petroleum residues were observed on Ewing Bank and it is possible that this may have caused localized mortalities, reduced the fecundity of surviving female decapods or reduced recruitment (Felder *et al*., 2014). Felder *et al* (2014) also notes that freshly caught soft-sediment decapod samples caught in early and mid-2011 near the spill site exhibited lesions that were severe enough to cause appendage loss and mortality.

Recovery of benthic habitats exposed to entrained hydrocarbons would be expected to return to background water quality conditions within weeks to months of contact. Several studies have indicated that rapid recovery rates may occur even in cases of heavy oiling (Committee on Oil in the Sea, 2003).

Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Not applicable to benthic fauna.
Water column (dissolved & entrained) (0-10 m from surface)	The OSTM predicts extensive areas where is a high probability that medium and high exposure thresholds are reached for dissolved and entrained oil. For much of this area, water depths are greater than 10 m and therefore ecological impacts to benthic fauna are unlikely. In areas of exposure at the seabed, the impacts are likely to be as described in the description of sensitivities. Where such areas contain coral reefs, shoals and/or banks, contact with dissolved and entrained oil may result in toxicity effects and potential mortality (see following tables). One of the key values of the JBG AMP is the Carbonate bank and terrace system of the Sahul Shelf KEF (unique seafloor feature with ecological properties of regional significance). Most of the JBG AMP is in water depths greater than 10 m, so hydrocarbons in the top 10 m of the water column are not likely to have significant impacts on this AMP value.

Shoreline	The shoreline sectors predicted to have the highest average shoreline loading of oil at moderate or high thresholds across all seasons, and their dominant shoreline types, are (moving from west to east): • Adele Island (WA) - sandy beach. • Browse Island (WA) - sandy beach, coral reef. • Wyndam-East Kimberley (WA) – tidal flats/mangroves, rocky shore, beach sediments. • Victoria-Daly (NT) - tidal flats/mangroves. • Thamarrurr (NT) - tidal flats/mangroves, sandy beach, rocky shore. The OSTM predicts extensive shoreline exposure at thresholds that can cause biological impacts (224 km for at moderate threshold). The shoreline of the spill EMBA has a diverse array of benthic fauna, including molluscs (such as mussels) and crustaceans (such as crabs) that live in or on beach sediments, mangroves, mudflats and rocks. At the moderate and high loading thresholds, there is expected to be injury or mortality of exposed benthic fauna due to oil toxicity, which will likely result in bioaccumulation impacts further up the food chain when seabirds, shorebirds and other fauna consume them. How extensive this is depends on the volume that reaches the shoreline and where the oil is deposited. Oiling and contamination of benthic communities on the shorelines closest to the well is likely to result in temporary exclusion of members of the Wunambal Gaambera, Balanggarra, Ngarinyin and/or Miriuwung Gajerrong people using their traditional coastal country to seek food and other resources.
Inherent impact consequence	Moderate

Table 8.25. Sensitivity and consequence evaluation of hydrocarbon exposure to subtidal communities – macroalgae and seagrasses

General sensitivity to oiling – macroalgal and seagrass communities	
Sensitivity rating of macroalgal species and seagrass communities:	Medium
A description of macroalgal species and communities in the spill EMBA is provided in:	Appendix 11, Section 11.3.2

Macroalgae are generally limited to growing on intertidal and subtidal rocky substrata in shallow waters to 10 m depth where they have access to light to photosynthesise. Seagrasses generally grow in sediments in intertidal and shallow subtidal waters where there is sufficient light, and are common in sheltered coastal areas such as bays, lees of islands and fringing coastal reefs. Macroalgae and seagrass are also common features of shoals. As such, they may be exposed to subsurface entrained and dissolved hydrocarbons.

Macroalgae

Smothering, fouling and asphyxiation are some of the physical effects that have been documented from oil contamination in marine plants (Blumer, 1971; Cintron *et al*., 1981). In macroalgae, oil can act as a physical barrier for the diffusion of CO_2 across cell walls (O'Brian & Dixon, 1976). The effect of hydrocarbons however is largely dependent on the degree of direct exposure and how much of the hydrocarbon adheres to algae, which will vary depending on the oils physical state and relative 'stickiness'. The morphological features of macroalgae, such as the presence of a mucilage layer or the presence of fine 'hairs' will influence the amount of hydrocarbon that will adhere to the algae. A review of field studies conducted after spill events by Connell et al (1981) indicated a high degree of variability in the level of impact, but in all instances, the algae appeared to be able to recover rapidly from even very heavy oiling. The rapid recovery of algae was attributed to the fact that for most algae, new growth is produced from near the base of the plant while the distal parts (which would be exposed to the oil contamination) are continually lost. Other studies have indicated that oiled kelp beds had a 90% recovery within 3-4 years of impact, however full recovery to pre-spill diversity may not occur for long periods after the spill (French-McCay, 2004).

Intertidal macroalgal beds are more prone to oil spills than subtidal beds because although the mucous coating prevents oil adherence, oil that is trapped in the upper canopy can increase the persistence of the oil, which impacts upon site-attached species. Additionally, when oil sticks to dry fronds on the shore, they can become overweight and break as a result of wave action (IPIECA, 2002).

The toxicity of macroalgae to hydrocarbons varies for the different macroalgal life stages, with water-soluble hydrocarbons more toxic to macroalgae (Van Overbeek & Blondeau, 1954; Kauss *et al*., 1973; cited in O'Brien and Dixon, 1976). Toxic effect concentrations for hydrocarbons and algae have varied greatly among species and studies, ranging 0.002–10,000 ppm (Lewis & Pryor, 2013). The sensitivity of gametes, larva and zygote stages however have all proven more responsive to petroleum oil exposure than adult growth stages (Thursby & Steele, 2003; Lewis & Pryor, 2013).

In addition to the potential impacts from direct smothering or exposure to entrained and dissolved hydrocarbons, the presence of entrained hydrocarbons within the water column can affect light qualities and the ability of plants to photosynthesise.

Seagrass

Seagrasses can be exposed to oil by direct contact (i.e., smothering) and by uptake by rhizomes through contaminated sediments. Exposure also can take place via uptake of hydrocarbons through plant membranes. In addition, seeds may be affected by contact with oil contained within sediments (NRDA, 2012).When seagrass leaves are exposed to petroleum oil, sub-lethal quantities of the WAF can be incorporated into the tissue, causing a reduction in tolerance to other stress factors (Zieman et al., 1984). The toxic components of petroleum oils are thought to be the PAH, which are lipophilic and therefore able to pass through lipid membranes and tend to accumulate in the thylakoid membranes of chloroplasts (Ren et al., 1994).

As such, the susceptibility of seagrasses to hydrocarbon spills will depend largely on distribution. Deeper communities will be protected from oiling under all but the most extreme weather conditions. Shallow seagrasses are more likely to be affected by dispersed oil droplets or, in the case of emergent seagrasses, direct oiling. Theoretically, intertidal seagrass communities would be the most susceptible because the leaves and rhizomes may both be affected.

Studies report that the phytotoxic effect of petroleum oil on seagrasses can lead to a range of sub-lethal responses including reduced growth rates (Howard & Edgar, 1994), bleaching, decrease in the density of shoots, reduced flowering success (den Hartog & Jacobs, 1980; Dean et al., 1998) and blackened leaves that can detach from the plant following oil contamination (den Hartog & Jacobs, 1980). Direct exposure, however, does not always induce toxic effects (Kenworthy et al., 1993; Dean et al., 1998), even under laboratory conditions (Wilson & Ralph, 2012).

Studies of actual spills have found no significant differences between oiled and un-oiled seagrass meadows comprising *Halodule uninervis*, *Halophila ovalis* and *Halophila stipulacea* following large spills of crude oil during the Gulf War (Kenworth *et al*., 1993). Similarly, a spill of heavy fuel oil contaminated by lighter fuel products in Gladstone Harbour (Queensland) did not result in measurably short- or long-term impacts on meadows of *Zostera capricorni*, *H. ovalis*, *H. decipiens*, *H. spinulosa* or *H. uninervis* (Taylor & Rasheed, 2011). Conversely, one laboratory study using Bass Strait crude and diesel fuel did observe mortality of affected seagrass, with slow recovery (Clarke & Ward, 1994).

One reason why seagrasses appear to be less vulnerable to oil impacts is that 50-80% of their biomass is in their rhizomes, which are buried in sediments, thus less likely to be adversely impacted by oil. Thus, even if the fronds are affected, the plant may still be alive and able to regrow (Zieman et al., 1984)

In addition to the effects described, the presence of entrained hydrocarbons within the water column can affect light qualities and the ability of seagrass to photosynthesise. Studies of photosynthetic impacts on seagrass used WAF of Tapis crude and IFO-180, with concentrations ranging from 3 – 522 mg/L-1, found minimal or no negative impacts (Wilson & Ralph, 2012).

Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Not applicable.
Water column (dissolved & entrained) (0-10 m from surface)	The OSTM predicts extensive areas where there is a high probability that medium and high exposure thresholds are reached for dissolved and entrained oil. All nearshore environments along the coastline of the spill EMBA are expected to contain some degree of marine plant life presence, whether this be isolated or extensive seagrass meadows or stands of green, red and brown algae (seaweed), noting however that there is scant information about the presence of seagrasses north of Broome (WA). Seaweed is of course omnipresent in the marine environment.

	Areas where such subtidal communities are likely to be present include offshore islands, sheltered bays, crevices among rocky shores and offshore shoals. As per the sensitivity description, the impacts to macroalgae and seagrasses may result in toxicity effects and potential mortality. Any reduced growth rates or temporary loss of grass cover (noting that rhizomes growing in seabed sediments would remain intact) may result in dieback of seagrasses. This may lead to a temporary reduction in fish nursery habitat, with consequent losses in fish diversity and abundance. This may have longer-term impacts on the size of fish populations. Contaminated macroalgae consumed by fish, turtles, dugongs and shorebirds will result in some level of bioaccumulation up the food chain. How extensive this is depends on the concentration of oil in the water column, the level of contamination of the macroalgae and the species exposed. Dugongs feed exclusively on seagrasses. The ecological spill EMBA intersects a very small area of the dugong foraging BIA in the area north of Broome, noting that there is only a 1% probability of oil contact at the low threshold in this area. This is not expected to have ecological consequences and therefore dugong present in the area are unlikely to be impacted by a contaminated food source.
Shoreline	Addressed in 'water column'.
Inherent impact consequence	Moderate

Table 8.26. Sensitivity and consequence evaluation of hydrocarbon exposure to subtidal communities – coral

General sensitivity to oiling – corals	
Sensitivity rating of coral (intertidal):	High
Sensitivity rating of coral (subtidal):	Medium
A description of coral reefs in the spill EMBA is provided in:	Appendix 11, Section 11.3.1

Experimental studies and field observations indicate all coral species are sensitive to the effects of oil, although there are considerable differences in the degree of tolerance between species. Differences in sensitivities may be due to the ease with which oil adheres to the coral structures, the degree of mucous production and self-cleaning, or simply different physiological tolerances.

Direct contact of coral by hydrocarbons may impair respiration and also photosynthesis by symbitotic zooanthellae (Peter *et al*., 1981; Knap *et al*., 1985). Coral gametes or larvae in the surface layer where they are exposed to the slick may also be fouled (Epstein *et al*., 2000). Larvae in the water column at the time of spawning are especially vulnerable to oil (Hook *et al*., 2016). Physical oiling of coral tissue can cause a decline in metabolic rate and may cause varying degrees of tissue decomposition and death (Negri and Heyward, 2000). Oil may also cling to certain types of sediment causing oil to sink to the seafloor, covering corals in oiled sediment (IPIECA, 2011).

Where corals come into direct contact with surface exposures (i.e., intertidal/shallow areas), they are more susceptible due to physical presence, than toxicity associated with dissolved oil components within the water column which, in some cases, may be more toxic than the floating surface slicks (Volkman *et al*., 1994). A range of impacts is reported to result from toxicity including partial mortality of colonies, reduced growth rates, bleaching and reduced photosynthesis.

Chronic effects of oil exposure have been consistently noted in corals and, ultimately, can kill the entire colony. Chronic impacts include histological, biochemical, behavioural, reproductive and developmental effects. Field studies of chronically polluted areas and manipulative studies in which corals are artificially exposed to oil show that some coral species tolerate oil better than other species (NOAA, 2010c).

Reproductive stages of corals have been found to be more sensitive to oil toxicity. Fertilisation of coral species has been observed to be completely blocked in Acropora tenuis at heavy fuel oil concentrations of 0.15 mg/L^{-1} (Harrison, 1994; 1999), with significant reductions in fertilisation of *A. millepora* and *A. valida* at concentrations between 0.58 and 5.8 mg/L_{-1}, in addition to developmental abnormalities and reduced survival of coral larvae at similar concentrations (Lane and Harrison, 2000). Lower concentrations of less than 0.1 mg/L^{-1} crude oil were observed to inhibit larval metamorphosis in *A. millepora* (Negri & Heywood, 2000).

Studies undertaken after the Montara spill (a light crude) in northwest Australia included diver surveys to assess the status of Ashmore, Cartier and Seringapatam coral reefs. These found that other than a region-wide coral bleaching event caused by thermal stress (i.e., caused by sea water exceeding 32°C), the condition of the reefs was consistent with previous surveys, suggesting that any effects of hydrocarbons reaching these reefs was minor, transitory or sub-lethal and not detectable (Heyward *et al*., 2010). This is despite AMSA observations of surface slicks or sheen nears these shallow reefs during the spill (Heyward *et al*., 2010). Surveys in 2011 indicated that the corals exhibiting bleaching in 2010 had largely survived and recovered (Heyward *et al*., 2012), indicating that potential exposure to hydrocarbons while in an already stressed state did not have any impact on the healthy recovery of the coral.

In addition, surveys undertaken after the Montara blowout on the plateau areas of Barracouta and Vulcan shoals (Heyward *et al*., 2010), which occur about 20-30 m below the water line in otherwise deep waters (generally >150 m water depth), and contain algae, hard coral and seagrass, found no obvious visual signs of major disturbance.	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Not applicable.
Water column (dissolved & entrained) (0-10 m from surface)	The OSTM predicts extensive areas where there is a high probability that medium and high exposure thresholds are reached for dissolved and entrained oil, which may impact coral reefs. Key areas within the ecological spill EMBA known to contain coral reef, and their risk of contact within the water column, are: • JBG AMP (Cth) – 66-97% (dissolved) and 83-100% (entrained) probability of contact across the seasons. • Ashmore Reef AMP (Cth) – 0% (dissolved) and 0-14% (entrained) probability of contact across the seasons. • Cartier Island AMP (Cth) – 0% (dissolved) and 0-15% (entrained) probability of contact across the seasons. • Mermaid Reef AMP (Cth) – 0-2% (dissolved) and 2-5% (entrained) probability of contact across the seasons. • Browse Island (WA) – 1-13% (dissolved) and not reported (entrained) probability of contact across the seasons. • Heywood Shoal (Cth) – 0-4% (dissolved) and 19-38% (entrained) probability of contact across the seasons. • Mermaid Reef (Cth) – 0-3% (dissolved) and 0-5% (entrained) probability of contact across the seasons. • Vulcan Shoal (Cth) – 0-3% (dissolved) and 0-22% (entrained) probability of contact across the seasons. • Scott Reef (north & south) (WA) – 0-2% (dissolved) and 1-6% (entrained) probability of contact across the seasons. • Seringapatam Reef (WA) – 0% (dissolved) and 0-7% (entrained) probability of contact across the seasons. • Ashmore Reef (Cth) – 0% (dissolved) and 0-14% (entrained) probability of contact across the seasons. • Hibernia Reef (Cth) – 0% (dissolved) and 0-5% (entrained) probability of contact across the seasons. As per the sensitivity assessment, the impacts to coral reef may result in localised or widespread areas of colony mortality, decreased growth rates, decreased survival of larvae, decreased gonadal development and increased bleaching (Hook *et al*., 2016). Such impacts to coral reefs will have consequences for the fish and other species dependent on coral habitat. Corals also accumulate oil from the water column, which can persist and become biologically available to fish and other fauna that graze on them (Hook *et al*., 2016). Recovery of coral reefs after

		exposure to oil can be slow and they may become overgrown by algae and become susceptible to other stressors, such as predators (Hook *et al*., 2016). Impacts to coral reefs within AMPs and state marine parks may reduce the ecological values of those parks and possibly lead to lower ecotourism visits and associated loss of income for tourism businesses dependent on tourists.
Shoreline		Addressed in 'water column'.
Inherent impact consequence:	Severe	

Table 8.27. Sensitivity and consequence evaluation of hydrocarbon exposure to intertidal communities – mangroves and salt marshes

General sensitivity to oiling – mangroves and salt marshes	
Sensitivity rating of mangroves and salt marshes:	High
A description of mangroves and salt marshes in the spill EMBA is provided in:	Appendix 11, Section 11.2.3

Mangrove and saltmarsh ecosystems are specially adapted to marine and estuarine conditions and play an important role in reducing wave energy at the coast and preventing shoreline erosion, with mangroves providing nursery habitat for many species of marine fauna (Hook *et al*., 2016).

Mangroves

The impacts of surface hydrocarbons on mangroves include damage as a result of smothering of lenticels (mangrove breathing pores) on pneumatophores or aerial roots (Hook *et al*., 2016), or by the loss of leaves (defoliation) due to chemical burning. It is also known that mangroves take up hydrocarbons from contact with leaves, roots or sediments, and it is suspected that this uptake causes defoliation through leaf damage and tree death (Wardrop *et al*., 1987).

Entrained and dissolved hydrocarbons may potentially impact mangrove communities through the sediment/mangrove root interface. Entrained and dissolved hydrocarbons contain contaminants that may become persistent in the sediments (e.g., trace metals, PAHs), leading to direct effects on mangroves due to direct uptake, or indirect effects due to impacts on benthic infauna and thus leading to reduced rates of bioturbation and subsequent oxygen stress on the plants root systems.

The following information is from IPIECA (1993) and NOAA (2014). Oil slicks enter mangrove forests when the tide is high and are deposited on the aerial roots and sediment surface as the tide recedes. This process commonly leads to a patchy distribution of the oil and its effects because different places within the forests are at different tidal heights. Mangroves can be killed by heavy or viscous oil that covers the trees' breathing pores thereby asphyxiating the subsurface roots, which depend on the pores for oxygen. This is also likely to apply to oil emulsions that may flow into mangrove forests. Observed thresholds for impacts are likely to vary depending on the health of the system, the spilt hydrocarbon and the environmental conditions, however observations by Lin and Mendelssohn (1996), demonstrated that more than 1 kg/m^2 of oil during the growing season would be required to impact marsh or mangrove plants significantly.

Mangroves can also be killed through the toxicity of substances in the oil, especially lower molecular weight aromatic compounds, which damage cell membranes in the subsurface roots. This in turn impairs the normal salt exclusion process, and the resulting influx of salt is a source of stress to the plants. The organisms among and on the mangrove trees are also affected by the oil. There may be heavy mortalities as a direct result of the oil penetrating burrows in the sediments, killing crabs and worms, or coating molluscs present on the sediment surface and aerial roots. Dead trees lead to loss of habitat for organisms living in the branches and canopy of the trees, and in the aerial root systems.

Over time, several factors reduce the toxicity of oil that has been deposited in mangrove forests. The amount of oil in the soil is reduced by rain and tides. As the oil weathers, chemical changes such as oxidation make the residual oil less toxic. Eventually the soil can support mangrove growth once more, with the time-scale involved varying according to local conditions such as the amount of water circulation in the immediate area.

White mangroves (*Avicennia marina*), which are found in pockets of the southern Australian coast, have been found to be highly susceptible to weathered crude oil, with field studies showing acute effects (mortality) of 96% to seedlings. Similar impacts may be expected for mangrove species in northern Australia. Observations from

oil spill in mangroves indicate mangrove stress occurs within the first two weeks of a spill (ranging from chlorosis to defoliation to death). Chronic effects to mangroves can be more difficult to detect than acute effects, with defoliation and death of mangroves taking place anywhere from 30 days to years after exposure to crude oil. Root and pneumatophore abnormalities have been reported as a response to chronic oil exposures (Hook *et al*., 2016). Mendelssohn et al (2012) notes that PAHs are the most toxic contaminants and are persistent in marshes. The highest levels generally occur below the sediment surface, where there is limited oxygen and a concomitant shift from aerobic to anaerobic bacterial taxa. In a heavily contaminated mangrove forest, PAH concentrations increase with increasing substrate depth and decreasing oxygen content. PAH-degrading anaerobic bacteria have been identified in contaminated wetland sediments, but given their low oil-degradation capability, it is unlikely that anaerobic bacteria could greatly reduce PAH contamination, except at low concentrations of PAH.

Oil entrained within mangrove sediments can be available to invertebrates and fish inhabiting these systems, causing toxic impacts and changes in community structure (Hook *et al*., 2016). Recovery from oil in mangrove habitats can be very slow because the sediments are anoxic, which slows the rate of oil degradation (Hook *et al*., 2016).

Saltmarsh

The following information is from IPIECA (2004), except where otherwise stated.

As with mangroves, oil will readily adhere to both tidal and muted tidal marshes with the extent of coating varying according to the water level at the time of oiling. Large slicks will persist through multiple tidal cycles and will coat the entire stem from the high-tide line to the base. Once oil is deposited into saltmarshes, the low energy environment means that oil is not rapidly washed away. Following the *Deepwater Horizon* oil spill in the USA, studies demonstrated that oil deposited in oxic (well oxygenated) sediments degraded quickly (within 18 months), whereas oil in anoxic (low oxygen) sediments is expected to persist for decades (Hook *et al*., 2016).

Saltmarsh vegetation offers a large surface area for oil absorption, which tends to trap oil. Additionally, many saltmarsh grasses, which can be dominant over large areas, have corrugated leaf surfaces that increases the holding capacity of oil.

Heavy oil coating will be restricted to the outer fringe of thick vegetation, although lighter oils can penetrate deeper, to the limit of tidal influence. Medium to heavy oils do not readily adhere to or penetrate the fine sediments composed of organic muds but can pool on the surface or in animal burrows and root cavities. Light oils can penetrate the top few centimetres of sediment and follow biological pathways burrows and cracks up to one meter deep.

Evidence from case histories and experiments shows that the damage resulting from oiling, and recovery times of oiled saltmarsh vegetation, are very variable. Lighter more penetrating oils are more likely to cause acute toxic damage than heavy or weathered oils.

In areas of light to moderate oiling where oil is mainly on perennial vegetation with little penetration of sediment, the shoots of the plants may be killed but recovery can take place from the underground systems. Good recovery commonly occurs within one to two years. Where thick deposits of viscous oil or mousse accumulate on the marsh surface, vegetation is likely to be killed by smothering and recovery will be delayed because persistent deposits inhibit recolonisation.

Oiling of shoots combined with substantial penetration of oil into sediments is more likely to happen with relatively fresh light crude oils (such as that predicted at Beehive-1) because these are less viscous. Damage to the underground systems and invertebrate communities results from the sub-surface oil, and recovery is delayed.

Abundant resident flora and fauna and high use by birds, fish and shellfish, means that oiling of saltmarsh environments can result in significant ecological impacts. Hook et al (2016) reports that there is expected to be a loss of invertebrate species diversity and abundance and productivity in oiled saltmarshes.

Damage to or dieback of saltmarshes can lead to coastal erosion (Hook *et al*., 2016). Recovery may be delayed if the species composition is altered as tolerant species gain a competitive advantage. Following the *Deepwater Horizon* oil spill in the USA, studies of the impacts to saltmarshes found that recovery was underway within one year of the spill but proceeded the slowest in the areas closest to the shoreline (Hook *et al*., 2016).	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Not applicable.
Water column	Addressed in 'shoreline.'
Shoreline	All of the shoreline sectors illustrated in Appendix 11 in the ecological spill EMBA have mangroves present (and likely saltmarshes), except for the Scott Reef/Browse Island and Ashmore Reef/Cartier Island sectors. The shoreline sectors with the highest probability of moderate to high exposure are: • Wyndham-East Kimberley (WA) Sector- up to 93% probability of contact, up to 408 m^3 of oil. Specifically within this sector, the following WA Marine Oil Pollution Risk Assessment (WAMOPRA) shoreline cells (defined by the WA DoT) contain expanses of mangroves: ○ East Cape Domett – WA/NT Border A, B (DoT Cell 1,2) - up to 49% probability of contact, up to 126.5 m^3 oil. ○ East Cape Domett – WA/NT C (Cambridge Gulf) (DoT Cell 3) - up to 52% probability of contact, up to 69 m^3 oil. ○ Aunty Islet – Thornburn Bluff (DoT Cell 9) - up to 63% probability of contact, up to 79.1 m^3 oil. ○ Cape Bernier – Elsie Island N (DoT Cell 10) - up to 38% probability of contact, up to 101.3 m^3 oil. ○ Cape Rulhieres – Unnamed Head B (King George River DoT Cell 13) - up to 75% probability of contact, up to 52.2 m^3 oil. ○ Cape Talbot - Cape Londonderry A (DoT Cell 15) - up to 35% probability of contact, up to 15.7 m^3 oil. ○ Cape Talbot - Cape Londonderry B (DoT Cell 16) - up to 16% probability of contact, up to 4.7 m^3 oil. ○ Low Island Point – Anjo A (Drysdale River – Napier Broome Bay – DoT Cell 17) - up to 33% probability of contact, up to 61.5 m^3 oil. ○ Cape Bougainville to Low Island Point B (DoT Cell 20) - no identified exposure. ○ Cape Bougainville to Low island C & D; Crystal Head – Cape Bougainville (Cape Bougainville – DoT Cells 21, 22, 23) - up to 61% probability of contact, up to 63.5 m^3 oil. ○ Davidson Point - Crystal Head B (Mitchell river – DoT Cell 25) - no identified exposure. • Victoria-Daly (NT) – up to 73% probability of contact, up to 258 m^3 of oil; • Thamarrurr (NT) – up to 74% probability of contact, up to 271 m^3 of oil; and

	• Daly (NT) – up to 41% probability of contact, up to 200 m^3 of oil (only during the summer period, minor quantities during winter and transition seasons). All mangrove forests and saltmarshes are considered to be important because of their habitat values, which includes fish breeding and nurseries, shorebird feeding, roosting and breeding habitat, and shoreline protection. Any long-term damage to the health of these habitats resulting from oil exposure will result in loss of habitat and reduced protection of the shoreline. There are a number of NIWs along the coast close to Beehive-1 (Ord Estuary System, Legune Wetlands, Moyle Floodplain and Hyland Bay System, Daly-Reynolds Floodplain Estuary System, Finniss Floodplain and Fog Bay System). Damage to mangroves and saltmarsh within these NIWs will impact on their ecological values, including potential loss of habitat for sawfish species, crocodiles and various shorebird species, such as magpie geese that breed in the Legune Wetlands.
Inherent impact consequence	Severe

Table 8.28. Sensitivity and consequence evaluation of hydrocarbon exposure to intertidal communities – sandy beaches

General sensitivity to oiling – sandy beaches	
Sensitivity rating of sandy beaches:	Low
A description of sandy beaches in the spill EMBA is provided in:	Appendix 11, Section 11.2.1

Sandy beaches are regularly exposed to wave action and have low sediment total organic carbon and therefore generally a low abundance of marine life (Hook *et al*., 2016). The low concentration of total organic carbon (TOC) and large particle size of sand means that oil deposited on the beach would not generally be retained. However, sandy beaches are important socio-economically, so hydrocarbons reaching this type of shoreline may attract attention that is disproportionate to its sensitivity (Hook *et al*., 2016). Sediment grain sizes between 2 and 64 mm are not considered sensitive to oil spills because they are regularly cleaned by wave action and have low TOC and therefore a low diversity and abundance of marine life (Hook *et al*., 2016).

The depth of penetration in sandy sediment is influenced by:

- Particle size - penetration is great in coarser sediments (such as beach sand) compared to finder sediments and mud;
- Oil viscosity – light oil quickly penetrates sandy sediments (compared to heavy oil);
- Drainage – coarse beach sands allow for rapid drainage (it may reach depths greater than one metre in coarse well-drained sediments); and
- Animal burrows and root pores - penetration into fine sediments is increased if there are burrows of animals such as worms, or pores left where plant roots have decayed.

Areas of heavy oiling (>1,000 g/m^2 threshold) would likely result in acute toxicity, and death, of many invertebrate communities, especially where oil penetrates into sediments through animal burrows (IPIECA, 1999). However, these communities would be likely to rapidly recover (recruitment from unaffected individuals and recruitment from nearby areas) as oil is removed from the environment. The results of exposure to oil may be acute (e.g., die off of amphipods and replacement by more tolerant species such as worms or chronic (i.e., gradual accumulation of oil and genetic damage) (Hook *et al*., 2016).

For example, following the *Sea Empress* spill (in west Wales, 1996) many amphipods (sandhoppers), cockles and razor shells were killed. There were mass strandings on many beaches of both intertidal species (such as cockles) and shallow sub-tidal species. Similar mass strandings occurred after the *Amoco Cadiz* spill (in Brittany, France, 1978) (IPIECA, 1999). Following the *Sea Empress* spill, populations of mud snails recovered within a few months but some amphipod populations had not returned to normal after one year. Opportunists such as some species of worm may actually show a dramatic short-term increase following an oil spill (IPIECA, 1999). Long-term depletion of sediment fauna could have an adverse effect on birds or fish that use tidal flats as feeding grounds (IPIECA, 1999).

In March 2014, small volumes of crude oil from an unidentified source (confirmed to not be offshore oil and gas production facilities) washed up along a 7-km section of sandy beach on the Victorian Gippsland coast as small (a few millimetres thick) granular balls (Gippsland Times, 2014; ABC News, 2014). AMSA (2014b) reported that no impacts were observed over the course of two months following the incident.

The *Deepwater Horizon* Macondo well blowout resulted in oil washing up on sandy beaches of the Alabama coastline. The natural movement of sand and water through the beach system continually transformed and re-distributed oil within the beach system, and 18 months after the event, mobile remnant oil remained in various states

of weathering buried at different depths in the beaches (Hayworth *et al*., 2011). Other results from beach sampling undertaken at Dauphin Island, Alabama, in May (pre-impact) and September 2011 (post-impact) found a large shift in the diversity and abundance of microbial species (e.g., nematodes, annelids, arthropods, polychaetes, protists, fungi, algae and bacteria). Post-spill, sampling indicated that species composition was almost exclusively dominated by a few species of fungi. DNA analyses revealed that the 'before' and 'after' communities at the same sites weren't closely related to each other (Bik *et al*., 2012). Similar studies found that oil deposited on the beaches caused a shift in the community structure toward a hydrocarbonoclastic consortium (petroleum hydrocarbon degrading microorganisms) (Lamendella *et al*., 2014).

Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Not applicable.
Water column	Not applicable.

Shoreline	Much of the shoreline within the ecological spill EMBA is dominated by mangroves and rocky shores, interspersed with short sections of sandy beaches.
	The shoreline sectors with large areas of sandy beaches with the highest probability of moderate to high exposure are:
	• Wyndham-East Kimberley (WA) - up to 93% probability of contact, up to 408 m^3 of oil. Specifically within this sector, the following WAMOPRA shoreline cells (defined by the WA DoT) contain expanses of sandy beaches:
	  ○ East Cape Domett to NT/WA Border (B) (Cape Domett – DoT Cell 2) - up to 38% probability of contact, up to 46.6 m^3 oil.
	  ○ Easte Cape Dommet - WA/NT Border C (Lacrosse Island – DoT Cell 3) - up to 52% probability of contact, up to 69 m^3 oil.
	  ○ Cape Bernier - Elsie Island N (Berkeley River - DoT Cell 10) - up to 38% probability of contact, up to 101.3 m^3 oil.
	  ○ Cape Talbot – Cape Londonderry B (DoT Cell 16) - up to 16% probability of contact, up to 4.7 m^3 oil.
	  ○ Low island Point – Anjo A (Sir Graham Moore Island – DoT Cell 17) - up to 33% probability of contact, up to 61.5 m^3 oil
	• Thamarrurr (NT) – up to 74% probability of contact, up to 271 m^3 of oil;
	• Daly (NT) – up to 41% probability of contact, up to 200 m^3 of oil (only during the summer period); and
	• Browse Island (WA) - up to 27% probability of contact, up to 57 m^3 of oil.
	Areas of low exposure loading to shoreline (<10 g/m^2) are not expected to exhibit ecological harm.
	Areas of high oil loading may result in acute toxicity impacts and therefore reduced infauna diversity and abundance, such as the loss of amphipods and replacement by more tolerant species, such as worms (Hook *et al*., 2016). This may then impact on species such as shorebirds and seabirds that feed on these animals.

	See Table 8.32 for impacts to turtles nesting in sandy beaches and Table 8.33 for shorebirds. Due to the remoteness of the coastline of the socio-economic EMBA, there is predicted to be negligible impacts to the socio-economic values of sandy beaches. There is little tourism in this region and the year-round presence of crocodiles and seasonal presence of stinging jellyfish means beaches are not used recreationally like they are in other parts of Australia. Isolated sections of the western shoreline of Bathurst Island are predicted to have some shoreline contact only in the summer metocean season (4-9% probability of contact at the low threshold) with low shoreline loadings (4-12 m^3). These beaches are located over 50 km from the Aboriginal township of Wurrumiyanga on the island (and 25 km from Pirlangimpi on Melville Island) and is not predicted to have any significant impacts on traditional beach-based fishing or recreational activities.
Inherent impact consequence	Moderate

Table 8.29. Sensitivity and consequence evaluation of hydrocarbon exposure to intertidal communities – rocky shores

General sensitivity to oiling – rocky shores	
Sensitivity rating of rocky shores:	Low
A description of rocky shores in the spill EMBA is provided in:	Appendix 11, Section 11.2.2
Cracks and crevices, rock pools, overhangs and other shaded areas provide habitat for soft bodied animals such as sea anemones, sponges and sea-squirts, and become places where hydrocarbons can become concentrated as it strands ashore. The same is true on stable boulder shores where the rich animal communities underneath the rocks are also the most vulnerable to hydrocarbon pollution. The vulnerability of a rocky shoreline to oiling is dependent on its topography and composition as well as its position. A vertical rock wall on a wave-exposed coast is likely to remain unoiled if an oil slick is held back by the action of the reflected waves. At the other extreme, a gradually sloping boulder shore in a calm backwater of a sheltered inlet can trap enormous amounts of hydrocarbons, which may penetrate deep down through the substratum. The complex patterns of water movement close to rocky coasts also tend to concentrate oil in certain areas. Some shores are well known to act as natural collection sites for litter and detached algae and oil is carried there in the same way. As on all types of shoreline, most of the oil is concentrated along the high tide mark while the lower parts are often untouched (IPIECA, 1995). It is not long before the waves and tides that carried the hydrocarbons onto the shore gradually remove it again, but the rate of such weathering is dependent on many factors. The wave exposure, weather conditions and the shore characteristics are most important. For example, a patch of oil on a rock exposed to heavy wave action is not going to remain there for long. However, it could take many years for the limited water movement in a sheltered bay to remove oil trapped under boulders or in gullies and crevices. Gradual leaching of this oil could result in constant low-level pollution of, for example, a rock pool. Microbial breakdown of the oil is rapid in tropical environments, such as that of northwest Australia. The presence of silt and clay particles can assist with oil removal by the process of flocculation. Grazing animals such as marine snails may also remove significant amounts of oil. As the oil is weathered it becomes more viscous and less toxic, often leaving little but a small residue of tar on upper shore rocks. This residue can remain as an unsightly stain for a long time but it is unlikely to cause any more ecological damage. Oil tends not to remain on wet rock or algae but is likely to stick firmly if the rock is dry (IPIECA, 1995). Rocky shorelines are generally considered not to be sensitive environments (Hook *et al*., 2016).	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Not applicable.
Water column	Not applicable.
Shoreline	Much of the shoreline within the ecological spill EMBA is dominated by rocky shores. The shoreline sectors with the largest sections of rocky shorelines and with the highest probability of moderate to high exposure are: • Wyndham-East Kimberley - up to 93% probability of contact, up to 408 m^3 of oil. Specifically within this sector, the following WAMOPRA shoreline cells (defined by the WA DoT) contain expanses of rocky shores:

	○ Bare Hill – East Cape Domett E (DoT Cell 8) - up to 60% probability of contact, up to 40.2 m^3 oil. ○ Aunty Islet - Thurburn Bluff (DoT Cell 9) - up to 63% probability of contact, up to 79.1 m^3 oil. ○ Unnamed Head – Cape Rulhieres A (DoT Cell 11) - up to 84% probability of contact, up to 183.9 m^3 oil. ○ Cape Rulhieres – Cape Bernier (DoT Cell 12) - up to 80% probability of contact, up to 55.7 m^3 oil. ○ Cape Rulhieres - Unnamed Head B (King George River - DoT Cell 13) - up to 75% probability of contact, up to 52.2 m^3 oil. ○ Cape Talbot – Cape Londonderry A (DoT Cell 15) - up to 35% probability of contact, up to 15.7 m^3 oil. ○ Cape Talbot – Cape Londonderry B (DoT Cell 16) - up to 16% probability of contact, up to 4.7 m^3 oil. ○ Low Island Point – Anjo A (DoT Cell 17) - up to 33% probability of contact, up to 61.5 m^3 oil. ○ Cape Bougainville - Low Island Point A (DoT Cell 19) - up to 39% probability of contact, up to 24.4 m^3 oil. • Thamarrurr (NT) – up to 74% probability of contact, up to 271 m^3 of oil; • Daly (NT) – up to 41% probability of contact, up to 200 m^3 of oil (only during the summer period); and • Browse Island (WA) - up to 27% probability of contact, up to 57 m^3 of oil. Areas of high oil loading may result in acute toxicity impacts and therefore reduced infauna diversity and abundance, such as the loss of macroalgae, lichen, sponges, bivalves and crustaceans (Hook *et al*., 2016). The large tidal range in the northwest region is expected to result in stranded oil being removed by the next tide once it's deposited. In high energy regions, where waves are crashing into the rocks, weathering will be rapid and it is not expected that oil would remain for a long period of time. There are no threatened species in the ecological spill EMBA known to be dependent on rocky shores.
Inherent impact consequence:	Moderate

Table 8.30. Sensitivity and consequence evaluation of hydrocarbon exposure to intertidal communities – tidal flats

General sensitivity to oiling – tidal flats	
Sensitivity rating of tidal flats	Medium
A description of tidal flats in the spill EMBA is provided in:	Appendix 11, Section 11.2.3
Tidal flats (also referred to as mud flats) are often associated with mangrove or saltmarsh environments. Tidal flats provide sheltered habitats that can provide a nursery ground for many species of fish and crustacean and provide shelter or nesting areas for birds. Sediments within tidal flats are typically of small grain size/fine mud that are high in total organic carbon and consequently deficient of oxygen (i.e., anoxic). Any oil that is deposited into tidal flats is likely to be persistent, due to low wave energy and slow rates of biodegradation (Hook *et al*., 2016). A survey of intertidal areas in Kuwait and Saudi Arabia conducted 12 years after the Gulf War oil spill found that oil was most persistent in tidal flat areas, with half of all samples taken still causing risk of environmental toxicity due to elevated PAH concentrations (Bejarano and Michel, 2010). Sedimentary infauna may be sensitive to oil. Studies have identified that small crustaceans (such as amphipods and crabs), some bivalves and surface grazing snails are sensitive to oil toxicity, whilst other taxa such as polychaete worms may have an opportunistic increase in abundance (Law *et.al.,* 2011). These species may also be sensitive to any clean-up efforts, especially those that translocate sediments. Oil that is present in these environments may be accumulated by sediment invertebrates and pose a risk to feeding migratory shorebirds (Velando *et al*., 2010). Shorebird species foraging for invertebrates on exposed sand and mud flats at lower tides will be at risk of both direct impacts through contamination of individual birds (ingestion or soiling of feathers) and indirect impacts through the contamination of foraging areas that may result in a reduction in available prey items (Clark, 2010). Mud flats and samphire communities may be exposed to entrained/dissolved condensate above impact thresholds. Any impacts to benthic habitats are expected to be localised and of short to medium term with a moderate consequence.	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Not applicable.
Water column	Not applicable.
Shoreline	The shoreline sectors with the largest sections (by length) of tidal flats and with the highest probability of moderate to high exposure are: • Derby-West Kimberley (WA) – the OSTM predicted there is no probability of moderate to high exposure, and a 2% probability of low exposure contact of up to 1.1 m^3 of oil. Specifically within this sector, the following WAMOPRA shoreline cells (defined by the WA DoT) contain expanses of tidal flats: o Shale Island – Raft Point (Wallcott Inlet – DoT Cell 45) – no identified exposure.

	○ Meda River Mouth Spit SW – Helpman Island B (Dot Cell 55) – no identified exposure. ○ Point Tormet - Meda River Mouth spit SW A, B (Derby - DoT Cell 56, 57) – no identified exposure. ○ Jangerie- Point Torment A, B (DoT Cell 58, 59) - no identified exposure. • Wyndham-East Kimberley (WA) - up to 93% probability of contact, up to 408 m^3 of oil. Specifically within this sector, the following WAMOPRA shoreline cells (defined by the WA DoT) contain expanses of tidal flats: ○ East Cape Domett – WA/NT Border C (Cambridge Gulf – DoT Cell 3) up to 52% probability of contact, up to 69 m^3 oil. ○ Cape Bernier - Elsie Island N (Berkeley River - DoT Cell 10) up to 38% probability of contact, up to 101.3 m^3 oil. ○ Cape Talbot - Cape Londonderry B (Drysdale River – DoT Cell 16) up to 16% probability of contact, up to 4.7 m^3 oil. ○ Low Island Point – Anjo A (Drysdale River – DoT Cell 17) up to 33% probability of contact, up to 61.5 m^3 oil. ○ Cape Bougainville - Low Island Point B (DoT Cell 20) – no identified exposure; ○ Davidson Point - Crystal Head A (Port Warrender - DoT Cell 24) up to 3% probability of contact, up to 1.1 m^3 oil. ○ Davidson Point - Crystal Head B (Mitchell River – DoT Cell 25) – no identified exposure. Areas of moderate to high loading may result in acute toxicity impacts and therefore reduced infauna diversity and abundance, such as the loss of bivalves and small crustaceans (Hook *et al*., 2016). Species such as green sawfish, nunivak bar-tailed godwit and migratory shorebirds such as lesser sand plovers and eastern curlew are known to have a strong association (either habitat for fish and/or foraging for shorebirds) with tidal flats within the ecological spill EMBA.
Inherent impact consequence:	Moderate

Table 8.31. Sensitivity and consequence evaluation of hydrocarbon exposure to oceanic communities - plankton

General sensitivity to oiling – plankton	
Sensitivity rating of plankton:	Low
A description of plankton communities in the spill EMBA is provided in:	Appendix 11, Section 11.3.3
Plankton is found in nearshore and open waters beneath the surface in the water column. These organisms migrate vertically through the water column to feed in surface waters at night (NRDA, 2012). As they move close to the sea surface it is possible that they may be exposed to both surface hydrocarbons but to a greater extent, hydrocarbons dissolved or entrained in the water column. Phytoplankton is typically not sensitive to the impacts of oil, though they do accumulate it rapidly due to their small size and high surface area to volume ratio (Hook *et al*., 2016). If phytoplankton is exposed to hydrocarbons at the sea surface, this may directly affect their ability to photosynthesize and would have implications for the next trophic level in the food chain (e.g., small fish) (Hook *et al*., 2016). In addition, the presence of surface hydrocarbons may result in a reduction of light penetrating the water column, which could affect the rate of photosynthesis for phytoplankton in instances where there is prolonged presence of surface hydrocarbons over an extensive area such that the phytoplankton was restricted from exposure to light. Oil can affect the rate of photosynthesis and inhibit growth in phytoplankton, depending on the concentration range. For example, photosynthesis is stimulated by low concentrations of oil in the water column (10-30 ppb), but become progressively inhibited above 50 ppb. Conversely, photosynthesis can be stimulated below 100 ppb for exposure to weathered oil (Volkman *et al*., 1994). Zooplankton (microscopic animals such as rotifers, copepods and krill that feed on phytoplankton) are vulnerable to hydrocarbons due to their small size and high surface area to volume ratio, along with (in many cases) their high lipid content (that facilitates hydrocarbon uptake) (Hook *et al*., 2016). Water column organisms that come into contact with oil risk exposure through ingestion, inhalation and dermal contact (NRDA, 2012), which can cause immediate mortality or declines in egg production and hatching rates along with a decline in swimming speeds (Hook *et al*., 2016). Plankton is generally abundant in the upper layers of the water column and acts as the basis for the marine food web, meaning that a hydrocarbon spill in any one location is unlikely to have long-lasting impacts on plankton populations at a regional level. Variations in the temporal scale of oceanographic processes typical of the ecosystem have a greater influence on plankton communities than the direct effect of spilt hydrocarbons. This is because reproduction by survivors or migration from unaffected areas would be likely to rapidly replenish any losses from permanent zooplankton (Volkman *et al*., 1994). Field observations from oil spills show minimal or transient effects on marine plankton (Volkman *et al*., 1994). Once background water quality conditions have re-established, the plankton community will take weeks to months to recover (ITOPF, 2011a), allowing for seasonal influences on the assemblage characteristics.	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Plankton found in open water of the ecological spill EMBA is expected to be widely represented in the northwest region as a result of the southerly movement of the Indonesian Throughflow and the southeast and northwest monsoonal wind-driven currents (Brewer *et. al*., 2007). Plankton in the upper water column are likely to be directly (e.g., through smothering and ingestion) and indirectly (e.g.,

Water column	toxicity from decrease in water quality and bioaccumulation) affected by surface, dissolved and entrained hydrocarbons at the moderate and high thresholds. Because the area affected by a spill will be smaller than that of the ecological EMBA (because the EMBA represents a combination of 100 random simulations, see also the deterministic OSTM results in Figures 8.7, 8.11, 8.15 and 8.19), once background water quality conditions are re-established following the natural weathering and dispersion of the hydrocarbons, plankton populations are expected to recover rapidly due to recruitment of plankton from surrounding waters.
Shoreline	Not applicable.
Inherent impact consequence:	Moderate

Table 8.32. Sensitivity and consequence evaluation of hydrocarbon exposure to oceanic communities - fish

General sensitivity to oiling –fish	
Sensitivity rating of fish (normal range):	Low
Sensitivity rating of fish (spawning habitats):	Medium
A description of fish in the spill EMBA is provided in:	Appendix 11, Section 11.3.4

The behaviours and habitat preferences of fish species (including sharks and rays) determine their potential for exposure to hydrocarbons and the resulting impacts. Demersal species may be susceptible to oiled sediments, particularly species that are site-restricted. Pelagic species that occupy the water column are more susceptible to entrained and dissolved hydrocarbons, however generally these species are highly mobile and as such are not likely to suffer extended exposure due to their patterns of movement. The exception would be in areas such as reefs and other seabed features where species are less likely to move away into open waters (i.e., they area site-attached).

Fish are exposed to hydrocarbon droplets through a variety of pathways, including:

- Direct dermal contact (e.g., swimming through oil or waters with elevated dissolved hydrocarbon concentrations and other constituents, with diffusion across their gills (Hook *et al*., 2016));
- Ingestion (e.g., directly or via food base, fish that have recently ingested contaminated prey may themselves be a source of contamination for their predators); and
- Inhalation (e.g., elevated dissolved contaminant concentrations in water passing over the gills).

Exposure to hydrocarbons at the surface or entrained or dissolved in the water column can be toxic to fish. Studies have shown a range of impacts including changes in abundance, decreased size, inhibited swimming ability, changes to oxygen consumption and respiration, changes to reproduction, immune system responses, DNA damage, visible skin and organ lesions, and increased parasitism. However, many fish species can metabolise toxic hydrocarbons, which reduces the risk of bioaccumulation of contaminants in the food web (and human exposure to contaminants through the consumption of seafood) (NRDA, 2012).

Sub-lethal impacts in adult fish include altered heart and respiratory rates, gill hyperplasia, enlarged liver, reduced growth, fin erosion, impaired endocrine systems, behavioural modifications and alterations in feeding, migration, reproduction, swimming, schooling and burrowing behaviour (Kennish, 1996). However, fish are high mobile and unlikely to remain in the area of a spill for long enough to be exposed to sub-lethal doses of hydrocarbons.

Fish are most vulnerable to hydrocarbon discharges during their embryonic, larval and juvenile life stages. Eggs and larvae of many fish species are highly sensitive to oil exposure, resulting in decreased spawning success and abnormal larval development (see ‘Plankton’).

Since fish and sharks do not generally break the sea surface, the impacts of surface hydrocarbons to fish and shark species are unlikely to occur. Near the sea surface, fish are able to detect and avoid contact with surface slicks meaning fish mortalities rarely occur in the event of a hydrocarbon spill in open waters (Volkman *et al*.,

1994). As a result, wide-ranging pelagic fish of the open ocean generally are not highly susceptible to impacts from surface hydrocarbons. Adult fish kills reported after oil spills occur mainly to shallow water, near-shore benthic species (Volkman *et al*., 1994).

Hydrocarbon in the water column can physically affect reef fish (that have high site fidelity and cannot move out of harm's way) exposed for an extended duration (weeks to months) by coating of gills, leading to lethal and sub-lethal effects from reduced oxygen exchange and coating of body surfaces that may lead to increased incidence of irritation and infection. Fish may also ingest hydrocarbon droplets or contaminated food, leading to reduced growth (Volkman *et al*., 1994).

The threshold value for species toxicity in the water column is based on global data from French et al (1999) and French-McCay (2002, 2003), which showed that species sensitivity (fish and invertebrates) to dissolved aromatics exposure >4 days (96-hour LC_{50}) under different environmental conditions varied from 6 to 400 µg/L (ppb), with an average of 50 ppb. This range covered 95% of aquatic organisms tested, which included species during sensitive life stages (eggs and larvae). Based on scientific literature, a minimum threshold of 6 ppb over 96 hours or equivalent was used to assess in-water low exposure zones, respectively (Engelhardt, 1983; Clark, 1984; Geraci and St Aubin, 1988; Jenssen, 1994; Tsvetnenko, 1998). French-McCay (2002) indicates that an average 96-hour LC_{50} of 50 ppb and 400 ppb could serve as an acute lethal threshold to 50% and 97.5% to biota, respectively.

Studies of oil impacts on bony fish report that light, volatile oils are likely to be more toxic to fish. Many studies conclude that exposure to PAHs and soluble compounds are responsible for the majority of toxic impacts observed in fish (e.g., Carls *et al*., 2008; Ramachandran *et al*., 2004). A range of lethal and sub-lethal effects to fish in the larval stage has been reported at water-accommodated fraction (WAF) hydrocarbon concentrations (48–hour and 96-hour exposures) of 0.001 to 0.018 ppm during laboratory exposures (Carls *et al*., 2008; Gala, 2001). In contrast, wave tank exposures reported much higher lethal concentrations (14-day LC_{50}) up to 1.9 ppm for herring embryos and up to 4.3 ppm for juvenile cod (Lee *et al*., 2011).

Toxicity in adult fish has been reported in response to crude oils, HFO and diesel (Holdway, 2002; Shigenaka, 2011). Uptake of hydrocarbons has been demonstrated in bony fish after exposure to WAF of between 24 and 48 hours. Danion et al (2011) observed PAH uptake of 148 µg/kg-1 after 48-hour exposures to PAH from Arabian Crude at high concentrations of 770 ppm. Davis et al (2002) report detectable tainting of fish flesh after a 24-hour exposure at crude concentrations of 0.1 ppm, marine fuel oil concentrations of 0.33 ppm and diesel concentrations of 0.25 ppm. The majority of studies, either from laboratory trials or of fish collected after spill events (including the *Hebei Spirit*, *Macondo*, and *Sea Empress* spills) find evidence of elimination of PAHs in fish tissues returning to reference levels within two months of exposure (Challenger and Mauseth, 2011; Davis *et al*., 2002; Gagnon & Rawson, 2011; Gohlke *et al*., 2011; Jung, 2011; Law, 1997; Rawson *et al*., 2011).

The toxicity of dissolved hydrocarbons and dispersed oil to fish species has been the subject of a number of laboratory studies (AMSA, 1998). Generally, concentrations in the range of 0.1–0.4 mg/L dispersed oil have been shown to cause fish deaths in laboratory experiments (96-hour LC_{50}). No reported studies of the impacts of oil spills on cartilaginous fish (including sharks, rays and sawfish) were found in the literature. It is not known how the data on the sensitivity of bony fishes would relate to toxicity in cartilaginous fishes.

The assessment of effects on fish species in the Timor Sea as a result of the Montara well blowout (a light gas condensate), conducted from November 2009 to November 2010 undertaken by Gagnon & Rawson (2011), found that of the species studied (mostly goldband snapper *Pristipomoides multidens*, red emperor *Lutjanus sebae*, rainbow runner *Elegatis bipinnulata* and Spanish mackerel *Scomberomorus commerson*), all 781 specimens were in good physical health at all sites. Results show that:

- Phase 1 study (November 2009, immediately after the blowout ceased) - indicated that in the short-term, fish were exposed to and metabolised petroleum hydrocarbons, however no consistent adverse effects on fish health or their reproductive activity were detected.
- Phase 2 study (March 2010, 5 months after the blowout ceased) – indicated continuing exposure to petroleum hydrocarbons, as detected by elevated liver detoxification enzymes and PAH biliary metabolites in three out of four species collected close to the MODU, and elevated oxidative DNA damage.
- Phase 3 study (November 2010, 12 months after the blowout ceased) – showed a trend towards a return to reference levels with often, but not always, comparable biomarker levels in fish collected from reference and impacted sites. This evidence of exposure to petroleum hydrocarbons at sites close to the spill location suggest an ongoing trend toward a return to normal biochemistry/physiology (Gagnon & Rawson, 2011).

The main finding of the Gagnon & Rawson (2011) study concluded that there were no detectable petroleum hydrocarbons found in the fish muscle samples, limited ill effects were detected in a small number of individual fish, and no consistent adverse effects of exposure on fish health could be detected within two weeks following the end of the well release. Notwithstanding, fishes from close to the Montara well, collected seven months after the discharge began, showed continuing exposure to hydrocarbons in terms of biomarker responses. Two years after the discharge, biomarker levels in fishes had mostly returned to reference levels, except for liver size. However this was potentially attributed to local nutrient enrichment, or to past exposure to hydrocarbons. Fishes near Heyward Shoal, approximately 100 km southwest of the Montara well, had elevated biomarker responses indicating exposure to hydrocarbons, but were collected close to the Cornea natural hydrocarbon seep. Studies on the Montara discharge have shown recovery in terms of the abundance and composition of fishes, and toxicological and physiological responses of fishes.

Sampling from January 2010 to June 2011 by the University of South Alabama and Dauphin Island Sea Lab found no significant evidence of diseased fish in reef populations off Alabama or the western Florida Panhandle as a result of the Macondo well blowout in the Gulf of Mexico (BP, 2014).

No reports of oil spills in open waters have been reported to cause fish kills (though mortality in aquaculture pens has), which is likely to be because vertebrates can rapidly metabolise and excrete hydrocarbons (Hook *et al*., 2016).

Recovery of fish assemblages depends on the intensity and duration of an unplanned discharge, the composition of the discharge and whether dispersants are used, as each of these factors influences the level of exposure to potential toxicants. Recovery would also depend on the life cycle attributes of fishes. Species that are abundant, short-lived and highly fecund may recover rapidly. However less abundant, long-lived species may take longer to recover. The range of movement of fishes will also influence recovery. The nature of the receiving environment would influence the level of impact on fishes.

Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	There is an extensive area in which moderate and high threshold hydrocarbons are predicted to occur on the sea surface. Fish associated with rafts of floating seaweed, such as syngnathid species, may come into contact with surface oil. Long exposure to the oil is likely to result in chronic toxicity effects, which is likely to lead to localised population reductions. The majority of fish tend to remain in the mid-pelagic zone, so they are not likely to come into contact with surface hydrocarbons.
Water column	Impacts to fish from exposure to hydrocarbons in the water column is likely to be spatially limited to the areas of moderate (for dissolved hydrocarbons) and high (for entrained hydrocarbons) threshold exposure and temporally limited due to the rapid weathering of the oil and the open, well-mixed waters of the JBG and Indian Ocean. NOAA (2013) and ITOPF (2011a) state that

	hydrocarbon spills in open water are so rapidly diluted that fish kills are rarely observed. Fish such as southern bluefin tuna and sharks such as the great white shark, shortfin mako and oceanic whitetip shark are highly mobile species and as such they are unlikely to remain in one area for a long period of time, minimising the risk that they would be exposed to toxic levels of hydrocarbons. Fish species with BIAs in the ecological spill area are: • Dwarf sawfish – this species is known to occur as adults and juveniles in waters 2-3 m deep along the coast of the ecological spill EMBA. Pupping is known to occur in the Keep River Estuary (NT) west of the Victoria River estuary. If long sections of coastline are impacted by dissolved and entrained oil, this species may not have alternative habitat to retreat to, so chronic toxicity affects may occur to multiple individuals, resulting in population reductions. • Green sawfish – this species is known to occur as adults and juveniles in waters along the coast of the ecological spill EMBA south of Derby along the Pilbara coastline, and there are also pupping areas likely to occur south of Broome (outside the ecological EMBA). If long sections of coastline are impacted by dissolved and entrained oil, this species may not have alternative habitat to retreat to, so chronic toxicity affects may occur to multiple individuals, resulting in population reductions. • Whale shark – foraging BIA is located outside of the JBG, so in the event of a LoWC, it is unlikely to be exposed to oil at the moderate or high threshold based on deterministic OSTM. At low thresholds, there would be little to no ecological impacts to this species. They are also unlikely to be present in the region at the time of drilling. Because vertebrate fish species can rapidly metabolise and excrete hydrocarbons (Hook *et al*., 2016), PAH levels in fish are expected to return to pre-spill levels within several months. Impacts to individuals and some populations will occur but are likely to be short-term. Widespread effects to fish populations (in terms of diversity and abundance) are not expected as a result of a LoWC based on the information presented for 'sensitivity to oil' and because of the wide geographical distribution of many of the fish species known to occur in the ecological spill EMBA.
Shoreline	Not applicable.
Inherent impact consequence:	Moderate

Table 8.33. Sensitivity and consequence evaluation of hydrocarbon exposure to oceanic communities - marine mammals

General sensitivity to oiling – marine mammals	
Sensitivity rating of marine mammals (breeding, aggregation, feeding areas):	High
Sensitivity rating of marine mammals (migration)	Medium
A description of cetaceans in the spill EMBA is provided in:	Appendix 11, Section 11.3.5

The pathways for exposure to oil to marine mammals (whales, dolphins and dugongs) is through:

- Internal exposure by consuming oil or contaminated prey;
- Inhaling volatile oil compounds when surfacing to breathe;
- Dermal contact, by swimming in oil and having oil directly on the skin and body; and
- Maternal transfer of contaminants to embryos (NRDA, 2012; Hook *et al*., 2016).

The effects of this exposure include:

- Hypothermia due to conductance changes in skin, resulting in metabolic shock (expected to be more problematic for non-cetaceans in colder waters);
- Toxic effects and secondary organ dysfunction due to ingestion of oil;
- Congested lungs;
- Damaged airways;
- Interstitial emphysema due to inhalation of oil droplets and vapour;
- Gastrointestinal ulceration and haemorrhaging due to ingestion of oil during grooming and feeding;
- Eye and skin lesions from continuous exposure to oil;
- Decreased body mass due to restricted diet; and
- Stress due to oil exposure and behavioural changes.

French-McCay (2009) identifies that a 10-25 µm oil thickness threshold has the potential to impart a lethal dose on marine species, however also estimates a probability of 0.1% mortality to cetaceans if they encounter these thresholds based on the proportion of the time spent at surface. Direct surface oil contact with hydrocarbons is considered to have little deleterious effect on whales, possibly due to the skin's effectiveness as a barrier to toxicity, and effect of oil on cetacean skin is probably minor and temporary (Geraci & St Aubin, 1988). Cetaceans in particular have mostly smooth skins with limited areas of pelage (hair covered skin) or rough surfaces such as

barnacled skin. Oil tends to adhere to rough surfaces, hair or calluses of animals, so contact with hydrocarbons by whales and dolphins may cause only minor hydrocarbon adherence.

The physical impacts from ingested hydrocarbon with subsequent lethal or sub-lethal impacts are both applicable to entrained oil. However, the susceptibility of cetaceans varies with feeding habits. Baleen whales (such as blue, southern right and humpback whales) are not particularly susceptible to ingestion of oil in the water column but are susceptible to oil at the sea surface as they feed by skimming the surface. Oil may stick to the baleen while they 'filter feed' near slicks. Sticky, tar-like residues are particularly likely to foul the baleen plates.

The inhalation of oil droplets, vapours and fumes is a distinct possibility if whales' surface in slicks to breathe. Exposure to hydrocarbons in this way could damage mucous membranes, damage airways or even cause death.

Toothed whales and dolphins may be susceptible to ingestion of dissolved and entrained oil as they gulp feed at depth. There are reports of declines in the health of individual pods of killer whales (a toothed whale species), though not the population as a whole, in Prince William Sound after the *Exxon Valdez* vessel spill (heavy oil) (Hook *et al*., 2016).

It has been stated that pelagic species will avoid hydrocarbons, mainly because of its noxious odours, but this has not been proven. The strong attraction to specific areas for breeding or feeding (e.g., use of the Camden Sound as a nursery area for humpback whales) may override any tendency for cetaceans to avoid the noxious presence of hydrocarbons. So weathered or tar-like oil residues can still present a problem by fouling baleen whale feeding systems.

Dolphin populations from Barataria Bay, Louisianna, USA, which were exposed to prolonged and continuous oiling from the Macondo oil spill in 2010, had higher incidences of lung and kidney disease than those in the other urbanised environments (Hook *et al*., 2016). The spill may have also contributed to unusually high perinatal mortality in bottlenose dolphins (Hook *et al*., 2016).

As highly mobile species, in general it is very unlikely that cetaceans will be constantly exposed to concentrations of hydrocarbons in the water column for continuous durations (e.g., >96 hours) that would lead to chronic toxicity effects.

<u>Dugong</u>

Dugongs can be exposed to oil in the same manner as whales and dolphins, as well as through ingestion of contaminated seagrass and sediments. Hook et al (2016) reports that no studies specifically report on the sensitivities of dugong to oil. Given that dugong consume vast amounts of seagrass, if the seagrass is contaminated, there is a high likelihood that acute toxicity and mortality may eventuate, or chronic long-term effects may result (such as organ damage).

Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Exposure to moderate and high thresholds of hydrocarbons at the sea surface is predicted to occur over a small portion of the JBG. The BIAs for the following marine mammal species are listed in Table 11.6 of Appendix 11; pygmy blue whale, humpback whale, Australian humpback dolphin, Australian snubfin dolphin, Indo-Pacific spotted bottlenose dolphin, and dugong. None of these BIAs are overlapped by the extent of moderate and high threshold oil, so impacts such as coating of skin when they surface are not expected. The seasonality of the presence of these species in the region also means they may not all be present at the time of drilling.

	Dugongs may be present along the Dampier Peninsula (the coastline north and south of Broome) and Cape Londonderry where seagrass meadows are present. In this area, the OSTM predicts no exposure for surface hydrocarbons. As such, there should be no ecological effects on individuals or dugong populations as they surface to breathe.
Water column	The ecological spill EMBA for dissolved and entrained hydrocarbons overlaps with seasonal presence for most of the marine mammals described in Section 11.3.5 of Appendix 11, except for dugong, which are known to occur in Ashmore Reef, around the Dampier Peninsula and at Vansittart Bay (near Bougainville), where dissolved and entrained hydrocarbons are predicted to occur in low concentrations and therefore not have ecological impacts. Impacts to cetaceans from exposure to hydrocarbons in the water column is likely to be spatially limited to the areas of moderate (for dissolved hydrocarbons) and high (for entrained hydrocarbons) threshold exposure and temporally limited due to the rapid weathering of the oil and the open, well-mixed waters of the JBG and Indian Ocean. The impacts are likely to be as per those described in 'sensitivity to oil', with effects such as injury (infections, lesions, disease, reduced growth, growth abnormalities) or mortality as a result of ingestion of oil, contact with and absorption through skin and inhalation at surface. Of the threatened cetaceans known to occur in the ecological spill EMBA, effects are predicted below: • Sei whale – prefers deep offshore waters, with no BIAs in the EMBA. They may be present in outer extents of the EMBA where water depths are deep, and these are the areas where the concentrations of dissolved and entrained hydrocarbons are low (due to distance from the well). Impact consequence to this species is therefore low. • Bryde's whale – may be present in the ecological spill EMBA, with no BIAs in the EMBA. If present during a spill, impact consequences may be as described in 'sensitivity to oil' and the severity would depend on the number of individuals exposed to oil. They mostly feed on pelagic fish (which are at low risk of impacts from a spill) and small crustaceans. • Blue whale – most likely to be present in the outer extents of the spill EMBA (northwest Australia) from September to December. This is outside the drilling period, so the impact consequence to this species is therefore negligible. • Fin whale – prefers deep offshore waters, with no BIAs in the EMBA. They may be present in outer extents of the EMBA where water depths are deep, and these are the areas where the concentrations of dissolved and entrained hydrocarbons are low (due to distance from the well). Impact consequence to this species is therefore low. In general, the low likelihood of having high numbers of marine mammals in the ecological spill EMBA, the absence of resident populations, seasonality of movements, their highly mobile nature and absence of BIAs in and around the operational area (where hydrocarbon concentrations will be highest) means that the impacts of a LoWC are likely to be limited to a small number of individuals in localised areas. Displacement behaviours and sub-lethal biological effects could occur to cetaceans.

	Where dugongs may be present (see above), the OSTM predicts low exposure for entrained hydrocarbons and no exposure to dissolved hydrocarbons. Their foraging BIA is not overlapped by the ecological spill EMBA. As such, there should be no ecological effects on individuals or dugong populations.
Shoreline	Not applicable.
Consequence evaluation based on an assessment against the EPBC Act *Significant Impact Guidelines 1.1* (DoE, 2013)	
This hydrocarbon spill scenario will not have a 'significant' impact on threatened cetacean species (see Section 5.3.5) when assessed against the EPBC Act *Significant Impact Guidelines 1.1* (DoE, 2013), which are:	
• Lead to a long-term decrease in the size of a population.	A spill would not lead to a long-term decrease in the size of a population given the small area of impact from a single spill, the rapid weathering of the crude and the low likelihood of a large portion of a cetacean population being present in the spill area at any one time.
• Reduce the area of occupancy of the species.	Given the small area of 'swept ocean' from a single spill, the rapid weathering of the crude, the area of occupancy may be temporarily reduced (noting that cetaceans may not necessarily avoid a spill at the surface or in the water column), but there will be no long-term reduction in the area of occupancy.
• Fragment an existing population into two or more populations.	In the event of a spill resulting from a LoWC, cetaceans have access to an expansive area of unpolluted waters. A spill would not be expected to split up a single population into two or more populations. A spill does not move quickly enough to result in a migrating population splitting to avoid a spill.
• Adversely affect habitat critical to the survival of a species.	The water quality of the impacted area would be temporarily reduced in the event of a spill. The portion of the oil that entrains or dissolves in the water column, where cetaceans spend the majority of their time, is dependent on ocean conditions during the spill (rough seas result in more entrainment than calm seas). The area affected by the oil is unlikely to form a significant part of marine mammal migration routes, so this habitat is not critical to their survival; they would be exposed to MDO for a very short period of time if a spill occurred during migration (minutes to hours).
• Disrupt the breeding cycle of a population.	Most of the cetacean species known to occur in the activity area and EMBA are not known to breed within these areas (other than the Australian snubfin dolphin, which breeds in Cambridge Gulf). Given the small area of 'swept ocean' from a single spill and the rapid weathering of the crude, it is highly unlikely that the breeding cycle of a cetacean population will be disrupted.
• Modify, destroy, remove, isolate or decrease the availability or quality of	The water quality of the ecological spill EMBA would be temporarily reduced in the event of a spill. Marine habitat will not be modified, destroyed, removed, isolated or decreased to the extent that one or more cetacean species will decline.

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.	A large-scale hydrocarbon spill is highly unlikely to result in the introduction and spread of IMS that are harmful to endangered marine mammals. Vessels that may be involved in the spill response strategies will be subject to strict IMS controls to ensure that ballast water is of 'low risk' and that hulls are free of IMS.
• Introduce disease that may cause the species to decline.	The risk of toxic impacts to individual species or populations is negligible due to the rapid weathering of the crude. The small extent of a single spill further reduces the risk to a small area. As such, it is unlikely that there would be a large number of 'oiled' cetaceans that may then become susceptible to disease.
• Interfere with the recovery of the species.	For all the reasons outlined above, a crude oil spill will not interfere with the recovery of a cetacean species.
Inherent impact consequence: Severe	

Table 8.34. Sensitivity and consequence evaluation of hydrocarbon exposure to oceanic communities - marine reptiles

General sensitivity to oiling – marine reptiles	
Sensitivity rating of marine reptiles (Critical Habitats)	Very High
Sensitivity rating of marine reptiles (turtle breeding/inter-nesting):	High
Sensitivity rating of marine reptiles (migration/foraging):	Medium
A description of marine reptiles in the spill EMBA is provided in:	Appendix 11, Section 11.3.6

Marine reptiles can be exposed to hydrocarbon through ingestion of contaminated prey, inhalation when surfacing to breathe or dermal exposure (Hook *et al*., 2016).

Sea turtles are vulnerable to the effects of oil at all life stages—eggs, post-hatchlings, juveniles, and adults in nearshore waters. Several aspects of sea turtle biology and behaviour place them at particular risk, including a lack of avoidance behaviour, indiscriminate feeding in convergence zones, and large pre-dive inhalations. Effects of oil on turtles include increased egg mortality and developmental defects, direct mortality due to oiling in hatchlings, juveniles, and adults; and negative impacts to the skin, blood, digestive and immune systems, and salt glands. Oil exposure affects different turtle life stages in different ways. Each turtle life stage frequents a habitat with notable potential to be impacted during an oil spill. Thus, information on oil toxicity needs to be organized by life stage. Turtles may be exposed to chemicals in oil in two ways:

- Internally – eating or swallowing oil, consuming prey containing oil-based chemicals, or inhaling of volatile oil related compounds; and
- Externally – swimming in oil or dispersants, or oil or dispersants on skin and body.

Records of oiled wildlife during spills rarely include marine turtles, even from areas where they are known to be relatively abundant (Short, 2011). An exception to this was the large number of marine turtles collected (613 dead and 536 live) during the *Macondo* crude oil spill in the GoM, although many of these animals did not show any sign of oil exposure (NOAA, 2013a). Of the dead turtles found, 3.4% were visibly oiled and 85% of the live turtles found were oiled (NOAA, 2013a). Of the captured animals, 88% of the live turtles were later released, suggesting that oiling does not inevitably lead to mortality.

Oil spill impacts to crocodiles is not well studied, with no papers available on toxicity of petroleum to crocodile species. While females generally nest near freshwater rivers and swamps, juvenile crocodiles are often forced out of their river habitat by large territorial males into coastal marine areas or open ocean. Saltwater crocodiles consume a variety of prey and have been observed on the beaches of northern Australia preying on turtle species, specifically nesting females, hatchlings and eggs (Ruberg *et al*., 2021). As a result, crocodiles may be vulnerable to oil spills when swimming in the open ocean and could come in contact with oil when foraging on turtle eggs, nests and hatchlings (Ruberg *et al*., 2021).

Impacts to sea snakes during marine hydrocarbon spills are known from limited assessments, undertaken following the Montara spill in the Timor Sea in 2009. Two dead sea snakes were collected during the incident, one of which was concluded to have died as a result of exposure to the oil, with evidence of inhaled and ingested oil and elevated concentrations of PAHs in muscle tissues. The second snake showed evidence of ingestion by oil but no accumulation in tissues or damage to internal organs and it was concluded that the oil was unlikely to be the cause of death (Curtin University, 2009; 2010).

There is potential for contamination of turtle eggs to result in similar toxic impacts to developing embryos as has been observed in birds. Studies on freshwater snapping turtles showed uptake of PAHs from contaminated nest sediments, but no impacts on hatching success or juvenile health following exposure of eggs to dispersed weathered light crude (Rowe *et al*., 2009). However, other studies found evidence that exposure of freshwater turtle embryos to PAHs results in deformities (Bell *et al*., 2006, Van Meter *et al*., 2006). Turtles may experience oiling impacts on nesting beaches and eggs through chemical exposure, resulting in decreased survival to hatching and developmental defects in hatchlings. Turtle hatchlings may be more vulnerable to smothering as they emerge from the nests and make their way over the intertidal area to the open water (AMSA, 2015). Hatchlings that contact oil residues while crossing a beach can exhibit a range of effects including impaired movement and bodily functions (Shigenaka, 2003). Hatchlings sticky with oily residues may also have more difficulty crawling and swimming, rendering them more vulnerable to predation. Ingested oil may cause harm to the internal organs of turtles. Oil covering their bodies may interfere with breathing because they inhale large volumes of air to dive. Oil can enter cavities such as the eyes, nostrils, or mouth. Turtles may experience oiling impacts on nesting beaches when they come ashore to lay their eggs, and their eggs may be exposed during incubation, potentially resulting in increased egg mortality and/or possibly developmental defects in hatchlings.	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	Exposure to moderate and high thresholds of hydrocarbons at the sea surface is predicted to occur over a small portion of the JBG. The BIAs and critical habitats for marine turtle species are described and mapped in Section 11.3.6 of Appendix 11. There is significant overlap of the flatback turtle nesting critical habitat and inter nesting BIA (present all year, peaking in June-September); green turtle foraging BIA (present all all year, peaking in Nov-March); olive ridley turtle foraging BIA (present all year, peaking Apr-Nov) and lesser overlap with the loggerhead turtle foraging BIA (present all year, peaking Nov-March) with the moderate and high surface oil thresholds within the JBG. Exposure impacts relating to oil inhalation for individuals on surfacing during foraging activities is possible. For an individual spill, the moderate and high surface oiling areas are spatially limited and temporary before weathering and mixing disperses and dilutes the concentrations to low (non-ecological) levels.
Water column	The ecological spill EMBA for dissolved and entrained hydrocarbons overlaps with foraging and inter-nesting BIAs for the loggerhead, green, hawksbill, olive ridley and flatback turtles. Impacts to marine reptiles from exposure to hydrocarbons in the water column is likely to be spatially limited to the areas of moderate to high (for dissolved hydrocarbons) and high (for entrained hydrocarbons) threshold exposure. These impacts will be temporally limited due to the rapid weathering of the oil and the open, well-mixed waters of the JBG and Indian Ocean. The impacts are likely to be as per those described in 'sensitivity to oil.' The potential impacts to each species within the ecological spill EMBA are predicted below:

	• Loggerhead turtle – this species feeds mainly on pelagic species, which in themselves are not overly sensitive to oil spills (see Table 8.31, 'Fish'). The foraging BIA to the immediate north of the JBG is overlapped, with probabilities of exposure to known feeding areas being:
	  ○ Pinnacles of the Bonaparte Basin KEF – 8-37% probability for entrained hydrocarbons and 1-3% probability for dissolved hydrocarbons; and
	  ○ Carbonate Bank and terrace system of the Sahul Shelf KEF – 87-100% probability for entrained hydrocarbons and 85-98% probability for dissolved hydrocarbons.
	• Green turtle – the foraging BIA occurs in the same area and is slightly larger than that for the loggerhead turtle, with the probabilities of exposure therefore being similar.
	• Hawksbill turtle – important foraging areas are located around Ashmore Reef and Cartier Island (also nesting areas), where they feed on a range of pelagic and benthic invertebrates and seagrass and algae that are not highly sensitive to crude oil. These are areas where the concentrations of dissolved and entrained hydrocarbons are low (due to distance from the well) and the probability of exposure to hydrocarbons in the water column is low:
	  ○ Ashmore Reef – 14% probability for entrained hydrocarbons and 1% probability for dissolved hydrocarbons; and
	  ○ Scott Reef – 1-6% probability for entrained hydrocarbons and 1% probability for dissolved hydrocarbons.
	• Olive ridley turtle – the foraging BIA occurs over much of the JBG, which has a 100% probability of exposure. As this species forages primarily at the seabed, they are less susceptible to entrained and dissolved hydrocarbons that generally occur in the top 10 m of the water column.
	• Flatback turtle - the foraging BIA occurs in the same area as that for the loggerhead turtle, with the probabilities of exposure therefore being the same. As this species forages primarily at the seabed, they are less susceptible to entrained and dissolved hydrocarbons that generally occur in the top 10 m of the water column.
	Sea snakes can be common in the shallow waters of reef lagoons and in shoals throughout the region, where the probabilities of exposure to moderate-high exposure thresholds vary from 0-72% depending on location and metocean season. There has been extremely limited study of the impacts of oil spills on sea snakes, so the effects of exposure are unknown.
	Crocodiles are common in the coastal waters of northern WA and the NT, where the probability of exposure to moderate-high exposure thresholds vary from 0-96% depending on the location and metocean season. There has been extremely limited study of the impacts of oil spills on crocodiles, so the effects of exposure are unknown.

Shoreline	See also Table 8.27 (sandy beaches).

	The following species are known to have nesting sites within the shoreline ecological EMBA (which have been defined as 'critical habitat' (i.e., critical to the survival of the species): • Flatback turtle – known to nest in the thousands at Cape Domett and Lacrosse Island (eastern side of the mouth of Cambridge Gulf). Breeding occurs year-round with a peak nesting period from July to September. This area has a 70-93% probability of contact at ecological thresholds. Elsewhere, nesting occurs primarily along the Arnhem Land coast, where the probabilities of shoreline loading at the ecological threshold are low (0-17%) and the WA coastline Islands centred around Cape Bougainville and Cape Londonderry where the probabilities of shoreline loading at the ecological level are moderate (0-44%). • Green turtle – known to nest at Browse Island year-round, with a peak between December and January (11-27% probability of shoreline loading). Important (but low density) nesting areas at Ashmore Reef and Scott Reef have low probabilities of exposure (3% and 2-7%, respectively). Critical habitat (nesting) is also present south of the Anjo Peninsula which has a low probability of exposure (2 -21%) above ecological thresholds). • Hawksbill turtle – known to nest as Ashmore Reef (low density) and Scott Reef, which have low probabilities of exposure (3% and 2-7%, respectively). • Olive ridley turtle – nesting occurs primarily along the Arnhem Land coast, where the probabilities of shoreline loading at the ecological threshold are low (0-17%). In these areas, oil coating the sand can become entrained in the beach and nesting turtles are therefore at risk of dragging oil into nests (with potential toxicity impacts on developing embryos) or hatchlings may travel through oiled sediments after they have emerged from the nest (with any oil stuck to them after entering the water resulting in toxic effects). This may cause mortality of individuals and cause localised population decline. The impacts described here will not impact on the long-term recovery objective (to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list) and interim recovery objectives listed in the Recovery Plan for Marine Turtles in Australia (DoEE, 2017).
Consequence evaluation based on an assessment against EPBC Act *Significant Impact Guidelines 1.1 (DoE, 2013)*	
This LoWC OSTM results indicate that this spill scenario will not have a 'significant' impact on threatened reptile species (see Appendix 11) when assessed against the EPBC Act *Significant Impact Guidelines 1.1* (DoE, 2013), as assessed below:	
• Lead to a long-term decrease in the size of the population	A spill would not lead to a long-term decrease in the size of a population given the small area of impact from a single spill, the rapid weathering of the crude and the low likelihood of a large portion of a turtle population being present in the spill area at any one time.

• Reduce the area of occupancy of the species	Given the small area of 'swept ocean' from a single spill, the rapid weathering of the crude, the area of occupancy may be temporarily reduced (noting that turtles may not necessarily avoid a spill at the surface or in the water column), but there will be no long-term reduction in the area of occupancy.
• Fragment an existing population into two or more populations	In the event of a spill resulting from a LoWC, turtles have access to an expansive area of unpolluted waters. As marine turtles migrate on a solitary basis, a spill would not be expected to split up a single population into two or more populations.
• Adversely affect habitat critical to the survival of the species	The water quality of the impacted area would be temporarily reduced in the event of a spill. The portion of the oil that entrains or dissolves in the water column, where turtles spend the majority of their time, is dependent on ocean conditions during the spill (rough seas result in more entrainment than calm seas). The area affected by the oil is unlikely to form a significant part of turtle inter-nesting areas or migration routes, so exposure times are expected to be short. Nesting beaches may be impacted by oil residues. Some turtle nesting areas that may be affected by a LoWC event are designated as critical (i.e., Cape Domett & Lacrosse Island). Prioritisation of these areas in the event of a spill with respect to response activities to prevent shoreline residues from reaching these areas (see Chapter 9) will ensure that any impacts to these critical habitats are temporary and do not significantly impact on this critical habitat.
• Disrupt the breeding cycle of a population	Refer to the row above.
• Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The water quality of the ecological spill EMBA would be temporarily reduced in the event of a spill. Marine habitat will not be modified, destroyed, removed, isolated or decreased to the extent that one or more turtle species will decline in number. Similarly, sandy beaches where nesting habitat is present may be temporarily impacted by a LoWC spill, however with spill response initiated (together with controls to prevent impacts), habitats will not be modified, destroyed, removed, isolated or decreased to the extent that one or more turtle species will 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	A large-scale hydrocarbon spill is highly unlikely to result in the introduction and spread of IMS that are harmful to endangered marine turtles. Vessels that may be involved in the spill response strategies will be subject to strict IMS controls to ensure that ballast water is of 'low risk' and that hulls are free of IMS.
• Introduce disease that could cause the species to decline	The risk of toxic impacts to individual species or populations of turtle is negligible due to the rapid weathering of the crude. The small extent of a single spill further reduces the risk to a small area such that it is unlikely large number of 'oiled' turtles become susceptible to disease.

	Oil spill response activities are not expected to introduce disease to marine turtles.
• Interfere with the recovery of the species	For all the reasons outlined above, a crude oil spill will not interfere with the recovery of a marine turtle species.
Consequence evaluation based on an assessment against actions identified in the *Recovery Plan for Marine Turtles in Australia (DoEE, 2017)*	
A1. Maintain and improve efficacy of legal and management protection	EOG is utilising the information contained in legal and management protection systems (e.g., spatial management systems that map BIAs and critical habitats, recovery plan management arrangements) to manage the anthropogenic impacts of drilling activities to ensure turtles are not displaced from their habitat.
A2. Actively manage turtle stocks to reduce risk and build resilience to climate change and variability	Limited applicability to EOG. Responsible agencies for this action are government agencies, research institutions, relevant NGOs and industry partners.
A3. Reduce the impacts from marine debris	Limited applicability to EOG, however all activity described in this EP demonstrates support for the EPBC Act *Threat Abatement Plan for the impacts of marine debris on vertebrate marine life (DoEE, 2018).*
A4. Minimise chemical and terrestrial discharge – specifically: *Ensure that spill risk strategies and response programs adequately include management for turtles and their habitats, particularly in reference to "slow to recover habitats" e.g., nesting habitat, seagrass meadows or coral reefs*	Spill response strategies have been developed ensuring that turtle habitats are managed to reduce impacts in the event of an oil spill (see Section 9).
A5. Address international take within and outside Australia's jurisdiction	Not relevant to EOG.
A6. Reduce impacts from terrestrial predation	Not relevant to EOG.
A7. Reduce international and domestic fisheries by-catch	Not relevant to EOG.

A8. Minimise light pollution – specifically: *Artificial light within or adjacent to habitat critical to the survival of marine turtles will be manages such that marine turtles are not displaced from these habitats.*	EOG will undertake shoreline survey/protection/clean-up response only during daylight hours such that light does not interfere with critical turtle habitats. Accommodation of shoreline responders is expected to be in offshore vessels.
A9. Address the impacts of coastal development/infrastructure and dredging and trawling	Not relevant to EOG.
A10: Maintain and improve sustainable indigenous management of marine turtles.	Not relevant to EOG.
B1, Determine trends at index beaches	Not relevant to EOG.
B2. Understand population demographics at key foraging grounds	Not relevant to EOG.
B3. Address information gaps to better facilitate the recovery of marine turtle stocks	Not relevant to EOG.
Inherent impact consequence:	Severe

Table 8.35. Sensitivity and consequence evaluation of hydrocarbon exposure to seabirds and shorebirds

General sensitivity to oiling – seabirds and shorebirds	
Sensitivity rating of seabirds:	High
Sensitivity rating of shorebirds:	High
A description of seabirds and shorebirds in the spill EMBA is provided in:	Appendix 11, Section 11.3.7

Seabirds and shorebirds are sensitive to the impacts of oiling, with their vulnerability arising from the fact that they cross the air-water interface to feed, while their shoreline habitats may also be oiled (Hook *et al*., 2016). Species that raft together in large flocks on the sea surface are particularly at risk (ITOPF, 2011a).

Birds foraging at sea have the potential to directly interact with oil on the sea surface some considerable distance from breeding sites in the course of normal foraging activities. Species most at risk include those that readily rest on the sea surface (such as shearwaters) and surface plunging species such as terns and boobies. As seabirds are top order predators, any impact on other marine life (e.g., pelagic fish) may disrupt and limit food supply both for the maintenance of adults and the provisioning of young.

In the case of seabirds, direct contact with hydrocarbons is likely to foul plumage, which may result in hypothermia due to a reduction in the ability of the bird to thermo-regulate and impair waterproofing (ITOPF, 2011a). A bird suffering from cold, exhaustion and a loss of buoyancy (resulting from fouling of plumage) may dehydrate, drown or starve (ITOPF, 2011a; DSEWPC, 2011; AMSA, 2013). It may also result in impaired navigation and flight performance (Hook *et al*., 2016). Increased heat loss as a result of a loss of water-proofing results in an increased metabolism of food reserves in the body, which is not countered by a corresponding increase in food intake, and may lead to emaciation (DSEPWC, 2011). The greatest vulnerability in this case occurs when birds are feeding or resting at the sea surface (Peakall *et al*., 1987). In a review of 45 marine hydrocarbon spills, there was no correlation between the numbers of bird deaths and the volume of the spill (Burger, 1993).

Toxic effects of hydrocarbons on birds may result where the oil is ingested as the bird attempts to preen its feathers, and the preening process may spread the oil over otherwise clean areas of the body (ITOPF, 2011a). Whether this toxicity ultimately results in mortality will depend on the amount of hydrocarbons consumed and other factors relating to the health and sensitivity of the bird. Birds that are coated in oil also suffer from damage to external tissues including skin and eyes, as well as internal tissue irritation in their lungs and stomachs. Studies of contamination of duck eggs by small quantities of crude oil, mimicking the effect of oil transfer by parent birds, have been shown to result in mortality of developing embryos. Engelhardt (1983), Clark (1984), Geraci & St Aubin (1988) and Jenssen (1994) indicated that the threshold thickness of oil that could impart a lethal dose to some intersecting wildlife individual is 10 µm (~10 g/m^2). Scholten et al (1996) indicates that a layer 25 µm thick would be harmful for most birds that contact the slick.

Shorebirds are likely to be exposed to oil when it directly impacts the intertidal zone due to their feeding habitats. Shorebird species foraging for invertebrates on exposed sand and mud flats at lower tides will be at potential risk of both direct impacts through contamination of individual birds (ingestion or soiling of feathers) and indirect impacts through the contamination of foraging areas that may result in a reduction in available prey items (Clarke, 2010). Breeding seabirds may be directly exposed to oil via a number of potential pathways. Any direct impact of oil on terrestrial habitats has the potential to contaminate birds present at the breeding sites

(Clarke, 2010). Bird eggs may also be damaged if an oiled adult sits on the nest. Fresh crude was shown to be more toxic than weathered crude, which had a medial lethal dose of 21.3 mg/egg (Clarke, 2010).	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface	The area of moderate and high threshold exposure at the sea surface does not overlap the foraging BIAs of any seabirds or shorebirds. Seabirds rafting, resting, diving or feeding at sea have the potential to come into contact with oil. However, because of the extensive ocean foraging habitat available to the species known to occur in the ecological spill EMBA, the area impacted by surface oil is unlikely to limit their ability to forage for unaffected prey. As such, surface oil is unlikely to affect species at a population level.
Water column	The area of high threshold exposure for entrained and moderate to high threshold exposure for dissolved hydrocarbons is extensive and is overlapped by BIAs for many seabirds and shorebirds (as described and mapped in Section 11.3.7 of Appendix 11). Seabirds spend a limited amount of time in the water column (diving for prey) and are therefore not likely to be significantly affected by hydrocarbons in the water column. Indirect effects through the ingestion of contaminated prey may affect individual birds but there are not likely to be impacts at the population level.
Shoreline	The northern WA and NT shorelines provide abundant feeding, roosting and nesting habitats for seabirds and shorebirds. The shoreline locations that intersect shorebird BIAs of the greatest significance are: • Finniss River floodplain (NIW and IBA, 1-14% probability of contact at the moderate threshold, peak volume of 5-51 m^3) – major breeding area for magpie geese and a major migration stopover for shorebirds. • Daly-Reynolds floodplain (N IW and IBA, 1-41% probability of contact at the moderate threshold, peak volume of 5-200 m^3) – at least 30 shorebird species, with a large number of magpie geese. • Moyle floodplain (NIW and IBA, 13-54% probability of contact at the moderate threshold, peak volume of 22-134 m^3) – 47 shorebird species, a significant breeding area for magpie geese, rookeries for darter and cormorant species. • Peron Islands (NT) (part of the Daly River IBA) (2-17% probability of contact at moderate threshold, peak volume of up to 32.4 m^3). • Legune wetlands (IBA, 24-47% probability of contact at the moderate threshold, peak volume of 20-29 m^3) – 47 shorebird species. • Ord River floodplain (Ramsar site, Cambridge Gulf, 70-93% probability of contact at the moderate threshold) – over 200 species of waterfowl, migratory shorebirds, mangrove birds and terrestrial species, including the threatened Australian painted snipe. • Bigge Island (west of the Mitchell River mouth, 70-93% probability of contact at the moderate threshold) – breeding BIA for the lesser crested tern. • Sir Graham Moore Island (north of Kalumburu, 70-93% probability of contact at the moderate threshold) – roseate tern breeding.

	• Cartier Island (5% probability of contact at the moderate threshold, winter only, peak volume of 11 m^3) – breeding BIAs for the lesser frigatebird, red-footed bobby, wedge-tailed shearwater and white-tailed tropicbird, along with habitat for lesser sand plovers, eastern reef egrets, ruddy turnstones, crested terns, bridled terns and roseate terns. • Ashmore Reef (Ramsar site, 3% probability of contact at the moderate threshold, winter only, peak volume of 14 m^3) – breeding BIAs for the lesser frigatebird, red-footed bobby, wedge-tailed shearwater and white-tailed tropicbird, along with roseate tern and greater frigatebird breeding and habitat for common noddies (second largest colony in Australia), sooty terns (largest colony in WA) and crested terns. • Browse Island (11-27% probability of contact at the moderate threshold, peak volume of 14-64 m^3) – breeding BIA for crested tern and habitat for eastern reef egrets, ruddy turnstones and sooty terns. In these areas, impacts to birds may include oiling of feathers, oiling of feeding, roosting and nesting habitats (e.g., mudflats, mangroves, sandy beaches) and contamination of their food sources. Depending on the degree of oiling and the timing of a spill, this could result in small or large bird populations being injured or dying. Migratory birds may be too injured to fly to other feeding or breeding areas, resulting in a reduction of the next generation's population size. The values of NIWs and Ramsar wetlands may be temporarily compromised.
Consequence evaluation based on an assessment against the EPBC Act guidelines	
This hydrocarbon spill scenario will not have a 'significant' impact on threatened migratory shorebird species (see Section 11.3.7 of Appendix 11) when assessed against *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act-listed migratory shorebird species Policy Statement 3.21* (DoEE, 2017d):	
• Loss of habitat.	The habitats along the shorelines of the ecological spill EMBA will not be lost.
• Degradation of habitat leading to a substantial reduction in migratory shorebird numbers.	Habitat quality will temporarily decrease in parts, but given the predicted weathering profile of the crude, there will be no long-term degradation. The presence of large areas of rocky shoreline in the ecological spill EMBA reduces the risk of degradation in those areas.
• Increased disturbance leading to a substantial reduction in migratory shorebird numbers.	Crude will rapidly percolate through sandy and muddy beach sediments, resulting in short-term disturbance. The most likely shoreline response option will be to monitor and evaluate (rather than actively undertake a clean-up in sensitive coastal habitats), further reducing the potential for disturbance to shorebirds.
• Direct mortality of birds leading to a substantial reduction in migratory shorebird numbers.	Depending on the nature of the spill, how it weathers and the location of shoreline loading, there is a low risk of direct mortality of birds. No one area of the EMBA, particularly the shoreline closest to the activity area, has high concentrations or a high percentage of a population of any migratory shorebird species. As such, a substantial reduction in migratory shorebird numbers is highly unlikely to occur.

This hydrocarbon spill scenario will not have a 'significant' impact on threatened seabird species (see Section 5.3.7) when assessed against the EPBC Act *Significant Impact Guidelines 1.1* (DoE, 2013), which are:	
• Lead to a long-term decrease in the size of a population.	A spill would not lead to a long-term decrease in the size of a population given the small area of 'swept ocean' from a single spill, the predicted rapid weathering of the crude and the low likelihood of a large portion of a seabird or shorebird population being present in the affected areas at any one time.
• Reduce the area of occupancy of the species.	Given the small area of 'swept ocean' from a single spill, the predicted rapid weathering of the crude and the abundance of suitable nearby habitat, sea surface water quality and some shoreline habitat quality will temporarily decrease and therefore the area of occupancy will be temporarily reduced but there will be no long-term reduction in the area of occupancy.
• Fragment an existing population into two or more populations.	Seabirds have access to an expansive area of unpolluted waters and shorebirds similarly have access to expansive areas of unpolluted shorelines. A spill would not be likely to fragment an existing population.
• Adversely affect habitat critical to the survival of a species.	The quality of marine and coastal habitats will be affected for a short period of time, but given the broad areas of habitat use by the species present in the ecological spill EMBA, the survival of any one species is not likely to be adversely affected.
• Disrupt the breeding cycle of a population.	Most of the seabird and shorebird species known to occur in the ecological spill EMBA (e.g., common noddy, streaked shearwater and frigatebirds) breed outside of Australia or beyond the spill EMBA. Important breeding areas in Australia (e.g., Ashmore Reef, Cartier Island, Browse Island) generally have a low risk of contact and small volumes of predicted stranded oil, which can be removed through various response strategies. It is highly unlikely that the breeding cycle of a seabird population will be disrupted.
• Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Given the small area of 'swept ocean' from a single spill and the predicted rapid weathering of the crude, the quality of marine waters and shorelines in the area of the spill will be temporarily reduced. However, marine and coastal habitat will not be modified, destroyed, removed, isolated or decreased to the extent that one or more seabird species will decline. Most of the seabird and shorebird species known to occur in the ecological spill EMBA breed outside of Australia or beyond the spill EMBA. This being the case, it is unlikely that adults would bring contaminated prey back to nests to feed chicks. For the species that do breed in Australian waters and shorelines, it is unlikely that spill-affected prey would be brought back to the nest in quantities significant enough to result in mortality of chicks and the loss of a generation.

• Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.	Response strategies employed to response to a spill are highly unlikely to result in the introduction and spread of IMS that are harmful to birds. Vessels that may be involved in spill response will be subject to strict IMS controls to ensure that ballast water is of 'low risk' and that hulls are free of IMS.
• Introduce disease that may cause the species to decline.	As described in 'sensitivity to oil', disease of individual birds or small populations may occur in the event of a spill. With the appropriate spill response strategies, this is unlikely to result in long-term decline of populations.
• Interfere with the recovery of the species.	For all the reasons outlined above, a spill from a LoWC is not likely to interfere with the recovery of bird species.
The activity will not impact on the objectives of the Wildlife Conservation Plan for Seabirds (Commonwealth of Australia, 2020), which are:	
1. International cooperation and collaboration continue to support the survival of seabirds and their habitats outside Australian jurisdiction. 2. Seabirds and their habitats are identified, protected, and managed in Australia. 3. The long-term survival of seabirds and their habitats is achieved through supporting priority research programs, coordinated monitoring, on-ground management and conservation. 4. Increase the Awareness of the importance of conserving seabirds and their habitats through community education and capacity building to support monitoring and on-ground management.	
Inherent impact consequence:	Severe

Table 8.36. Sensitivity and consequence evaluation of hydrocarbon exposure to socio-economic - commercial fisheries

General sensitivity to oiling – commercial fishing	
Sensitivity rating of commercial fisheries (socio-economic rating):	Medium
A description of commercial fisheries operating in the spill EMBA is provided in:	Appendix 11, Section 11.6.1

Commercial fishing has the potential to be impacted through contaminated of fish stock, exclusion zones associated with the spill, the spill response and subsequent reduction in fishing effort. Exclusion zones may impede access to commercial fishing areas, for a short period of time, and nets and lines may become oiled. The impacts to commercial fishing from a public perception perspective, and its impacts on fish markets and customer consumption patterns, may be much more significant and longer term than the spill itself.

Fishing areas may be closed for fishing for short or long periods because of the risks of the catch being tainted by oil. Concentrations of petroleum contaminants in fish, crustacean and mollusc tissues could pose a significant potential for adverse human health effects, and until these products have been cleared by the health authorities, they could be restricted for sale and human consumption. Indirectly, the fisheries sector will suffer a heavy loss if consumers are either stopped from using or unwilling to buy fish from the region affected by the spill.

Impacts to fish stocks have the potential for reduction in profits for commercial fisheries, and exclusion zones exclude fishing effort. Davis et al (2002) report detectable tainting of fish flesh after a 24-hour exposure at crude concentrations of 0.1 ppm.

The Montara spill (as the most recent [2009] example of a large hydrocarbon spill in Australian waters) occurred over an area fished by the Northern Demersal Scalefish Managed Fishery (with 11 licences held by 7 operators), with goldband snapper, red emperor, saddletail snapper and yellow spotted rockcod being the key species fished (PTTEP, 2013). As a precautionary measure, the WA Department of Fisheries advised the commercial fishing fleet to avoid fishing in oil-affected waters. Testing of fish caught in areas of visible oil slick (November 2009) found that there were no detectable petroleum hydrocarbons in fish muscle samples, suggesting fish were safe for human consumption. In the short-term, fish had metabolised petroleum hydrocarbons. Limited ill effects were detected in a small number of individual fish only (PTTEP, 2013). No consistent effects of exposure on fish health could be detected within two weeks following the end of the well release. Follow up sampling in areas affected by the spill during 2010 and 2011 (PTTEP, 2013) found negligible ongoing environmental impacts from the spill.

Since testing began in the month after the Macondo well blowout in the Gulf of Mexico (GoM) (2010), levels of oil contamination residue in seafood consistently tested 100 to 1,000 times lower than safety thresholds established by the USA FDA, and every sample tested was found to be far below the FDA's safety threshold for dispersant compounds (BP, 2015). FDA testing of oysters found oil contamination residues to be 10 to 100 times below safety thresholds (BP, 2014a). Sampling data shows that post-spill fish populations in the GoM since 2011 were generally consistent with pre-spill ranges and for many shellfish species, commercial landings in the GoM in 2011 were comparable to pre-spill levels. In 2012, two years after the initial spill, shrimp (prawn) and blue crab landings were within 2.0% of 2007-09 landings. Recreational fishing harvests in 2011, 2012 and 2013 exceeded landings from 2007-09 (BP, 2014).

In the event of a spill resulting from a LoWC, temporary fisheries closure may be put in place by AFMA, the WA or NT fishery authorities (or voluntarily by the fishers themselves). Oil may foul the hulls of fishing vessels and associated equipment, such as gill nets. A temporary fisheries closure, combined with oil tainting of target species (actual or perceived), may lead to financial losses to fisheries and economic losses for individual licence holders. Fisheries closures and the flow on losses from

the lack of income derived from these fisheries are likely to have short-term but widespread socio-economic consequences, such as reduced employment (in fisheries service industries, such as tackle and bait supplies, fuel, marine mechanical services, accommodation and so forth).		
Consequence evaluation based on the Beehive-1 OSTM		
OSTM predicts extensive areas may be exposed to entrained and dissolved hydrocarbons at the moderate and high exposure (ecological) thresholds. A short- or long-term fishing closure may be implemented by AFMA, the WA and/or NT fishery authorities, with the duration depending on the results of water quality testing and fish sample testing. Fishers may lose access to traditional fishing grounds with consequential income losses and possible supply shortages to their commercial customers. In all instances, the worst-case deterministic OSTM results indicate that hydrocarbons in the water column would occupy small areas of each fishery. This section evaluates the consequences on a fishery-by-fishery basis.		
Commonwealth-managed fisheries (those known to fish within the spill EMBA)		Inherent impact consequence
NPF	The area overlapped by the socio-economic spill EMBA represents 32% of the area available to the fishery. Given that drilling is expected to start late Q1/early Q2 with a duration of 55-100 days and that the fishery is closed from 1st December to 1st August, if a LoWC occurred, its effects would likely not result in lost fishing time.	Moderate
North West Slope Trawl	The area overlapped by the socio-economic spill EMBA represents 64% of the area available to the fishery. Fishing is concentrated in water depths greater than 200 m, which represents waters that will have lower in-water hydrocarbon concentrations than those closer to the well. Target species are generally benthic or demersal, where hydrocarbon concentrations will be low (they are generally concentrated in the top 10 m of the water column).	Moderate
Southern bluefin tuna	The area overlapped by the socio-economic spill EMBA represents 42% of the area available to the fishery. There has been no active fishing in the region for many years, but tuna spawn in the region between September and March. Given that drilling is expected to startin late Q1/early Q2 with a duration of 55-100 days, if a LoWC occurred, its effects would likely not result in toxicological effects to tuna spawning and larvae and therefore have a negligible to minor consequence on the fishery off the southern states where the tuna migrate to.	Minor
WA-managed fisheries (those known to fish within the spill EMBA)		Inherent impact consequence
Mackeral Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 38% of the area available to the fishery.	Moderate

	As a pelagic migratory species, mackeral are not likely to spend long periods of time in one location (e.g., waters with high hydrocarbon concentrations), so the risk of contamination is low. The fishing season overlaps the drilling window. If a LoWC occurred, a temporary fishery closure would be likely. In the Kimberley region, less than five vessels operate and catch levels are generally less than 300 t. There would be some impact to several fishers and some lost catch as a result of a fishery closure.	
Northern Demersal Scalefish Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 73% of the area available to the fishery in Area 1 and 98% of Area 2. Fishing is assumed to occur year-round, so it will overlap with the drilling window. Given that the target species are generally benthic or demersal, where hydrocarbon concentrations will be low (they are generally concentrated in the top 10 m of the water column), impacts to fish stock are likely to be low. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 1,000 and 1,500 t.	Moderate
Kimberley Crab Managed Fishery (North Coast Crab Fishery)	The area overlapped by the socio-economic spill EMBA represents 86% of the area available to the fishery. Fishing occurs from March to November, so it will overlap with the drilling window. Coastal waters in which the fishery operates would be exposed to hydrocarbons in the water column. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where six people are employed and who annual catches vary between 3 and 15 t.	Severe
Kimberley Prawn Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 97% of the area available to the fishery. Fishing occurs from April to mid-June, so it will overlap with the drilling window. Coastal waters in which the fishery operates would be exposed to hydrocarbons in the water column. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 100 and 333 t.	Moderate
Kimberley Gillnet and Barramundi Fishery	The area overlapped by the socio-economic spill EMBA represents 71% of the area available to the fishery. Fishing occurs predominantly from April to September, so it will overlap with the drilling window. Coastal waters in which the fishery operates would be exposed to hydrocarbons in the water column. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 73 and 92 t.	Moderate

Pearl Oyster Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 70% of the area available to the fishery. The fishery operates predominantly between March and June, so it will overlap with the drilling window. As a filter feeding species, oysters are sensitive to hydrocarbons in the water column, so the consequence of filtering large volumes of contaminated water could be severe. If a LoWC occurred, there could be contamination or loss of stock (and associated financial losses), with annual production varying between 468,000 and 614,000 shells.	Severe
Abalone Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 48% of the area available to the fishery. The fishery operates predominantly between October and May, so it will overlap with the drilling window. Coastal waters in which the fishery operates would be exposed to hydrocarbons in the water column. As a filter feeding species, abalone are sensitive to hydrocarbons in the water column, so the consequence of filtering large volumes of contaminated water could be severe. If a LoWC occurred, there could be contamination or loss of stock (and associated financial losses), with annual production varying between 47 and 51 t.	Severe
Marine Aquarium Fish Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 27% of the area available to the fishery. Fishing is assumed to occur year-round, so it will overlap with the drilling window. Waters in which the fishery operates would be exposed to hydrocarbons in the water column of various concentrations given the extent of the fishery. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 12,000 and 27,500 individuals.	Severe
Broome Prawn Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 78% of the area available to the fishery. There is a very low risk of entrained (1-2%) hydrocarbons reaching the fishing area, and very low instantaneous concentrations (30-65 ppb). The probability of dissolved hydrocarbons in the area is not reported in the OSTM. As such, impacts are expected to be minor and effects to target species will be minor and there would be limited to no effects to the fishery.	Minor
Nickol Bay Managed Prawn Fishery	The area overlapped by the socio-economic spill EMBA represents 39% of the area available to the fishery. There is a very low risk of entrained (<1-2%) hydrocarbons reaching the fishing area, and very low instantaneous concentrations (<30-65 ppm). The reporting thresholds for dissolved hydrocarbons were not met in the OSTM. As such, impacts to target species will be minor and there would be limited to no effects to the fishery.	Negligible

Onslow Managed Prawn Fishery	The area overlapped by the socio-economic spill EMBA represents 26% of the area available to the fishery. There is a very low risk of entrained (<1-2%) hydrocarbons reaching the fishing area, and very low instantaneous concentrations (<30-65 ppm). The reporting thresholds for dissolved hydrocarbons were not met in the OSTM. As such, impacts to target species will be minor and there would be limited to no effects to the fishery.	Negligible
Specimen Shell Fishery	The area overlapped by the socio-economic spill EMBA represents 48% of the area available to the fishery. Fishing (hand collection) is assumed to occur year-round, so it will overlap with the drilling window. This fishery is not expected to be affected by an oil spill because it does not depend on catching live specimens for sale.	Negligible
Pilbara Demersal Scalefish Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 33% of the area available to the fishery. Fishing (hand collection) is assumed to occur year-round, so it will overlap with the drilling window. The fishery covers a large area so target pelagic species would be exposed to in-water hydrocarbon at various concentrations. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 1,800 and 3,000 t.	Moderate
Pilbara Crab Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 30% of the area available to the fishery. There is a very low risk of entrained (<1-2%) hydrocarbons reaching the fishing area, and very low instantaneous concentrations (<30-65 ppb). The reporting thresholds for dissolved hydrocarbons were not met in the OSTM. As such, effects to target species will be minor and there would be limited to no effects to the fishery.	Negligible
West Coast Deep Sea Crustacean Managed Fishery	The area overlapped by the socio-economic spill EMBA represents 39% of the area available to the fishery. Fishing occurs from January to June, with the greatest intensity in January and February. This high intensity fishing period is outside the drilling window. Given that the target species are benthic and in deep waters (targeting the 150 m bathymetry contour), where hydrocarbon concentrations will be low (they are generally concentrated in the top 10 m of the water column), impacts to deep sea crustacean stock are likely to be low. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 153 and 164 t.	Minor

NT-managed fisheries (those known to fish within the spill EMBA)		Inherent impact consequence
Seafarms Project Seadragon – onshore prawn aquaculture (planned)	Project Sea Dragon has a sub-lease on an area of the Legune Pastoral Lease, southwest of the mouth of the Victoria River. Seafarms is focused on land-based production of Australia prawns for the domestic and international markets. It is currently (late 2022) in the construction phase and not yet operational. The quality of seawater from the Victoria River area tidal creeks is important to underpinning potential prawn production in sub lease area. The probabilities of contact in the Victoria-Daly OSTM sector at the low threshold are as follows (ranges account for seasons): • Shoreline – 48-78%; • Sea surface – 36-67%; • Dissolved – 46-59%; and • Entrained – 53-80%. If a LoWC occurred, seawater intakes would need to be closed as a precautionary measure to protect water quality of the aquaculture operations (if it is operational at the time of drilling). This could result in the loss of stock and therefore loss of income associated with that stock.	Severe
Demersal Fishery	The area overlapped by the socio-economic spill EMBA represents 38% of the area available to the fishery. The fishing season is year-round, so it overlaps the drilling window. Given that the target species are demersal, where hydrocarbon concentrations will be low (they are generally concentrated in the top 10 m of the water column), the effects of a spill on target fish species are likely to be low. If a LoWC occurred, a temporary fishery closure would be likely. About seven vessels operate and annual catch levels are generally up to 3,000 t. There would be some impact to several fishers and some lost catch as a result of a fishery closure.	Minor
Spanish Mackerel Fishery	The area overlapped by the socio-economic spill EMBA represents 39% of the area available to the fishery. The fishing season is year-round, so it overlaps the drilling window. As a pelagic migratory species, mackerel are not likely to spend long periods of time in one location (e.g., waters with high hydrocarbon concentrations), so the risk of contamination is low. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 357 and 411 t.	Severe
Offshore Net and Line Fishery	The area overlapped by the socio-economic spill EMBA represents 39% of the area available to the fishery. There is little information available for this fishery, so it is assumed that the fishing season overlaps the drilling window.	Moderate

	The fishery targets shark and mackerel. As pelagic (and migratory in the case of mackerel) species, they are not likely to spend long periods of time in one location (e.g., waters with high hydrocarbon concentrations), so the risk of contamination is low. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers.	
Coastal Line Fishery	There is little information available for this fishery, so it is assumed that the fishing season overlaps the drilling window. The fishery covers the entire NT coastline and is concentrated around Darwin. There probability of entrained hydrocarbons around Darwin is 0-28% with instantaneous concentrations of 583-1,354 ppb, and for dissolved hydrocarbons it is 0-12% with instantaneous concentrations of 45-497 ppb. At these concentrations, sub-lethal effects to marine fauna are possible, though black jewfish, like other fish, are able to metabolise and excrete hydrocarbons. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 124 and 173 t.	Moderate
Barramundi Fishery	There is little information available for this fishery. The fishery operates from February to September, so it overlaps the drilling window. The fishery is focussed on tidal mud flats and inside a restricted number of rivers, presumed to be concentrated around Darwin. There probability of entrained hydrocarbons around Darwin is 0-28% with instantaneous concentrations of 583-1,354 ppb, and for dissolved hydrocarbons it is 0-12% with instantaneous concentrations of 45-497 ppb. At these concentrations, sub-lethal effects to marine fauna are possible, though barramundi, like other fish, are able to metabolise and excrete hydrocarbons. If a LoWC occurred, a temporary fishery closure would be likely. The greatest impact would come from a precautionary closure of the fishery and associated loss of income for fishers, where annual catches vary between 276 and 392 t.	Moderate

Table 8.37. Sensitivity and consequence evaluation of hydrocarbon exposure to socio-economic sensitivities – protected areas

General sensitivity to oiling – protected areas	
Sensitivity rating of protected areas (MNPs (sanctuary zones) and Ramsar wetlands):	Very High
Sensitivity rating of protected areas (MNPs (habitat protection zones) and NIWs):	High
Sensitivity rating of protected areas (MNPs (multiple use zones) and fish habitat protection areas):	Medium
Protected areas are declared for their various physical, ecological, biological and social values, and these are described in various sections of Appendix 11, as noted below. An assessment of the risk of a LoWC on the management actions of the protected areas in the spill EMBA is presented in Appendix 14.	
Consequence evaluation based on the Beehive-1 OSTM	
Marine parks	AMPs and state marine parks in the spill EMBA are described in Sections 11.4.1 and 11.4.9 respectively, in Appendix 11. Appendix 14 lists the probabilities of contact and exposure values for Commonwealth AMPs, WA and NT marine parks in the spill EMBA, along with providing an assessment against the relevant management plans. While the values of each of the marine parks vary, they support all the habitats and faunal groups described in the previous tables. A decrease in water quality in the marine parks will impacts on their habitat and fauna receptors and therefore have an adverse impact on the values of these reserves. This may have flow-on effects to tourism and a loss of revenue for coastal communities that provide access to these marine reserves. Marine parks often provide protected nursery grounds for fisheries species and therefore have a role in maintaining healthy fish stocks for commercial and recreational fisheries.
Ramsar wetlands	Ramsar wetlands in the spill EMBA are described in Section 11.4.4 in Appendix 11, and the probabilities of contact and exposure values are listed in Section 10 of Appendix 14. The Ramsar wetland with the highest probability of shoreline contact is the Ord River Floodplain, with a 70-93% probability of contact, depending on season. Receptors are risk at this wetland include mangroves, mud flats, sawfish, crocodiles and migratory shorebirds. The wetland also contains various Aboriginal cultural heritage artefacts. **Inherent impact consequence:** severe.
TECs	There is one TEC in the spill EMBA, which is described in Section 11.4.5 in Appendix 11. This is the monsoon vine thickets on the coastal sand dunes of Dampier Peninsula. It occurs on dunes just above the high tide mark. The risk of shoreline contact in this area is 1%. **Inherent impact consequence:** negligible.
KEFs	KEFs in the spill EMBA are described in Section 11.4.7 in Appendix 11, and the probabilities of contact and exposure values are listed in Section 10 of Appendix 14.

	These KEFs are subsea features, generally reefs, shoals, canyons, banks and pinnacles. As subsea physical features, they are generally at low risk from a spill associated with a LoWC. Impacts to the biological values of these KEFs, including fish and corals, are addressed in earlier tables. **Inherent impact consequence:** moderate.
NIWs	NIWs in the spill EMBA are described in Section 11.4.8 in Appendix 11, and the probabilities of contact and exposure values are listed in Section 10 of Appendix 14. The NIWs with the highest probabilities of shoreline contact at the moderate threshold are: • Ord Estuary System (70-93% probability); • Legune Wetlands (24-47% probability); • Moyle Floodplain and Hyland Bay System (13-54% probability); and • Daly-Reynolds Floodplain-Estuary System (1-41% probability). The key values of the NIWs are associated with fish (see Table 8.31) and birds (see Table 8.33). **Inherent impact consequence:** severe.
National Heritage	The spill EMBA intersects the West Kimberley National Heritage Place, which is described in Section 11.4.3 in Appendix 11. The section of coastline it covers is vast, with probabilities of shoreline contact ranging from 0-99% depending on location and season. The values most relevant to the marine environment is Roebuck Bay as a migratory hub for shorebirds. Roebuck Bay is located south of Broome and does not fall within the ecological spill EMBA. As such, the key marine values associated with the West Kimberley National Heritage Place will not be affected by a spill. **Inherent impact consequence:** negligible.

Table 8.38. Sensitivity and consequence evaluation of hydrocarbon exposure to First Nations cultural heritage values and sensitivities

General sensitivity to oiling – First Nations cultural heritage values and sensitivities	
Sensitivity rating:	High
A description of First Nations cultural heritage values and sensitivities in the spill EMBA is provided in:	Appendix 11, Section 11.5
Sea Country values of First Nations people may be impacted in a number of ways by a hydrocarbon spill – at the physical, biological and spiritual levels. To EOG's knowledges, this is not an area that has been subject to documented research. Impacts at the physical and biological levels (e.g., shorelines, fauna) are described in the earlier tables in this section. Physical and biological impacts may temporarily prevent or restrict access to traditional lands or seas for hunting and social gatherings (e.g., ceremonies). It is unknown how these impacts may translate to the spiritual level (e.g., rituals, song lines, animal totems), though it is likely that the visual presence of floating oil or shoreline oil accumulations will cause impacts.	
Consequence evaluation based on the Beehive-1 OSTM	
Sea surface Water column	Oil will be present on the sea surface and in the water column, the concentrations and locations of which are dependent on a number of factors at the time of a spill (e.g., volume released, weather, trajectory, etc). In discussions with EOG, the BAC has stated that they have important connections to Country, including coastal and marine areas. Connections to Sea Country may be affected in this case. An oil spill is likely to impact Sea Country values, but the exact nature of these impacts is not known. It is assumed that Sea Country activities such as hunting (e.g., fish, turtles, dugong) may be impacted if oil results in death or oil tainting of fauna, or if oil slicks make offshore travel unsafe, and that values such as water quality may be impacted.
Shoreline	There is likely to be an accumulation of oil at various shorelines. Many of the shorelines in the EMBA occur adjacent to Native Title claim areas and therefore, these are likely to be shorelines that are important to various First Nations groups and individuals. The presence of oil at these sites (likely to be weathered and degraded by the time they reach the coast, with little toxicity) may result in restrictions to food collection (e.g., shellfish on coastal rocky reefs, fish in shallow waters) in order to avoid food contamination. To extent to which such avoidance results in limiting the food supplies of groups or individuals cannot be predicted as this depends on the volume of oil released, its trajectory, weathering and persistence, along with any seasonality patterns related to food collection along the coast. The BAC has made EOG aware that there are rock arts sites along the coast of the spill EMBA. Aboriginal heritage sites along the coast (such as coastal rock art, dunes, shell middens, etc) will not be impacted by a spill as these sites are located above the high-water mark. During the consultation process for this activity, EOG has not received information regarding particular Country/Sea Country sensitivities and values that can be assessed here. Nevertheless, EOG understands that an oil spill may impact such values.
Inherent impact consequence:	Moderate

8.7.6 Risk Assessment

Table 8.39 presents the risk assessment for a LoWC.

Table 8.39. Risk assessment for a LoWC

Summary		
Summary of risks	Widespread and temporary reduction in water quality. Sub-lethal to lethal toxicity impacts to marine life. Temporary fisheries closures.	
Extent of risks	The spill EMBA is presented in Figure 11.1 in Appendix 11.	
Duration of risks	Days, weeks or months, depending on the location, level of contact and receptor.	
Level of certainty of risks	HIGH – the environmental impacts of spilled hydrocarbons are well understood.	
Risk decision framework context	Decision type	B – new to the organisation or geographical area.
	Activity	Infrequent activity.
	Risk & uncertainty	Risks amenable to assessment using well-established data and methods. Some uncertainty.
	Stakeholder influence	Pressure groups likely to object, significant media interest.
Defined acceptable level	No LoWC that results in a crude oil spill.	

Risk Assessment (inherent)			
Receptor	Consequence	Likelihood	Risk rating
Benthic fauna	Severe	Rare	High
Macroalgae & seagrass	Severe	Rare	High
Coral	Severe	Rare	High
Mangroves & saltmarshes	Severe	Rare	High
Sandy beaches	Severe	Rare	High
Rocky shores	Moderate	Rare	Low
Tidal flats	Moderate	Rare	Low
Plankton	Moderate	Rare	Low
Fish	Moderate	Rare	Low
Marine mammals	Severe	Rare	High
Marine reptiles	Severe	Rare	High
Seabirds & shorebirds	Severe	Rare	High
Commercial fisheries	Minor to Severe	Rare	Negligible to High
Protected areas	Negligible to Severe	Rare	Negligible to High

Aboriginal cultural heritage values and sensitivities	Moderate	Rare	Low
Assessment of Proposed Control Measures			
Control measure	Control type	Adopt	Justification
PDSA investigation results are used to inform MODU positioning to avoid shallow gas hazards **(RSK-07: EPS-01)**.	Engineering	Yes	**EB:** Avoiding gas pockets and ensuring the stability of the MODU while drilling minimises the risk of an unplanned hydrocarbon release. **C:** Significant cost (millions of dollars). **Ev:** The significant costs are outweighed by the benefits of not drilling through a gas pocket and avoiding a significant release of gas.
BOP is fitted and tested **(RSK-07: EPS-02, -03, -04)**.	Engineering	Yes	**EB:** Fitting a BOP and ensures its correct functioning reduces the likelihood of a spill resulting from a LoWC. **C:** BOPs are available with every MODU, and the cost of their supply and maintenance is built into MODU day rates, which are significant (up to $1 million per day). **Ev:** Having a BOP fitted is best practice and required as part of the Safety Case regime. The environmental benefits outweigh the significant costs.
Pre-campaign MODU assurance inspection **(RSK-07: EPS-05)**.	Engineering & Administrative	Yes	**EB:** Ensures that the physical status of the MODU, along with the systems and processes that govern its day-to-day operations, are suitable for this drilling program, and therefore minimises the likelihood of a LoWC. **C:** Moderate costs. **Ev:** It is best practice to conduct an independent review of the physical status of the MODU and its operating systems. The cost of doing so is outweighed by the environmental benefits.
WCMP **(RSK-07: EPS-06, -07, -08)**.	Engineering & Administrative	Yes	**EB:** Considering all engineering and safety risks when drilling a well through the development of, continuous updates and training in detailed plans available for each stage of well design ensures best practice engineering design is achieved and minimises the risk of a LoWC. **C:** High cost of developing and continuously refining this system. **Ev:** It is best practice to have in place a management system to consider and plan for

			risks. The high costs are outweighed by environmental benefits.
Maintain a second MODU on standby for the purpose of drilling a relief well.	Engineering & Administrative	No	**EB:** Would reduce the mobilisation time for drilling a relief well, thereby minimising the volume of crude spilled to the sea. **C:** Significant, likely up to $1 million per day. Would also require an in-force Safety Case/SCR, which could cost several hundred thousand dollars more to prepare. **Ev:** With all other control measures in place, the significant cost of this measure is grossly disproportionate to the low risk of a LoWC.
Maintain support vessels on standby for the purpose of responding to a LoWC.	Engineering & Administrative	No	**EB:** Would reduce the mobilisation time for deploying spill response equipment, thereby potentially minimising the impacts of spilled crude oil. **C:** Significant, likely several hundred thousand dollars per day. **Ev:** With all other control measures in place, the significant cost of this measure is grossly disproportionate to the low risk of a LoWC.
Time drilling to avoid the cyclone season (start November to end April).	Administrative	No	**EB:** Avoiding the cyclone season minimises the risk of having to quickly de-man the MODU in the event of a cyclone and minimises the risk of unintentionally leaving the well in an unsafe safe (and potentially prone to a LoWC). **C:** Removes 6 months of the year from the drilling schedule, meaning that securing access to a MODU would be extremely difficult. **Ev:** Drilling throughout the cyclone season in northwest Australia has taken place for decades, with well-established and tested de-manning practices in place. The high costs associated with not being able to drill the well to schedule are not commensurate with the low risks of securing the MODU and de-manning in the event of a cyclone.
Accepted Safety Case, SCR and WOMP are in place **(RSK-07:EPS-07)**.	Administrative	Yes	**EB:** Ensures titleholder has plans in place to safely operate the MODU and drill the well, thereby minimising the risk of a LoWC. **C:** Moderate costs involved in preparing documents through to acceptance. **Ev:** It is a regulatory requirement to have these documents in place. The moderate costs are outweighed by environmental

			benefits in terms of minimising the risk of a LoWC.
International Alliance for Well Control (IAWC)/IADC WellCap training **(RSK-07:EPS-09)**.	Administrative	Yes	**EB:** Ensures that the Drilling Superintendent and DSV are equipped to properly respond to a well kick and LoWC, which may reduce the volume of oil lost to the sea through an efficient technical response. **C:** Moderate cost to undertake initial and refresher training. **Ev:** Moderate costs are outweighed by environmental benefits in the event of a spill.
Accepted OPEP is in place **(RSK-07:EPS-10)**.	Administrative	Yes	**EB:** Ensures titleholder has considered risks and planned for a response, which may reduce impacts to marine fauna and sensitive shoreline habitats. **C:** Significant cost to prepare plan and put in place agreements and contracts with suppliers. **Ev:** It is a regulatory requirement to have this document in place. High costs are outweighed by environmental benefits in the event of a spill.
The SCERP (including the RWP) is in place and reviewed regularly **(RSK-07:EPS-11)**	Administrative	Yes	**EB:** The pre-drilling identification of MODUs in the region suitable as drilling a relief well, and mobilisation planning, will aid in a prompt response to drilling a relief well in the event of a LoWC. This is considered industry best practice. **C:** Low cost involved in preparing RWP. **Ev:** The low cost of preparing the RWP is outweighed by the environmental benefits.
All DIMT positions have undertaken relevant spill response training (e.g., IMO II or III) **(RSK-07:EPS-12).**	Administrative	Yes	**EB:** Spill response trained ensures a response is smoother than it otherwise would be, with potential benefits in reducing the volume of oil lost and/or the volume of oil recovered. **C:** Moderate, depending on the number of personal requiring training. **Ev:** There is significant benefit in personnel being trained and practiced in their responsibilities in the event of a LoWC. The cost is outweighed by the environmental benefits.
Mutual aid agreement (MAA) is in place for access to other MODUs **(RSK-07:EPS-13)**.	Administrative	Yes	**EB:** Access to other MODUs operating in the region reduces the response time with regards to drilling a relief well, in turn potentially reducing the volume of oil released to the ocean.

			C: High costs of AEP membership and cost of time in negotiating access to the MAA. **Ev:** The high costs are outweighed by the environmental benefits.
Agreement(s) in place with well blowout engineering expertise **(RSK-07:EPS-18)**.	Administrative	Yes	**EB:** Access to well blowout expertise (e.g., WWC) reduces the response time with regards to killing the well, in turn potentially reducing the volume of oil released to the ocean. This is considered industry best practice. **C:** Moderate costs of putting agreement in place and maintaining access. **Ev:** The high costs are outweighed by the environmental benefits.
Agreement(s) are in place with spill response organisations **(RSK-07:EPS-17, -18)**.	Administrative	Yes	**EB:** Access to organisations such as AMOSC and OSRL ensure that there is access to expert spill response preparedness advice during the planning phase and advise and response in the event of a LoWC. This may reduce the volume of oil released to the ocean and maximise the volume of oil recovered. This is considered industry best practice **C:** Significant costs of initial membership and maintaining access (hundreds of thousands to millions of dollars). **Ev:** The significant costs are outweighed by the environmental benefits.
Agreement(s) are in place with OSMP service provider(s) **(RSK-07:EPS-20)**.	Administrative	Yes	**EB:** Access to organisations that can implement OSMP studies quickly and to a high standard allows impacts to be quantified, in turn informing spill response activities. **C:** Significant costs of initial membership and maintaining access (hundreds of thousands to millions of dollars). **Ev:** The moderate costs are outweighed by the environmental benefits and is considered industry best practice in Australia.
Accepted OSMP **(RSK-07:EPS-20)**.	Administrative	Yes	**EB:** Ensures titleholder has considered plans to monitor impacted areas, which will inform future response efforts. **C:** Significant cost to prepare plan and put in place agreements and contracts with suppliers. **Ev:** It is a regulatory requirement to have this document in place. High costs are outweighed by environmental benefits in the event of a spill.

Compensate for economic loss due to a spill associated with a LoWC **(RSK-7:EPS-21)** [same as **IMP-02:EPS-04**].	Administrative	Yes	**EB:** Affected third-party marine users are compensated for any economic loss due to a LoWC, thereby mitigating the potential socio-economic consequences. **C:** Minor costs to prepare the procedure and administer the claims process. Potentially significant costs for a claim or claims. **Ev:** The principal of the control measure is to ensure that other marine users are no worse off as a result of drilling so that all parties maintain their rights to access the ocean. The benefits outweigh the high costs of potential claims.

Environmental Controls and Performance Measurement		
EPO	EPS	Measurement criteria
Preparedness		
No LoWC will occur for the duration of the activity.	**(RSK-07:EPS-01)** The results of the PDSA investigations are used to avoid shallow gas hazards and to determine the location for a relief well.	MODU station records verify that it is pinned on location that avoid hazards identified in the PDSA reports.
	(RSK-07:EPS-02) A functional and reliable BOP is installed on top of the surface casing that meets the requirements of API Standard 53 (Blowout Prevention Equipment Systems for Drilling Wells).	DDRs confirm BOP is fitted. Survey report confirms that the BOP meets the standard.
	(RSK-07:EPS-03) The BOP is routinely function and pressure tested in accordance with the manufacturer's specification and in alignment with the MODU contractor's PMS.	BOP function and pressure tests are available.
	(RSK-07:EPS-04) The BOP is pressure tested (high and low) prior to deployment, upon initial latch-up with the wellhead and every 21 days in accordance with API Standard 53. The BOP is function tested every 7 days.	BOP testing records confirm testing is performed to schedule.
	(RSK-07:EPS-05) EOG will arrange for an independent pre-campaign assurance check of the MODU, including the BOP system.	Independent assurance report is available and confirms the BOP system is functional.
	(RSK-07:EPS-06) The Beehive-1 well is designed in accordance with the WCMP (as endorsed by EOG) to ensure that the well is designed in accordance with all required codes of practice and industry standards.	EOG's review of the well design verifies that the WCMP has been adhered to.

	(RSK-07:EPS-08) The DSV ensures that well kick drills are undertaken during the campaign in accordance with the MODU contractor's schedule.	DDRs confirm that well kick drills are undertaken.
	(RSK-07:EPS-09) The DSV and Drilling Superintendent are trained and qualified to International Well Control Forum (IWCF)/IADC WellCap well control standards so that well control emergencies are efficiently and properly managed.	Training records and certificates confirm these personnel are qualified and trained in well control.
EOG maintains preparedness to respond to a LoWC.	**(RSK-07:EPS-10)** A Beehive-1 OPEP and ERP are in place and prior to the activity commencing, a desktop LoWC and spill response exercise is conducted to test the DIMT functions.	Oil spill response exercise report verifies that an LoWC desktop exercise was undertaken.
	(RSK-07:EPS-11) The RWP is developed consistent with the *Source Control Emergency Response Planning Guide for Subsea Wells*, Report 594 (IOGP/IPIECA, 2019) at least 3 months prior to the start of drilling.	RWP is place prior to the start of drilling.
	(RSK-07:EPS-12) All DIMT roles have undertaken the necessary external training to fulfil their roles.	Training records verify that all DIMT roles have undertaken the necessary training (e.g., IMO II or III).
	(RSK-07:EPS-13) MAA is in place to provide access to other MODUs operating in Australia to reduce mobilisation time.	AEP MAA MoU signed by EOG prior to the start of drilling.
	(RSK-07:EPS-14) Agreement(s) are in place with well blowout engineering expertise (e.g., WWC) prior to the start of drilling.	Agreement(s) with WWC are in place prior to the start of drilling.
	(RSK-07:EPS-15) Agreement(s) will be in place with oil spill response organisations (AMOSC & OSRL) prior to the start of drilling.	Agreements with AMOSC and OSRL are in place prior to the start of drilling.
	(RSK-07:EPS-16) Agreement(s) will be in place with OSMP service provider(s) prior to the start of drilling.	Agreement with OSM provider is in place prior to the start of drilling.
Emergency response		
The DIMT responds in accordance with the OPEP, ERP and their training.	**(RSK-07:EPS-17)** The DIMT will be activated and support resources (such as AMOSC and OSRL) will be mobilised to implement the OPEP and ERP.	DDRs and incident investigation reports verify that the OPEP and ERP were implemented.

	(RSK-07:EPS-18) The RWP will be implemented to stop the LoWC within 77 days.	DDRs and incident investigation reports verify that the RWP was implemented.
Recording & reporting		
Regulatory authorities are promptly made of aware of a spill.	**(RSK-07:EPS-19)** EOG will report a spill associated with a LoWC to regulatory authorities within 2 hours of becoming aware of the incident.	Incident report verifies that contact with regulatory agencies was made within 2 hours.
Monitoring		
Characterise environmental impacts of a LoWC spill.	**(RSK-07:EPS-20)** EOG will undertake operational and scientific monitoring in accordance with the OSMP.	Daily operations reports and overall study reports verify that the OSMP was implemented.
Compensation		
Compensate for economic loss due to a spill associated with a LoWC.	As per **IMP-02:EPS-04** and **IMP-02:EPS-05.**	As per **IMP-02:EPS-04** and **IMP-02:EPS-05.**

Risk Assessment (residual)			
Receptor	Consequence	Likelihood	Risk rating
Benthic fauna	Severe	Remote	Medium
Macroalgae & seagrass	Severe	Remote	Medium
Coral	Severe	Remote	Medium
Mangroves & saltmarshes	Severe	Remote	Medium
Sandy beaches	Severe	Remote	Medium
Rocky shores	Moderate	Remote	Low
Tidal flats	Moderate	Remote	Low
Plankton	Moderate	Remote	Low
Fish	Moderate	Remote	Low
Marine mammals	Severe	Remote	Medium
Marine reptiles	Severe	Remote	Medium
Seabirds & shorebirds	Severe	Remote	Medium
Commercial fisheries	Minor to Severe	Remote	Negligible to Medium
Protected areas	Negligible to Severe	Remote	Negligible to Medium
Aboriginal cultural heritage values and sensitivities	Moderate	Remote	Low
The reasons for the LoWC risk ratings are outlined in the previous tables corresponding to each faunal group or habitat type or socio-economic sensitivity.			

Demonstration of ALARP		
The 'medium' residual risk ratings are considered to be intolerable and higher order risks. However, the adopted control measures and associated EPS cannot lower the risk ratings any lower. Engineering risk assessments including BOP risk assessments, well integrity risk assessments and the precautionary principle have been factored into the control measures.		
Demonstration of Acceptability		
Policy compliance	EOG's Safety and Environmental Policy objectives are met.	
EMS compliance	Chapter 10 describes the EP implementation strategy to be employed for this activity.	
Risk matrix standard compliance	The residual risk for each receptor ranges from negligible to medium.	
External context	Chapter 4 summarises the concerns raised by relevant persons (WA DoT, WAFIC, Seadragon Project, BAC and CCWA) regarding a large-scale hydrocarbon spill resulting from drilling.	

Legislative context	The EPS align with the requirements of:
	• OPGGS Act 2006 (Cth):
	  ○ Section 572A-F (Polluter pays for escape of petroleum).
	• OPGGS(E):
	  ○ Part 3 (Incidents, reports and records).
	• *Protection of the Sea (Prevention of Pollution by Ships) Act* 1983 (Cth):
	  ○ Section 9 (Prohibition of discharge of oil or oily mixture to sea).
	  ○ Section 11A (SOPEP).
	  ○ AMSA Marine Orders Part 91 (Marine pollution prevention – oil).	

Industry practice	The consideration and alignment of EPS with the mitigation measures in the below-listed codes of practice and guidelines demonstrates that BPEM will be implemented in this activity	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS developed for this activity are in line with the management measures listed for major spills from exploration facilities in Section 4.7.4 of the guidelines: • Well design undertaken in accordance with industry best practice **(RSK-07: EPS-06 to -013)**. • OSTM undertaken to determine potential impacts to the surrounding environment (**part of ERA)**. • Blowout prevention measures to focus on maintaining wellbore hydrostatic pressure **(RSK-07: EPS-02 to -05)**. • Well integrity testing to be performed **(RSK-07: EPS-07 to -011)**. • RWP in place to regain control of the well if there is a loss of integrity **(RSK-07: EPS-07, -015)**.
	Best Available Techniques Guidance	The EPS developed for this activity are in line with the management measures listed for well blowouts in Section 18.2 of the guidelines:

	Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	• Have in place a spill contingency plan **(RSK-07: EPS-014 to -020)**. • Primary and secondary well control **(RSK-07: EPS-02, -03, -04, -05, -11)**. • Well monitoring **(RSK-07: EPS-08, -09, -10, -11)**. • Relief well planning **(RSK-07: EPS-015)**.
	Health, Safety and Environmental Case Guidelines for Mobile Offshore Drilling Units (IADC, 2015)	The EPS developed for this activity are in line with Section 2.3.12 of the guidelines (drilling and well control operations), which specify that: • Personnel involved in the operations are competent **(RSK-07: EPS-013, -016)**. • Drilling and well control procedures are in place to shut-in and abandon the well **(RSK-07: EPS-07)**.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	The EPS developed for this activity are in line with the following parts of the guidelines: • Section 75 (Spills): Conducting a spill risk assessment, implementing personnel training and field exercises, ensuring spill response equipment is available **(RSK-07: EPS-015 to -019)**. • Sections 76-79 (Spill response planning): A spill response plan should be prepared **(RSK-07: EPS-014, -015)**. • Section 115 (Well blowout). Blowout prevention measures should focus on maintaining wellbore hydrostatic pressure by effectively estimating formation fluid pressures and the strength of subsurface formation **(RSK-07: EPS-09)**. • Section 116 (Well blowout). A BOP system should be installed that can be closed rapidly. It should be tested at regular intervals (at least every 14 days) **(RSK-07: EPS-02, -03, -04)**. • Section 118 (Well blowout). Contingency plans should be prepared for well operations **(RSK-07: EPS-014, -015, -024)**. • Section 119 (Well blowout). A dedicated blowout risk analysis and emergency plan should be prepared, detailing the measures in place to prevent a blowout, the provisions for well control in a blowout scenario and the time necessary for intervention **(RSK-07: EPS-015)**.
	AEP CoEP (APPEA 2008)	The EPS for this activity meet the code's following objectives for offshore geophysical surveys: • To reduce the risk of damage and cross-flow between fluid strata to ALARP and an acceptable level.
Environmental context	MNES	
	AMPs	As per Table 8.36.

	Ramsar wetlands	As per Table 8.36.
	TECs	As per Table 8.36.
	Nationally threatened and migratory species	As per Tables 8.31 to Table 8.34.
	Other matters	
	KEFs	As per Table 8.36.
	NIWs	As per Table 8.36.
	State marine parks	As per Table 8.36.
	Species Conservation Advice/ Recovery Plans/ Threat Abatement Plans	Marine pollution is a threat identified for many fish, marine mammal, turtle and bird species. In general, population monitoring is the suggested action to deal with marine pollution. The Beehive-1 OSMP addresses this. The WCP for seabirds (2020) identifies acute pollution (oil spills) as a moderate threat to seabirds. The EPS outlined within this table mitigate the chance of an oil spill, and therefore, reduce the probability of acute pollution impacts on seabirds.
ESD principles	The EIA presented throughout this EP demonstrates that ESD principles (a), (b), (c) and (d) are met (noting that principle (e) is not relevant).	
Statement of acceptability	EOG considers the risk of a spill resulting from a LoWC to be acceptable as: • It will adhere to the company's Safety and Environmental Policy; • The residual risk ratings are as low as can be achieved; • An Implementation Strategy (described in Chapter 9) is in place to ensure the EPS are achieved. • Input from engagement with relevant persons has been considered and incorporated into the risk assessment; • Relevant legislation and industry best practice will be complied with; • A spill is not predicted to have long-term or significant impacts on MNES; • The management of a spill is not inconsistent with the aims of recovery plans/conservation plans/advice that are in force for EPBC Act-listed threatened and migratory species; • The management of a spill is not inconsistent with the aims of relevant marine reserve management plans; and • The management of a spill is not inconsistent with ESD principles.	
Environmental Monitoring		
• As per the OPEP and OSMP.		
Record Keeping		
• PDSA data reports. • AEP MoU. • Agreements with service providers.	• BOP IAT Part 2 report. • Crew training records and certificates. • WCMP review.	

- Emergency response exercise reports.
- DDRs.
- BOP installation and testing reports.
- DIMT training records.
- Incident reports.