CARNARVON
PETROLEUM LTD

WA-523 P
Drilling Exploration and Appraisal EP Summary

Rev 1 – JUNE 2019

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1 INTRODUCTION

1.1 Overview

Carnarvon Petroleum Ltd. (CVN) has an active exploration focus on Australia's North Western Shelf (NWS), Western Australia (WA). CVN intend to undertake drilling of one exploration well (Buffalo East-1) and up to two appraisal wells (Buffalo East 2 and 3) in the Buffalo field in Australian waters, directly adjacent to the Joint Petroleum Development Area (JDPA). The wells will be drilled within permit area WA-523-P, approximately 560 km north-west of Darwin.

1.2 Titleholder Details

Carnarvon Petroleum are the titleholder of permit area WA-523-P and will be the operator for the proposed activity.

Details of titleholder:

a. **Name:** Carnarvon Petroleum Ltd.
b. **Business Address:** Level 2, 76 Kings Park Road, West Perth WA 6005
c. **Telephone Number:** 08 9321 2665
d. **Email Address:** admin@cvn.com.au

1.3 Activity Duration and Timing

The first well (Buffalo-1 East) is planned to commence in Q2 2020 , depending on equipment and vessel availability. An additional two wells may be drilled in 2021 or 2022 subject to the findings of the first well Buffalo East-1. Activities will be conducted 24 hours per day, seven days per week and the drilling of each well is expected to be approximately 35 days inclusive of rig positioning. However this may extend in the event of technical difficulties or delays (e.g. due to weather).

Surveys may be conducted prior to the rig arriving on site and these will take approximately two days. Following departure of the rig from location, additional surveys may be conducted taking an additional approximately two days. Activities may not be continuous during these timeframes, and the rig and vessels may depart and return on numerous occasions during this period. All activities are expected to be completed by end of Q2 2023.

1.4 Contact Person

Further information can be obtained from:

a. **Name:** Graham Chapman
b. **Business Address:** Level 2, 76 Kings Park Road, West Perth WA 6005
c. **Telephone Number:** 08 9321 2665
d. **Email Address**: gchapman@cvn.com.au

2 ACTIVITY LOCATION

The Activity is located within permit area WA-523-P in Australian Commonwealth waters (**Table 2-1**). The surface location of possible future appraisal wells (Buffalo East-2 and 3) will be within very close range (10 -25 m) of each other and the Buffalo East-1 well, and will be contained within the defined Operational area (i.e. the 1 km radius around Buffalo East-1).

2.1 Operational Area

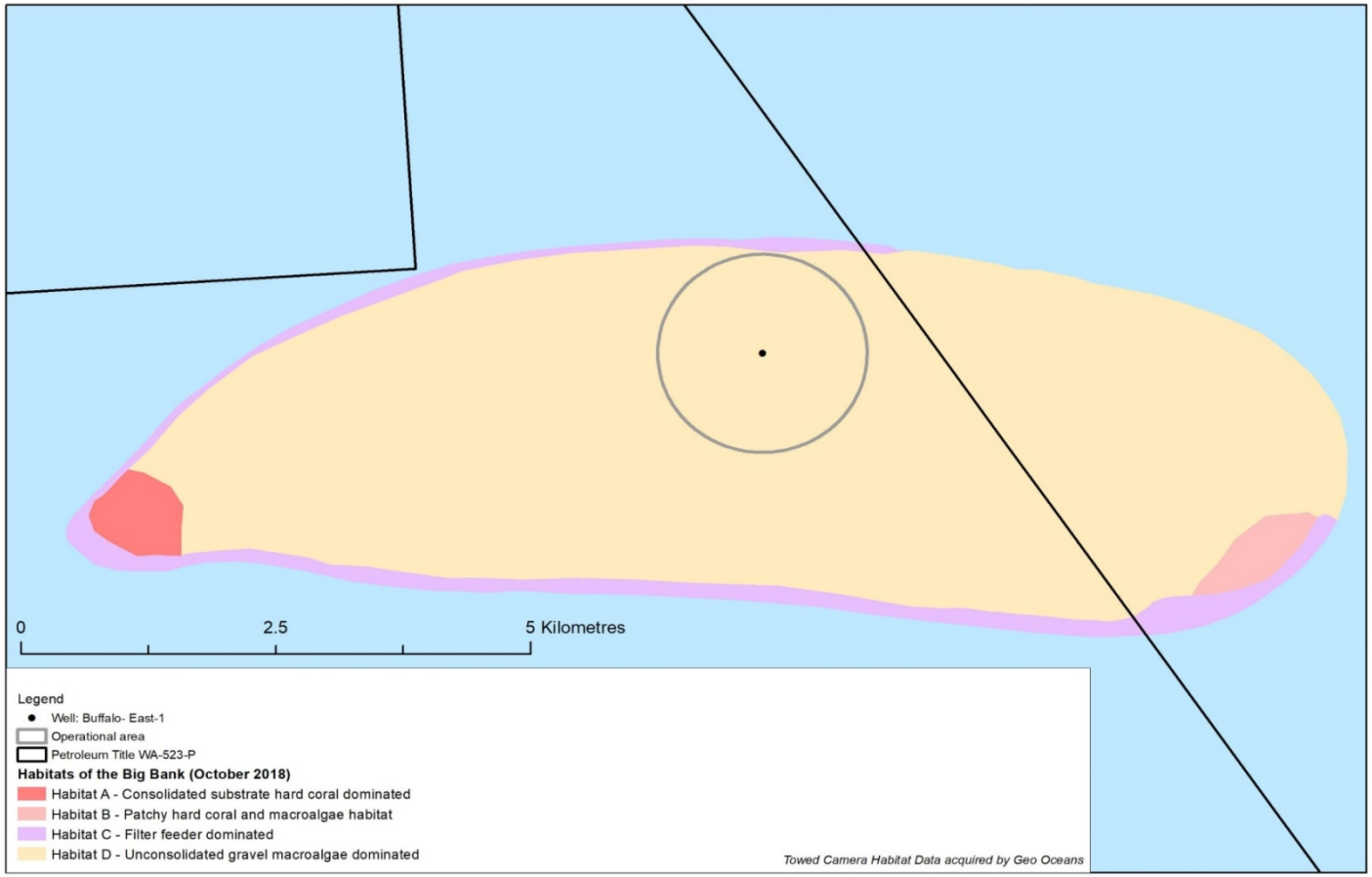
The Operational area for the three wells comprising the activity is defined as a 1 km radius around the proposed well location(s) in **Table 2-1,** and the '**disposa**l' location as defined in **Table 2-2**. This area encompasses the proposed drilling rig and petroleum safety zone, and vessels in situ supporting the drilling activity, and any supporting activities conducted under this EP including the disposal of cuttings at the disposal location. A 500 m radius petroleum safety zone will be in place around the drilling rig within the Operational area. Water depths over the Operational area range from approximately 25 to 27 m around the proposed drilling rig site on the Big Bank structure to around 300 m at the disposal site.

Table 2-1: Indicative Co-ordinates of Well Location

Well	Latitude	Longitude
Buffalo East -1	10° 40' 19.2" S	126° 6' 52" E

Table 2-2: Disposal Location

Location	Latitude	Longitude
Disposal	10° 38' 47.244" S	126° 5' 25.812" E



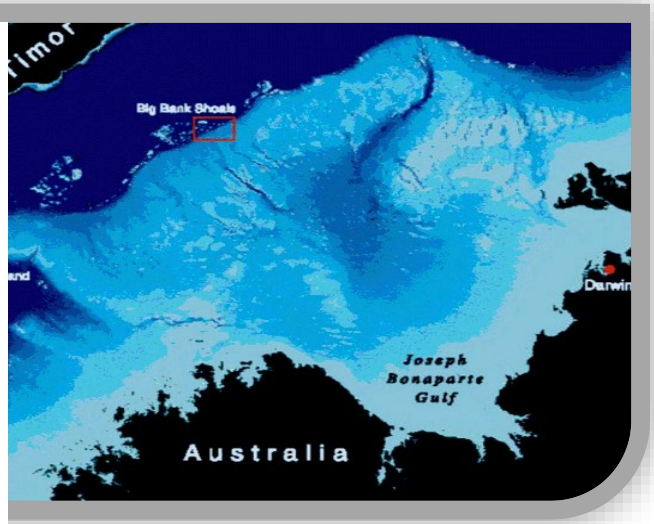


Figure 2-1: Location of WA-523-P (Habitat Mapping from GeoOceans 2018)

3 DESCRIPTION OF THE ACTIVITY

The EP covers the drilling of the Buffalo East-1 well and possible Buffalo East-2 and 3 appraisal wells. The drilling may include any/all of the following activities as part of each of the wells:

- Jack up drill rig (including moving and positioning to location);
- Riserless drilling system;
- Riserless mud return (RMR) system with drill cuttings collected and transferred to a disposal vessel for disposal in deeper water within WA-523–P permit;
- Seabed disposal of cuttings not captured by RMR;
- Installation of blowout preventer;
- Use of Water Based Muds (WBM);
- Contingency for use of Loss Circulation Material (LCM) as required;
- Use of chemicals for drilling activities;
- Installation and cementing of conductor casing;
- Formation evaluation and wireline logging including Vertical Seismic Profiling (VSP);
- Liner cemented in place If the results from the formation evaluation and wireline logging determine that the well will be suspended for future production;
- A mud line suspension well head system will be used to allow future tie back to surface facilities;
- Temporary placement of equipment on the seabed; and
- Use of support vessels, helicopters and remotely operated vehicles (ROV).

While not planned as part of the operations, there are options for side-track drilling, re-drilling of particular sections of the well and possible re-spud of the well if warranted.

3.1 Drilling Program

The Buffalo East-1 well design entails drilling a conductor surface hole section (36”), two intermediate hole sections (17 ½ and 12 ¼”) and the 8 ½” production[1] hole section. The surface intervals (or conductor hole) will be drilled ‘riserless’ using seawater with viscous sweeps utilising bentonite or a viscosifying polymer and a viscosified brine. Fifteen percent (15%) of cuttings (54.5 m^3) and well returns (e.g. sweeps) from the 36” open hole will discharge directly into the seabed.

Cement will be used to form permanent barriers and fix casing strings in place in accordance with the approved NOPSEMA Well Operations Management Plan (WOMP) and industry best practice. Once the surface conductor string is cemented into place, a closed loop circulating system will be created firstly by use of the riserless system (RMR) for the 17 ½” hole section then via the high pressure rig drilling riser and BOP’s. Following drilling the 17 ½” hole the 13 3/8” intermediate casing string will be ran and cemented in place. The Drilling rigs high pressure drilling riser and BOP’s will then be installed for the remainder of the well. After the surface blow-out preventers (BOPs) have been installed, recirculating water-based drilling fluids will be used to drill the remainder of the well in the 12 ¼ and 8 ½” hole sections with 44% of cuttings (159.1 m^3) circulated to the MODU for mechanical separation and treatment.

[1] The naming convention used for the third drilling section (i.e. ‘production’) refers to the section at which the target reservoir will be encountered and not to the purpose of the drilling section or the Activity covered in this EP. This EP does not cover production activities that may follow drilling this well

The well returns will be treated on-board the MODU to separate the drilled solids and drilling fluids. Primary solids control will be achieved by the use of shale shakers. Centrifuges may also be used at times to remove ultra-fine solids suspended in the recovered drilling fluids.

Drill cuttings from the 17 ½", 12 ¼" and 8 ½" hole sections and the residual drilling fluids will be transferred to the standby vessel and disposed of at the designated deep water disposal site off Big Bank.

On completion of the drilling program drilling mud and unused bulks material (dry bulks including cement, barite and bentonite) would be retained on the rig for resale onshore or transferred for disposal at the disposal site.

3.2 Evaluation

To reduce operational risks, no conventional coring, drill stem testing, production testing or flow testing will be performed. The well will be evaluated using Logging While Drilling (LWD) techniques and mud logging. Additional wireline logging and sampling may be performed based on the results of the LWD evaluations. The wireline evaluation is also planned to include VSP for two to three days' duration.

3.3 Drilling Chemicals and Discharges

Drilling discharges account for:

- Drill cuttings;
- Drilling fluids and solids (including brine and cement);
- Loss of Circulation Material;
- Residual Drilling Fluid Discharges.

Chemicals (including Water Based Muds (WBM)) will be selected in accordance with the CVN Chemical Selection Process and may include, but are not limited to: brines, acids, weighting materials, water soluble polymers, pH controllers, alkalinity controllers, defoamers, detergents and contingency lost circulation materials; as well as cement and cement additives. Tracer dyes may also be used for leak detection and cementing operations.

3.4 Operational Discharges

In addition to the drilling discharges described, other operational waste streams are likely to include:

- Cleaning discharges (for example from flushing of mud pits, cement mixing/holding tanks and bulk storage tanks and cement system);
- Deck drainage/stormwater;
- Putrescible waste and sewage/grey water;
- Cooling water;
- Desalination plant effluent (brine) and backwash water discharge;
- Bulk product tank venting; and
- Ballast water.

3.5 Support Vessels

The rig will be assisted by up to three support vessels (used for towing, equipment and material transfers, standby operations, disposing drill cuttings, and emergency response). Support vessels will not moor or anchor within the Operational area during the activity. Refuelling of support vessels will not take place within the Operational area.

3.6 Helicopters

Helicopters will be used to transfer crew and equipment, and assist in Health Safety Environment (HSE) or operational emergencies as required. Refuelling of helicopters may take place in the Operational area.

3.7 Surveys

Prior to positioning of the rig legs (cans) on the seabed at the well locations, a survey may be undertaken using a remotely operated vehicle (ROV) and/or sidescan sonar to understand the seabed conditions and minimise any potential risks caused by subsea hazards (e.g. infrastructure). This may be undertaken by a vessel in advance of the rig arriving. During the activity, opportunistic surveys may be completed from the rig or vessels of the subsea infrastructure, using an ROV or similar, within the Operational area and seabed habitat.

3.8 End of Activity

The activity is considered complete once the rig and vessels have departed the Operational area and no further surveys are required, or the EP expires . In the event that the well(s) are plugged and abandoned, the surface wellhead will be removed and no equipment will be left above the seabed. In the event of one or more wells being suspended past end of the EP and left in situ, CVN would prepare an alternate Environment Plan for the amended activity.

4 EXISTING ENVIRONMENT

4.1 Summary of Values in Operational Area

A summary of the values and sensitivities identified for the Operational area are provided in **Table 4-1**.

A description of key physical attributes within the Operational area can be found in **Table 4-2**.

Table 4-1: Summary of Operational Area Values and Sensitivities

	Sensitive Receptor	Description
Habitats	Critical Habitat – EPBC Listed	• No Critical Habitats or Threatened Ecological Communities, as listed under the *EPBC Act*, are known to occur within the Operational area.
	Marine Primary Producers	• Big Bank ~89% unconsolidated gravel macroalgae-dominated habitat covers the central area of the plateau (GeoOceans 2018). • Generally characterised by mixed turfing and calcareous algae (*Halimeda* sp.), sponge and soft coral communities with some hard corals on the more consolidated sediments (Heyward *et al*. 1997). *Halimeda* has highly variable inter-annual coverage due to natural wave disturbance (Heyward *et al*. 1997). • Coral habitat restricted to small areas on the western (~1.6% cover of Big Bank) and eastern (~1.3%) edges of the plateau, with 20-40% coral cover in those patches. Some branching *Acropora* sp., *Montipora* sp. and *Goniopora* sp. (GeoOceans 2018). • Filter feeder dominated habitat occurs around the perimeter edge of the plateau where depth starts to preclude coral habitat (~8% cover of Big Bank). • Strong wave action appears to cause high levels of natural perturbation and periodic cycles in benthic cover.
	Lifecycle Stages 'Critical' Habitats	No lifestyle stages or critical habitat occur in Operational area.
	Other Communities/ Habitats	<u>Benthic Communities</u> • Big Bank: Mixed community of sponges, ascidian and gorgonians interspersed with macroalgae and hard coral communities. Sponges, sea ferns and sea whips also present around the perimeter of the plateau. • Infauna and epifauna within the Operational area is likely to consist of a mixed assemblage of nemerteans (including polychaete worms), crustaceans, molluscs, echinoderms and sponges. Species present are likely to be regionally distributed on nearby shoals and banks (Heyward *et al*. 1997). <u>Plankton</u> • Plankton in the Operational area is likely to be regionally representative and likely to reflect the conditions of the offshore waters in the Timor Sea. Primary productivity of the NWMR appears to be largely driven by offshore influences (as reported by Brewer *et al*. 2007), with periodic upwelling events and cyclonic influences driving coastal productivity with nutrient recycling and advection. • Zooplankton biomass at Big Bank ~65-155 mgm^{-3} and may include organisms that complete their lifecycle as plankton (e.g. copepods, euphausiids) as well as larval stages of other taxa such as fishes, corals and molluscs. Peaks in zooplankton such as mass coral spawning events (typically in March and April) (Rosser and Gilmour 2008; Simpson *et al*. 1993) and fish larvae abundance (CALM 2005) can occur throughout the year.

	Sensitive Receptor	Description
Protected Species	BIAs	• The pygmy blue whale BIA intersects the Operational area. Small numbers of pygmy blue whales may transit the Operational area, particularly during their annual migrations between warm water breeding grounds and cold water feeding grounds. Animals may frequent waters that in the EMBA/Operational area particularly between August and October. They tend to pass along the shelf edge at depths of 500 m out to 1000 m (McCauley and Jenner 2010).
	Marine Mammals	• Four listed threatened species of cetacean were identified in the EPBC Protected Matters search as potentially occurring or having habitat in the Operational area; the sei whale, blue whale, fin whale and humpback whale. Threatened and migratory species overlapping Operational area: <u>Sei whale</u> • Likely to infrequently occur within the Operational area, mainly during winter months when the species may move away from Antarctic feeding areas. <u>Blue whale</u> • May occur within the Operational area in small numbers during migration (Operation area occurs in the general distribution BIA) but preference for shelf edge depths of 500 m-1000 m. Foraging may occur in the Operational area also. <u>Fin whale</u> • Likely to infrequently occur within the Operational area, mainly during winter months when the species may move away from Antarctic feeding areas. <u>Humpback whale</u> • Unlikely to occur within the Operational area, due to their preference for more shallow coastal water. The Big Bank Operational area does not contain any regionally significant feeding, breeding or aggregation areas for marine mammals and the operational area represents only a small area of the broader Timor Sea and Bonaparte Basin. Humpback whale nearest BIA (migration, calving area in Camden Sound/Lacepede Islands ~445 km). <u>Bryde's Whale (Migratory)</u> • Individuals may be encountered within the Operational area or EMBA year round as no seasonal cycle has been observed. <u>Orca/Killer Whale (Migratory)</u> • Killer whales are known to make seasonal movements, and are likely to follow regular migratory routes, however little is known about either local or seasonal movement patterns of the species (DoEE 2017b), so individuals may be encountered within the Operational area and are also likely to occur within the EMBA. <u>Sperm Whale (Migratory)</u>

	Sensitive Receptor	Description
		• Given the concentration of this species in a narrow area only a few miles wide at the shelf edge off Albany, it is considered unlikely that individuals would be encountered within the Operational Area. <u>Spotted Bottlenose Dolphin (Migratory)</u> Due to the distance from the coast and deeper waters of the Operational area, spotted bottlenose dolphins are not expected to occur, particularly given the preference for shallower, coastal waters. Given their cosmopolitan distribution, the species may be encountered within the EMBA. The nearest BIA boundaries for other marine mammals: • Dugong – (Foraging) Kimberley coast near Dampier Peninsula (~718 km). • Australian Snubfin Dolphin, Indo-Pacific Humpback Dolphin and Indo-Pacific Spotted/Bottlenose Dolphin – Closest is ~352 km (Snubfin Dolphin Breeding, calving and foraging).
	Marine Reptiles	• Six species of listed threatened marine turtle were identified in the *EPBC Act* Protected Matters search as potentially occurring in, or relating to, the Operational area; loggerhead, green, leatherback, hawksbill, olive ridley/Pacific ridley and flatback turtles. • Marine turtles are predominantly oceanic species except in the nesting season when they come ashore. There are no shorelines in close proximity to the Operational area, noting nesting on Timor Leste and some Indonesian Islands. However, turtles may transit the offshore waters in proximity to the Operational area and may forage on algae at Big Bank and nearby shoals. The Operational area does not contain any regionally significant feeding, breeding or aggregation areas for marine reptiles and is located in open ocean, which is vast and represents only a small area of the broader region. The Operational area does not intersect any Habitat Critical for the Survival of marine turtles, with the closest area being ~355 km away (green turtle nesting area at Cartier Island). Migratory species are likely to forage at nearby shoals that provide similar habitat/foraging areas to that of Big Bank. • The nearest BIA boundaries are >100 km away: - Flatback turtle - Foraging and internesting – ~120 km foraging, ~396 km Internesting - Green turtle - Foraging, nesting and internesting – ~120 km foraging, ~355 km Cartier Island nesting - Hawksbill turtle - Internesting – ~363 km (Ashmore Reef) - Leatherback turtle - Internesting – ~683 km - Loggerhead turtle - Foraging – ~120 km - Olive Ridley - Foraging - ~120 km, Internesting ~445 km.
	Seasnakes	No threatened seasnake species were identified as occurring within the Operational area. GeoOceans (2018) recorded two species of snakes. Sea snakes tend to inhabit shallow, coastal, tropical waters with the exception of the yellow bellied seasnake (*Pelamis platurus*)

	Sensitive Receptor	Description
		that lives a pelagic life (Guinea 2013), making it the most likely of species to have been observed during the recent GeoOceans survey (GeoOceans 2018).
	Seahorses and Pipefish	• No threatened species were identified as occurring within the Operational area. This is likely due to the distance offshore, as bycatch data indicates seahorses and pipefish are uncommon in deeper continental shelf waters (>50 m) (Department of Fisheries 2010).
	Sharks, Sawfish and Rays	• A search of the *EPBC Act* Protected Matters database (**Appendix A**) identified the threatened Great white shark as potentially occurring or having habitat in the Operational area. • There are no known feeding, breeding or aggregation areas for fish, sharks or rays within the Operational area. Species are expected only to traverse the through the area. Migratory species are likely to forage at nearby shoals that provide similar habitat/foraging areas to that of Big Bank. • The nearest BIA boundaries: - Whale shark - Foraging ~107 km (truncated by EEZ).
	Oceanic Seabirds and/or Migratory Shorebirds	• Three listed threatened birds (red knot, curlew sandpiper, eastern curlew) and an additional seven migratory species (Common Noddy, Streaked Shearwater, Lesser Frigatebird, Great Frigatebird, Common Sandpiper, Sharp-tailed Sandpiper, Pectoral Sandpiper) were identified by the EPBC Protected matters search as potentially occurring or having habitat in the Operational area. • No emergent land exists in the shoals or surrounding offshore areas in the vicinity of the Operational area to support breeding populations of seabirds or migratory shorebirds. • The nearest islands in the vicinity, that support a large number of seabirds and migratory shorebirds are Cartier Island and Ashmore Reef, which are located ~355 km and ~378 km, respectively, from the Operational area.
	Fish	<u>Pelagic and Demersal Fish Populations</u> • Fish species in the Operational area are likely to comprise of a range of small and large pelagic fish, as well as demersal species, but abundance is not high (Heyward *et al*. 1997, GeoOceans 2018). • Species previously recorded include saddle-tailed snapper, gold-band snapper, threadfin big-eye, Spanish mackerel and black-banded king fish. A number of these species are commercially targeted.
Socio-economic	Cultutal Heritage	• There are no known sites of Indigenous or European cultural or heritage significance within the Operational area. • There are no heritage listed sites within, or immediately adjacent, to the Operational area.
	Ramsar Wetlands	• There are no Ramsar wetlands within the Operational area.
	Fisheries - Commercial	• No Commonwealth, State or Territory commercial fisheries overlap the Operational area.

	Sensitive Receptor	Description
		• There are no aquaculture leases within or adjacent to the Operational area.
	Fisheries - Traditional	• The Operational Area is located ~170 km from the Timor Leste and ~ 168 km from the Indonesian coastline, and it is considered likely that the area is utilised by indigenous fishers. • Trawling by fishermen from Indonesia and Timor Leste is undertaken in the vicinity of Sahul Bank and Echo Shoals, and boats may pass through the Operational area in transit to and from these fishing grounds (BHP 2007). • Most Indigenous (Aboriginal and Torres Strait Islander) fishing activity off Australia occurs close to communities and outstations, inland or near WA and NT coastal waters (up to 3 nm; DPIF 2015) and are not likely to frequent the Operational area on Big Bank.
	Tourism and Recreation	• No tourism activities are known to take place specifically within the Operational area due to distance offshore.
	Shipping	• No AMSA shipping fairways pass through the Operational area. The area is frequented by offshore support vessels transiting to the nearby Laminaria-Corallina development.
	Oil and Gas Infrastructure	• The Operational area is located within an area of established oil and gas operations in the Timor Sea. • The Operational area is approximately 7.1 km south-west of the Laminara Platform and ~15 km from the Correlina – Northern Endeavour.
	Defence	• The Operational area does not overlap any known defence areas. It is ~250 km to the North Australian Exercise Area from the Operational area.
	Values and Sensitivities	• No protected areas overlap the Operational area.

Table 4-2: Physical Environment

Attribute	Description
Climate and Meteorology	The Bonaparte Basin and Timor Sea region experiences a dry tropical climate with hot northwest monsoon (summer) and mild southeast monsoon (winter). Rainfall typically occurs during the northwest monsoon (wet season), with highest falls observed during tropical cyclones and low pressure systems. Winds vary seasonally, with steady, moist, west/northwest winds during the northwest monsoon and southeast winds during the southeast monsoon. Tropical cyclone activity can occur between November and April and is most frequent during December to March.
Oceanography	Regionally influenced by Indonesian Through Flow Current and Holloway Current. Tidal currents flood to the ESE and ebb to the WNW but local bathymetry can be expected to influence the local orientation of this flow. Peak tidal excursions over Big Bank are ~5 km (mean tidal speeds 0.4 m/s), compared to ~4 km at the adjacent deep ocean floor (Heyward *et al*. 1997). Currents are predominantly tidal with pronounced seasonal cycle of drift currents, linked to the changing wind fields of the monsoons. During the southeast monsoon period (Australian winter) the drift current flow is to the west into the Indian Ocean. During the northwest monsoon (Australian summer) the flow weakens and even reverses direction over the inshore part of the shelf.
Marine Sediment	Top sediments (to 1 - 2 m depth) unconsolidated sands, calcareous *Halimeda* rubble and silts. Some outcrops of consolidated carbonaceous sediment in areas within Big Bank. Cores found unconsolidated sandy gravel to 38 m and calcite limestone underneath. Sediments at the base of the bank in 200 – 300 m of water consists of a fine, sandy substratum that is highly rippled, typical of the deeper seabed in the region. Some rocky, limestone outcrops at ~300 m (Heyward *et al*. 1997).
Water Quality	The Operational area is located in an open ocean environment and is likely to reflect regional conditions. Turbidity is likely to be generally low (e.g. <0.2 NTU), as observed on banks and shoals in the region (Jacobs 2016a). Strong currents keep the waters well-mixed.
Air Quality	There is limited air quality data for the region, however, ambient air quality in the Operational area is expected to be of high quality.
Bathymetry	Regionally, the seabed generally comprises a relatively flat and featureless habitat, although numerous seamount or banks can be found along the perimeter of the Australian continental shelf. These mounts, such as Big Bank, rise steeply from depths of ~300 m to an average depth of 35 m. The shoals and banks in the NWMR share a tropical marine biota consistent with that found on emergent reef systems of the Indo West Pacific region, such as Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef.

4.2 Environment That May be Affected

Potential impacts or environmental affects arising from the Activity are most likely to be contained the 'Operational area'. Potential environmental effects extending beyond this area would only occur from unplanned hydrocarbon spills, with the worst-case Loss of Well Control (LOWC) scenario predicted to pose the largest environmental risk, and thus defined the EMBA.

Oil Spill Modelling (OSM) was undertaken for one (1) unplanned hydrocarbon release scenario of a loss of well control from the BOP at the rig floor (sea surface) for one week with an oil release rate of 96,861 bbl/day and 10 weeks from the seafloor with a decreasing weekly rate from 85,168 bbl/day in Week 2 to 47,004 bbl/day in Week 11 (total release of 5,007,618 bbl or 796,124 m^3). The gas release rate decreased from 11,526 MScf/day in Week 1 to 5,593 MScf/day in Week 11 (total 595,907 MScf).

Modelling was carried out with SINTEF's Oil Spill Contingency and Response (OSCAR) system (Version 9.0.1). OSCAR is a system of integrated models to quantitatively assess the fate and transport of hydrocarbons in the marine environment, as well as evaluate the efficacy of response measures (Reed et al. 2001; Reed et al. 2004). The model was configured in stochastic mode to simulate a range of environmental conditions. The start dates for the stochastic simulations were staggered approximately fortnightly across the five (5) years of hydrodynamic and wind data. A total of 120 individual 'realisations' made up the full stochastic set for the loss of well control scenario. For each of the 120 stochastic realisations, OSCAR spatially tracks the surface oil, entrained oil droplets in the water column, dissolved oil and oil on shorelines. To present this large amount of simulated data in a meaningful way, thresholds are applied to each of the hydrocarbon components and OSCAR generates statistical spatial outputs of the instances when (and where) each threshold was exceeded.

To assess environmental effects from an unplanned hydrocarbon release, three separate hydrocarbon components that pose differing environmental risks were evaluated:

- Surface hydrocarbons – hydrocarbons that are 'on' the water surface;
- Total water accommodated fraction (WAF) hydrocarbons – combination of entrained and dissolved hydrocarbons 'in' the water; and
- Dissolved WAF hydrocarbons – only the dissolved component of WAF 'in' the water.

Threshold concentrations for each of the three hydrocarbon phases were developed and applied to the modelling outputs to define the EMBA for each phase. A receptor was considered 'effected' by one of the phases as soon as the threshold for the phase at that location was exceeded (i.e. instantaneous impact approach).

The EMBAs for floating (10 g/m^2), entrained (500 ppb) and dissolved aromatic (100 ppb) hydrocarbon concentration thresholds for the worst-case spill scenario for this EP is shown in **Figure 4-1**. In addition hydrocarbons stranded on shorelines were also considered in the area affected in the consequence assessment.

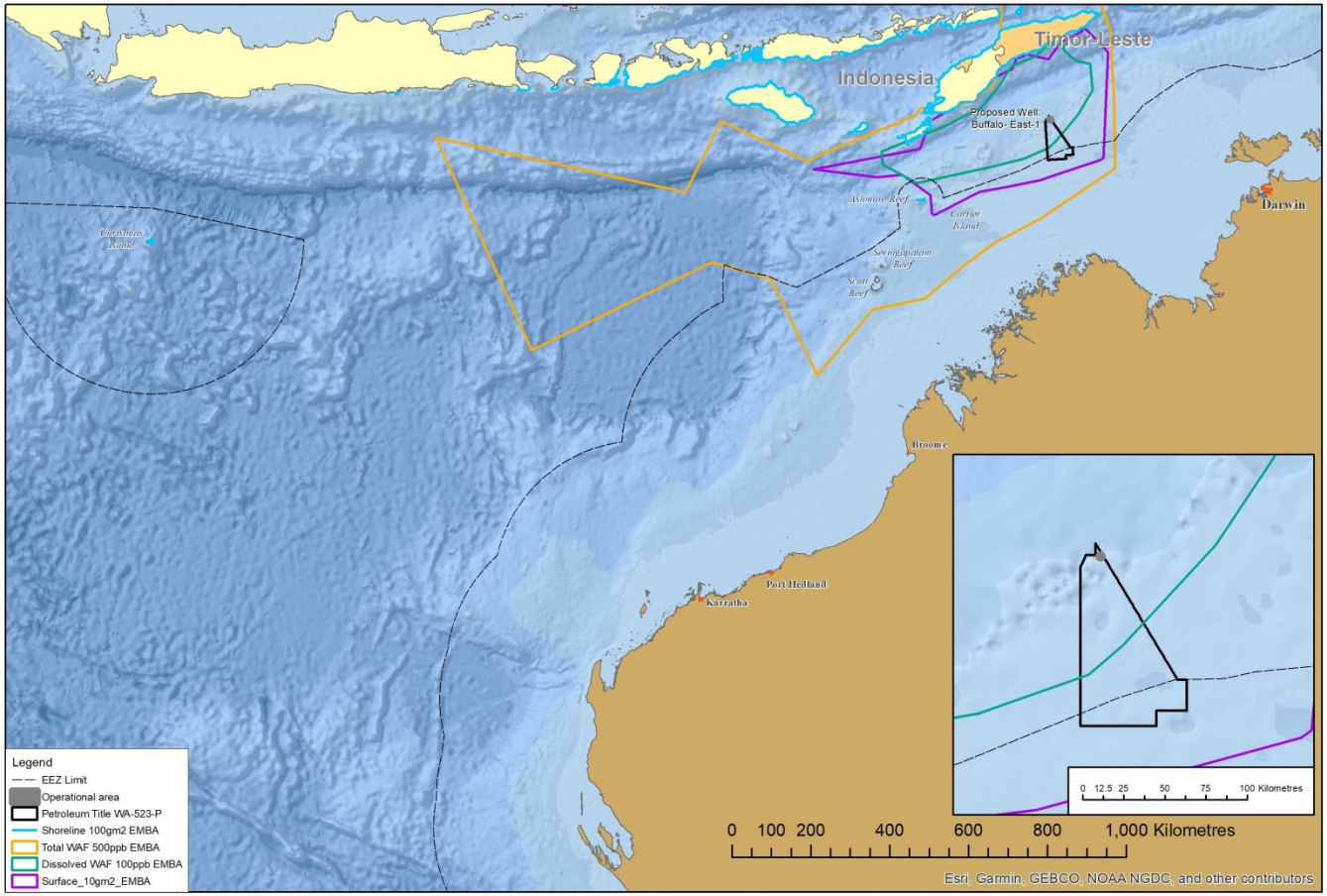


Figure 4-1: Environment That May Be Affected (EMBA)

4.3 Habitats within the EMBA

Given the spatial extent of the EMBA and the inclusion of shallow water and shoreline areas, there is a wide variety of marine and coastal habitats present. **Table 4-3** provides an indication of the distribution of these habitats.

The benthic habitats on Big Bank have been recently re-surveyed (GeoOceans 2018) and are shown in **Figure 2-1**. Big Bank is generally characterised by flat unconsolidated gravel and rubble substrates, mixed turfing and calcareous algae (*Halimeda* sp.), sponge and soft coral communities with some hard corals on the more consolidated substrate on the western and eastern ends of the bank (Heyward *et al*. 1997; GeoOceans 2018). The Operational area is located towards the middle of the bank in the sparsely populated, unconsolidated gravel macroalgae-dominated habitat. Heyward *et al*. (1997) found high interannual variability in benthic cover of algae between years at the Big Bank Shoals, indicating an environment subject to natural disturbances (e.g. tropical cyclones and high wave energy).

While the Operational area is partially situated on Big Bank, the surrounding area consists of extensive shelf flats, characterised by soft sediments (covering 97% of the benthos), with a sparse assemblage of species (polychaetes, crustaceans, sponges, ascidians, echinoderms, gorgonians and soft corals). The deeper waters off the shelf (~300 m depth) are flat, with very sparse sponge and invertebrate communities (<1%). These deep water areas areas of soft substrate typically support a low abundance, low richness and low diversity of burrowing organisms. These habitats were dominated by polychaete worms and crustaceans (mostly amphipods, shrimps and isopods), which made up 84% of the animals sampled, with smaller proportions of holothurians (sea cucumbers), echnioderms (sea urchins), molluscs (tusk shells and bivalves), nemerteans (ribbon worms), sponges and fish (Heyward *et al*. 1997).

In the areas mapped as macroalgae-dominated by GeoOceans (2018), there were three raised seabed features recorded, consisting of consolidated substrate that were colonised by marine growth consisting of macroalgae and hard coral. Two of these features were located within 50 m from the 'previous well' GPS location. Considering the general lack of coral within this sedimentary habitat, it may be that these features are the remains of infrastructure from previous development, although this could not be confirmed as the structures were 100% covered by marine growth (GeoOceans 2018).

A ROV survey conducted in 2001 (Nexen 2003), reported drill cuttings beneath the previous well head platform had raised the seabed one metre above the pre-existing level and that the cutting substrate was devoid of epi-benthos. To verify the habitats and existing infrastructure surrounding the previous WHP location, there were five towed camera transects completed by GeoOceans that targeted this area. On these five transects, there was no obvious sign of cuttings piles and macroalgae had colonised the gravel and rubble substrates beneath. No pipelines were evident in the GeoOceans survey (GeoOceans 2018).

Table 4-3: Benthic and Shoreline Habitats of the Bioregional Provinces within the EMBA

Receptor	Within Operational Area	Presence in EMBA					
		Timor	Northwest shelf	Northwest transition	Northwest shelf transition	Christmas Island	Other (Indonesia, Timor Leste, Tiwi Islands)
Benthic Habitats							
Coral	Not present	Ashmore Reef, Cartier Island, Hibernia, Scott and Seringapatam reefs, shoals and banks of the Sahul Shelf	Present but no significant areas	Present but no significant areas	Browse Island	Christmas Island	Indonesia (west) Timor-Leste (east - Coral Triangle)
Seagrasses	Not present	Ashmore Reef, Scott Reef, Seringapatam reefs	Present but no significant areas	Present but no significant areas	Present but no significant areas	Present but no significant areas	Indonesia (west) Kepulauan Seribu National Park Timor-Leste Tiwi Islands
Macroalgae	Turfing algae and calcareous *Halimeda* sp.	Ashmore Reef, Scott Reef, Seringapatam reefs, shoals and banks of the Sahul Shelf	Present but no significant areas	Present but no significant areas	Present but no significant areas	Present but no significant areas	Present but no significant areas
Non-coral benthic Invertebrates	Soft coral, sponges, filter feeders (sea whips and sea ferns), epifauna, infauna	Ashmore Reef, Scott Reef, Seringapatam reefs, shoals and banks of the Sahul Shelf	Present but no significant areas	Rowley Shoals	Present but no significant areas	Present but no significant areas	Present but no significant areas
Shoreline Habitats							

Receptor	Within Operational Area	Presence in EMBA					
		Timor	Northwest shelf	Northwest transition	Northwest shelf transition	Christmas Island	Other (Indonesia, Timor Leste, Tiwi Islands)
Mangroves	Not present	Not present	Present but no significant areas	Not present	Present but no significant areas	Present but no significant areas	Indonesia (west); Sumbawa, Karimunjawa National Park, Kepulauan Seribu National Park, Meru Betiri National Park, Bali Barat National Park, Komodo National Park Timor-Leste Tiwi Islands
Intertidal sand/mud flats	Not present	Not present	Present but no significant areas	Not present	Present but no significant areas	Present but no significant areas	Indonesia; Karimunjawa National Park, Lombok Timor-Leste (Irebere Estuary)
Intertidal platforms	Not present	Scott Reef, Ashmore Reef, Cartier Island	Present but no significant areas	Not present	Present but no significant areas	Present but no significant areas	Present but no significant areas
Sandy beaches	Not present	Scott Reef (Sandy Island)	Present but no significant areas	Not present		Present but no significant areas	Indonesia; Meru Betiri National Park Timor-Leste; present but no significant areas Tiwi Islands
Rocky shorelines	Not present	Not present	Present but no significant areas	Not present	Present but no significant areas	Present	Present but no significant areas

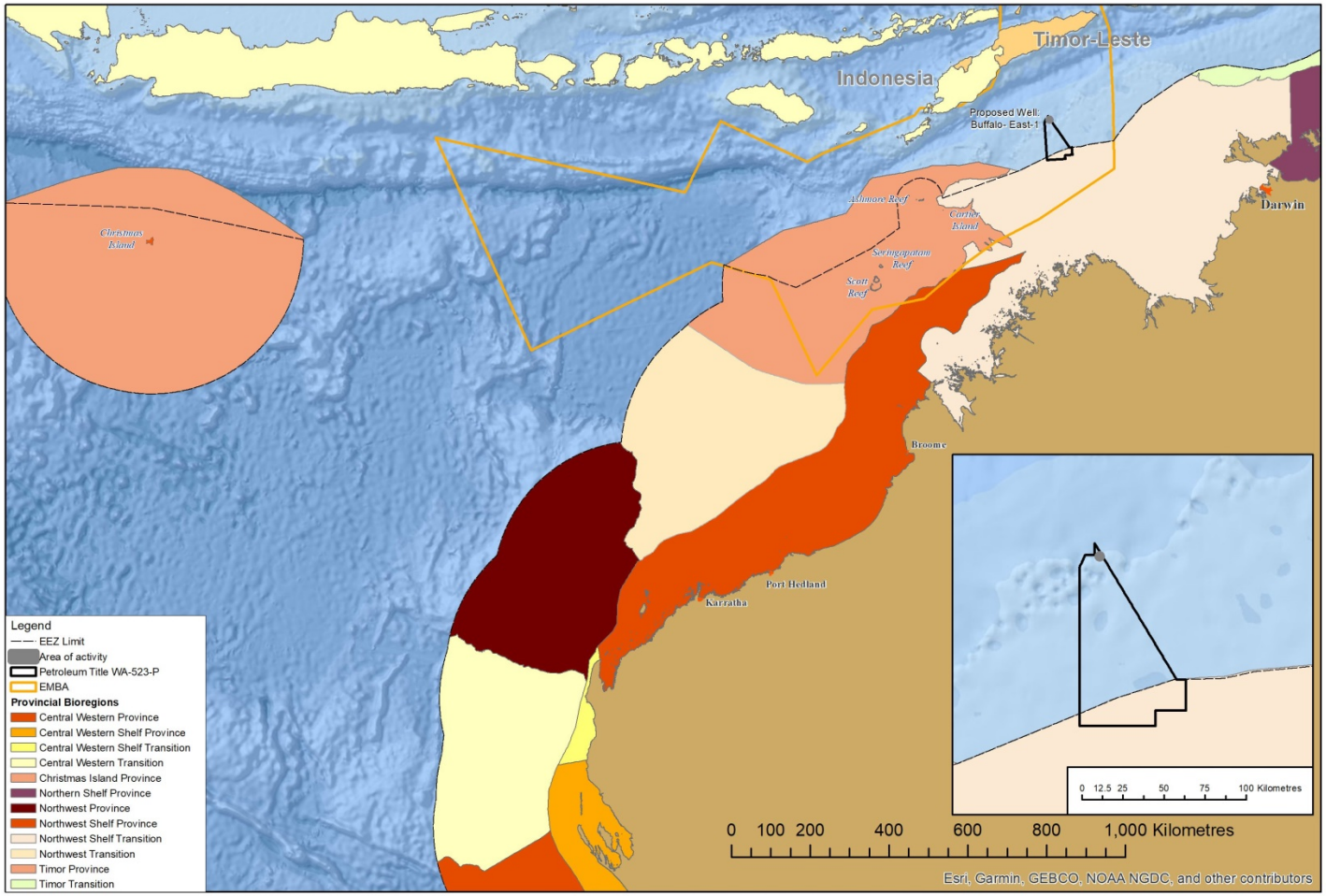


Figure 4-2: Bioregional Provinces of Interest

4.4 Protected and Significant Areas within the EMBA

Protected and significant areas within the EMBA and have been identified in **Table 4-4**.

Table 4-4: Environmental Values and Sensitivities – Protected/Significant Areas

Value/Sensitivity	EMBA Presence	Distance from Operational Area
Australian Marine Parks	Ashmore Reef – Sanctuary Zone (IUCN Ia) and Recreational Use Zone (IUCN IV)	~370 km
	Cartier Island – Sanctuary Zone (IUCN Ia)	~355 km
	Oceanic Shoals Marine Reserve – Multiple Use Zone (IUCN VI)	~86 km
	Argo-Rowley Terrace Marine Reserve (IUCN VI)	733 km
	Kimberley - Multiple Use Zone (IUCN VI), Habitat Protection (IV) and National Park (II)	290 km
State and Territory Marine Parks (MP) and Marine Management Areas (MMA)	Browse Island (WA)	481 km
	Christmas Island	~2,300 km
	Unnamed WA41775 (WA)	481 km
World Heritage	Nil	
Wetlands of International Importance (Ramsar)	Ashmore Reef National Nature Reserve	~370 km
	The Dales	~2,300 km
National Heritage Places	Nil	
Commonwealth Heritage Places	Ashmore Reef National Nature Reserve	~370 km
	Christmas Island Natural Areas	~2300 km
Threatened Ecological Communities	Nil	
Key Ecological Features (KEF)	Ashmore Reef and Cartier Island and surrounding Commonwealth waters	~355 km
	Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex	~558 km
	Continental Slope Demersal Fish Communities	~352 km
	Ancient Coastline at 125 m Depth Contour	~338 km
	Carbonate Bank and Terrace System of the Sahul Shelf	88 km
	Pinnacles of the Bonaparte Basin	120 km
	Canyons linking the Argo Abyssal Plain and Scott Plateau	820 km

The EMBA extends into international waters to the north west of the Operational area and includes the southern waters adjacent Lesser Sunda Islands, Bali, and Java. Indonesian and Timorese National Parks close to the EMBA are listed in **Table 4-5**.

Table 4-5: Indonesian and Timor Leste National Parks close to the EMBA

Name	Year	Area (km^2)	Marine Area (km^2)	International Status
Indonesia				
Karimunjawa	1986	1,116	most	
Meru Betiri	1982	580	8.5	
Bali Barat	1995	190	32	
Komodo	1980	1,817	1,199	World Heritage Site World Network of Biosphere Reserves
Savu Sea Marine Conservation Area	2014	29,454	All	IUCN Category II
Timor Leste				
Nino Konis Santana	2007	12,36	556	IUCN Category II

Australian Marine Parks

The Operational area is not located within any Australian Marine Parks (AMPs). There are five AMPs overlapping with the EMBA including:

- Ashmore Reef;
- Cartier Island;
- Oceanic Shoals;
- Argo-Rowley Terrace; and
- Kimberley.

Big Bank Shoal is part of the Commonwealth Marine Area. A Commonwealth Marine Area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory waters.

Table 4-6: Description of Australian Marine Parks within the EMBA

Australian Marine Park	Distance from Operational Area	Key Features of Conservation Significance	IUCN Zone within EMBA	Rules/Requirements	Relevant Events
Ashmore Reef	~378 km	• Atoll-like structure with three low vegetated islands, sandbanks, lagoon areas, and surrounding reef • Largest of only three emergent oceanic reefs present in the north-eastern Indian Ocean • Only oceanic reef in the region with vegetated islands • The Ashmore Reef Ramsar site is located within the boundary of the Marine Park. The site was listed under the Ramsar Convention in 2002 (site 1220) and is a wetland of international importance under the *EPBC Act* • Reef covers an area of 227 km^2 • Ecosystems, habitats and communities associated with the North West Shelf, Timor Province, and emergent oceanic reefs • Noted for the world's highest recorded abundance and diversity of sea snakes • Is an important biological stepping stone facilitating the transport of biological material to the reef systems along the Western Australian coast • Critical nesting and inter-nesting habitat for green turtles. Low nesting activity by loggerhead turtles has also been recorded • Large and significant feeding populations of green, hawksbill and loggerhead turtles occur around the reefs • Supports a small dugong population of less than 50 individuals that breeds and feeds around the reef. This population is thought to be genetically distinct from other Australian populations • A migratory pathway for pygmy blue whales • An important seabird rookery and provides important staging/feeding areas for many migratory seabirds • Cultural and heritage sites including Indonesian artefacts and grave sites • Subject to the Memorandum of Understanding between Australia and Indonesia (MoU Box) Indigenous Australians: • Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. At the commencement of this plan there is limited information about the cultural significance of this Marine Park Indonesian: • The Marine Park contains Indonesian artefacts and grave sites and Ashmore lagoon is still accessed as a rest or staging area for traditional Indonesian fishers travelling to and from fishing grounds within the MoU Box • No international or national heritage listings apply to the Marine Park at commencement of the management plan (DoNP 2018a) Commonwealth heritage: • Ashmore Reef was listed on the Commonwealth Heritage List in 2004, meeting Commonwealth heritage listing criteria A, B and C • Tourism, recreation and scientific research are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation	Sanctuary Zone (IUCN 1a)	Australian Marine Parks: North-west Marine Parks Network Management Plan 2018 (DoNP 2018). Sanctuary Zone (IUCN category Ia)—managed to conserve ecosystems, habitats and native species in as natural and undisturbed a state as possible The zone allows only authorised scientific research and monitoring Emergency response permitted	Unplanned Hydrocarbon Release
Cartier Island	~355 km	• The Marine Park includes an unvegetated sand island (Cartier Island), mature reef flat, a small, submerged pinnacle (Wave Governor Bank), and two shallow pools to the north-east of the island • Covers an area of 172 km^2 • Ecosystems, habitats and communities associated with the Timor Province • Internationally significant for its abundance and diversity of sea snakes • Is an important biological stepping stone facilitating the transport of biological material to the reef systems along the Western Australian coast • Large and significant populations of green, hawksbill and loggerhead turtles occur around the reefs (nesting, interesting and feeding habitat) • An important seabird rookery and provides important staging/feeding areas for many migratory seabirds • Provides foraging habitat for whale sharks	Sanctuary Zone (IUCN 1a)	Australian Marine Parks: North-west Marine Parks Network Management Plan 2018 (DoNP 2018). Sanctuary Zone (IUCN category Ia)—managed to conserve ecosystems, habitats and native species in as natural and undisturbed a state as possible. The zone allows only authorised scientific research and monitoring.	Unplanned Hydrocarbon Release

Australian Marine Park	Distance from Operational Area	Key Features of Conservation Significance	IUCN Zone within EMBA	Rules/Requirements	Relevant Events
		• Cultural and heritage site of the Ann Millicent historic shipwreck. • High diversity and abundance of hard and soft corals, gorgonians (sea fans), sponges and a range of encrusting organisms • Reef crests are generally algal dominated • Reef flats feature ridges of coral rubble and large areas of seagrass (Director of National Parks 2018a) • Foraging habitat for whale sharks (DoEE 2018c) • Two KEFs: Ashmore Reef and Cartier Island and surrounding Commonwealth waters and Continental Slope Demersal Fish Communities • Subject to the Memorandum of Understanding between Australia and Indonesia (MoU Box) • Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. At the commencement of the management plan (DoNP 2018 a), there is limited information about the cultural significance of this Marine Park. • Scientific research is an important activity in the Marine Park			
Oceanic Shoals	~86 km	• Examples of the ecosystems of two provincial bioregions: the Northwest Shelf Transition Province and the Timor Transition Province • Important internesting area for flatback and olive ridley turtles • Important foraging area for loggerhead and olive ridley turtles • Four key ecological features: carbonate bank and terrace system of the Van Diemen Rise; carbonate banks of the Joseph Bonaparte Gulf; pinnacles of the Bonaparte Basin; and shelf break and slope of the Arafura Shelf.	National Park Zone (IUCN II) Multiple Use Zone (IUCN VI)	Australian Marine Parks: North Marine Parks Network Management Plan 2018 (DoNP 2018). The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species	Unplanned Hydrocarbon Release
Argo-Rowley Shoals	~733 km	• Provides important foraging areas for migratory seabirds and the endangered loggerhead turtle • Important area for sharks, which are found in abundance around the Rowley Shoals relative to other areas in the region • The reserve provides protection for the communities and habitats of the deeper offshore waters of the region in depth ranges from 220 m to over 5,000 m • The reserve provides connectivity between the existing Mermaid Reef Marine National Nature Reserve and reefs of the Western Australian Rowley Shoals Marine Park and the deeper waters of the region • 2 KEFs: The canyons linking the Argo Abyssal Plain with the Scott Plateau and Mermaid Reef and the Commonwealth waters surrounding Rowley Shoals • Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. At the commencement of the management plan (DoNP 2018a) there is limited information about the cultural significance of this Marine Park • Commercial fishing and mining are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation • No international, Commonwealth or national listings apply to the Marine Park • Historic shipwrecks: • The Marine Park contains two known shipwrecks listed under the *Historic Shipwrecks Act 1976*: *Alfred* (wrecked in 1908) and *Pelsart* (wrecked in 1908)	Multiple Use Zone (IUCN VI) National Park (II) Special Purpose [Trawl] (VI)	Australian Marine Parks: North-west Marine Parks Network Management Plan 2018 (DoNP 2018). Multiple Use Zone (IUCN category VI)—managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining where they are consistent with park value. The objective of the Special Purpose Zone (Trawl) (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species, while applying special purpose	Unplanned Hydrocarbon Release

Australian Marine Park	Distance from Operational Area	Key Features of Conservation Significance	IUCN Zone within EMBA	Rules/Requirements	Relevant Events
				management arrangements for specific activities. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	
Kimberley	290 km	• The Wunambal Gaambera, Dambimangari, Bardi Jawi and the Nyul Nyul people's sea country extends into the Kimberley Marine Park and supports key cultural values and future socio-economic opportunities • 2 KEFs: the ancient coastline at the 125-m depth contour and continental slope demersal fish communities • Provides connectivity between deeper offshore waters, and the inshore waters of the adjacent Western Australia North Kimberley Marine Park and Lalang-garram/Camden Sound Marine Park • Breeding and foraging habitat for seabirds • Internesting and nesting habitat for marine turtles • Breeding, calving and foraging habitat for inshore dolphins • Calving, migratory pathway and nursing habitat for humpback whales, migratory pathway for pygmy blue whales • Foraging habitat for dugong and foraging • Habitat for whale sharks. • Adjacent to important foraging and pupping areas for sawfish and important nesting sites for green turtles (DoE 2016a) • No international, Commonwealth or national heritage listings apply to the Marine Park at commencement of the management plan (DoNP 2018a), however the Marine Park is adjacent to the national heritage place of The West Kimberley • Historic shipwrecks: The Marine Park contains more than 40 known shipwrecks listed under the *Historic Shipwrecks Act 1976* • Tourism, commercial fishing, mining, recreation, including fishing, and traditional use are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation	Multiple Use Zone (IUCN VI) Habitat Protection (IV) National Park (II)	Australian Marine Parks: North-west Marine Parks Network Management Plan 2018 (DoNP 2018). Multiple Use Zone (IUCN category VI)—managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining where they are consistent with park value The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.	Unplanned Hydrocarbon Release

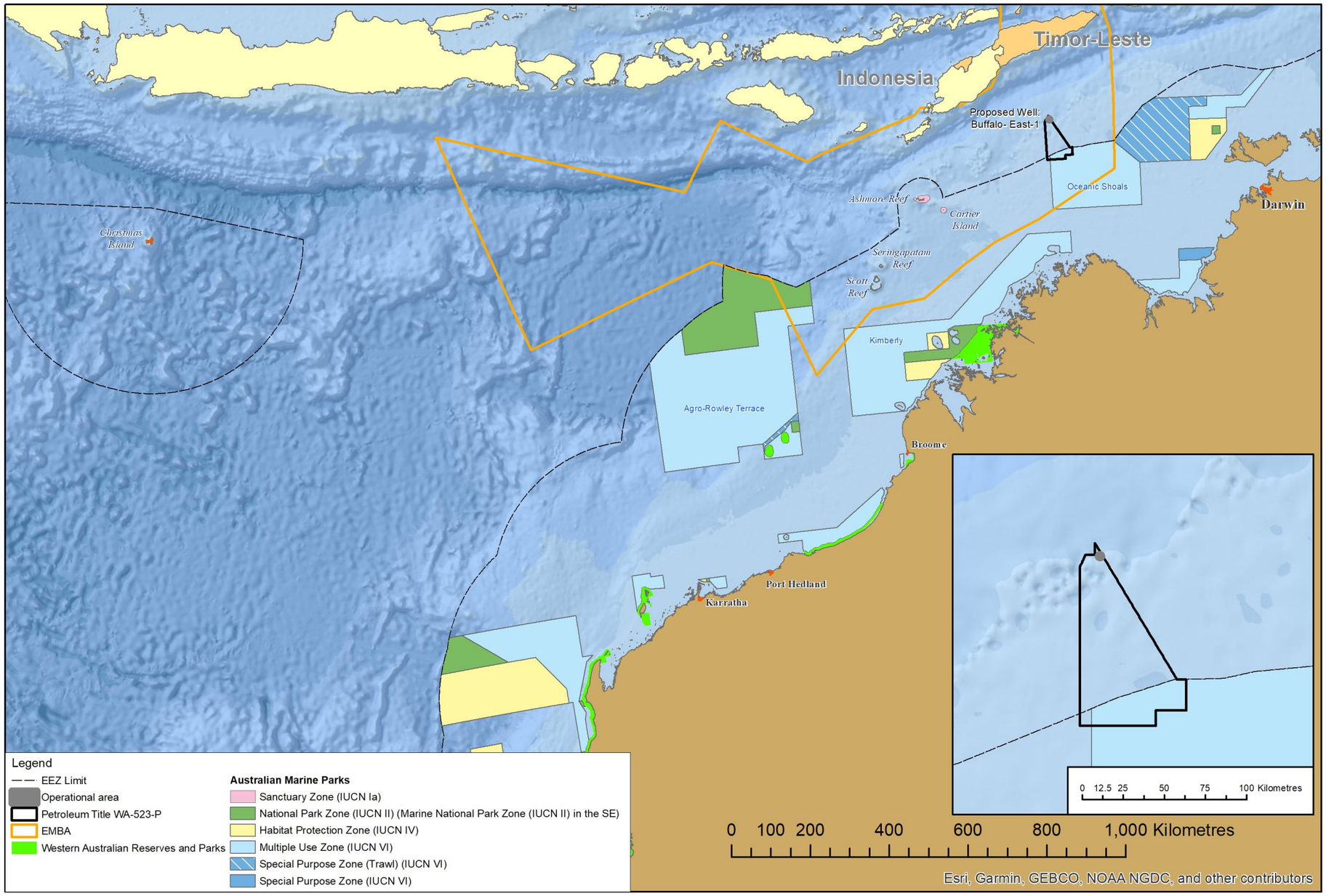


Figure 4-3: Australian Marine Parks (AMPs)

Table 4-7: Description of State and Territory Marine Parks within the EMBA

State or External Territory Marine Park	Distance from Operational Area	Key Features of Conservation Significance	IUCN Zone within EMBA	Rules/Requirements	Relevant Events
Browse Island Nature Reserve	481 km	• Small, approx. 14 ha uninhabited island. • Browse Island is surrounded by a minor fringing coral reef. Assemblages at Browse Island are characteristic of coral platform reefs throughout the Indo-West Pacific region, particularly Cartier Island. Coral diversity was greatest on the reef faces and shallow lagoons but these areas were of very limited extent (URS 2010a). • Nesting site for green turtles • Seabird nesting site • Fringing coral reefs with the waters around the island a site of upwelling associated with concentrations of tropical krill • There have been unconfirmed reports of Humpback Whales feeding • 9 historic shipwrecks (1 on register of National Estate) • Historical human impact from guano mining, lighthouse construction and introduction of house mice • Surrounding waters visited by Indonesian fisherman.	Not Class A	No MP in place	Unplanned Hydrocarbon Release
Christmas Island	2,300 km	• Christmas Island is an isolated oceanic island, approximately 135 km2 in area. It rises steeply from the sea floor from depths of 5,000 m. The Christmas Island National Park covers approximately 85 km^2 (63%) of the island's land area. In addition, the park includes a marine zone extending 50 m seaward of the low water mark and incorporates much of the island's fringing coral reef system (Director of National Parks 2014). • High level of endemism - 254 endemic species and 165 species occurring nowhere else in Australia (including 50 fish species). • Whale sharks generally migrate through the island's waters between November and April,	National Park (IUCN II)	Christmas Island National Park Management Plan (2014-2024) The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems,	Unplanned Hydrocarbon Release

State or External Territory Marine Park	Distance from Operational Area	Key Features of Conservation Significance	IUCN Zone within EMBA	Rules/Requirements	Relevant Events
		• The waters surrounding the island are critical for the survival of the island's land crabs, including tens of millions of red crabs, as they release their eggs into the sea as part of their breeding life cycle • Two marine turtles listed as vulnerable under the *EPBC Act*, the green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*), are found in the park's waters and green turtles occasionally nest on Dolly Beach. • Christmas Island is one of the world's significant seabird islands. More than 100 migrant and vagrant species have been recorded, including nine resident breeding seabird species (with three of these being endemic or endemic subspecies) and 23 vagrant/non-breeding seabirds. The Abbott's booby and the Christmas Island frigatebird have their only extant nesting habitat in the world on Christmas Island. • Fringing coral reefs and significant geomorphological features such as the island's terraces and cave systems, including anchialine cave systems (caves containing a subterranean water body with connections to the ocean) which provide animal habitat. Anchialine cave systems occur at only one other known locality in Australia • The Dales and Hosnies Spring wetlands which are listed as Wetlands of International Importance under the Ramsar Convention • High recreational value.		habitats and native species in as natural a state as possible	
Unnamed WA41775	481 km	• A terrestrial reserve located on Browse Island and Classified as a 5(1)(h) reserve under State legislation in 1991.	Not considered further as terrestrial and no potential for impact		

4.5 Key Ecological Features within the EMBA

4.5.1 *Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters*

Ashmore Reef and Cartier Island are emergent, oceanic reefs situated in the north-east Indian Ocean, lying 45 km apart (EA 2002). Ashmore Reef and Cartier Island are both Australian Marine Parks and are discussed in **Table 4-6**.

4.5.2 *Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex*

Seringapatam and Scott reefs are emergent, oceanic reefs on the north-west continental slope (Falkner *et al*. 2009). The reefs are located approximately about ~550 km from the Operational area and 23 km apart. As two of the few offshore reefs in the north-west region, they are an important biophysical environment in the region. Seringapatam Reef is a remote atoll with an enclosed lagoon, covering an area of 55 km^2. Dominant benthic habitats of the reef include turf algae, macroalgae, hard and soft corals, and filter feeders (sponges, gorgonians, hydroids and sea pens) (Heyward *et al*. 2013).

The Scott Reef complex, consisting of two reefs (North and South), lies approximately 558 km from the Operational area. Scott Reef is a particularly biologically diverse system and includes more than 300 species of reef-building corals, approximately 400 mollusc species, 118 crustacean species, 117 echinoderm species, and around 720 fish species (Woodside 2009). Two species of marine turtle, the green and hawksbill, nest during the summer months on Sandy Islet (a small sand cay), located on Scott Reef South. These species also internest and forage in the surrounding waters (Guinea 2006). The reef also provides foraging areas for seabird species, such as the lesser frigatebird, wedge-tailed shearwater, brown booby and roseate tern (Donovan *et al*. 2008).

Seringapatam and Scott reefs are regionally significant because of their high representation of species not found in coastal waters off Western Australia, and for the unusual nature of their fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific, as well as the reefs of the Indonesian region. These coral communities play a key role in maintaining the species richness and subsequent aggregations of marine life identified as conservation values for this KEF. Seringapatam and Scott reefs, and the waters surrounding them, attract aggregations of marine life, including humpback whales and other cetacean species, whale sharks and seasnakes (Donovan *et al*. 2008; Jenner *et al*. 2009; Woodside 2009).

4.5.3 *Continental Slope Demersal Fish Communities*

The continental slope demersal fish community is, at its nearest, approximately 350 km from the EMBA. The level of endemism (i.e. unique to a location) of demersal fish species in this community is the highest among Australian continental slope environments. The Continental Slope consists of two distinct community types associated with the upper and mid slope, 225 – 500 m and 750 – 1000 m, respectively. The Timor Province and Northwest Transition bioregions are the second-richest areas for demersal fish across the entire continental slope (DSEWPaC 2012a). The bacteria and fauna that is present in the system on the Continental Slope are the basis for the food web for demersal fish and higher order consumers in the system. Further information of this system has been poorly researched, though it has been suggested that it is a detritus-based system, where infauna and epifauna become prey for a range of fish, molluscs and crustaceans (Brewer *et al*. 2007). The higher order consumers supported by this system are likely to be carnivorous fish, deep water sharks, large squid and toothed whales (Brewer *et al*. 2007). The pelagic production is phytoplankton based, with hotspots near oceanic reefs and islands (Brewer *et al*. 2007).

4.5.4 *Ancient Coastline at 125 m Depth Contour*

The shelf of the NWMR contains several terraces and steps which reflect changes in sea level that occurred over the last 100,000 years. The most prominent of these features occurs at a depth of 125 m as an escarpment along the North West Shelf and Sahul Shelf, located ~340 km from the Operational area (**Figure 4-4**). Where the ancient submerged coastline provides areas of hard substrate it may contribute to higher biological diversity. Little detailed knowledge is available, but the hard substrate of the escarpment is likely to support sponges, crinoids, molluscs, echinoderms (DSEWPaC 2012). It is understood that changes in topography at these depths are critical points for the generation of internal waves (Holloway *et al*. 2001 cited in DEWHA 2008b), playing a minor role in aiding localised upwelling or at least regional mixing associated with the seasonal changes in currents and winds. It is also believed that this prominent floor feature could be important as a migratory pathway for cetaceans and pelagic species such as the whale shark and humpback whale, as they move north and south between feeding and breeding grounds (DEWHA 2008b).

4.5.5 *Carbonate Bank and Terrace System of the Sahul Shelf*

The carbonate bank and terrace system of the Sahul Shelf is located in the western Joseph Bonaparte Gulf, approximately 88 km from the Operational area (**Figure 4-4**). It is recognised as a KEF for its biodiversity values (a unique seafloor feature with ecological properties of regional significance), which apply to both its benthic and pelagic habitats. The banks consist of a hard substrate with flat tops. Each bank occupies an area generally less than 10 km^2 and is separated from the next bank by narrow channels up to 150 m deep (DSEWPaC 2012). Although little is known about the bank and terrace system of the Sahul Shelf, it is considered to be regionally important due to its continuous and large expanse, as well as the ecological role it is likely to play in the biodiversity and productivity of the Sahul Shelf (DSEWPaC 2012). The banks support a high diversity of organisms, including reef fish, sponges, soft and hard corals, gorgonians, bryozoans, ascidians and other sessile filter-feeders (Brewer *et al*. 2007). They are foraging areas for loggerhead, olive ridley and flatback turtles. Humpback whales and green and freshwater sawfish are also likely to occur in the KEF (Donovan *et al*. 2008). However, due to their ecology, sawfish (generally estuarine rather than open-ocean species), are not expected to be present within the open-ocean.

4.5.6 *Canyons linking the Argo Abyssal Plain and Scott Plateau*

The Scott Plateau connects with the Argo Abyssal Plain via a series of canyons, the largest of which are the Bowers and Oates canyons (DSEWPaC 2012). The canyons cut deeply into the south-west margin of the Scott Plateau and act as conduits for transport of sediments from an approximate depth of 2,000–3,000 m to depths of more than 5,500 m (DSEWPaC 2012). The water masses at these depths are deep Indian Ocean water on the Scott Plateau and Antarctic bottom water on the Argo Abyssal Plain. Both water masses are cold, dense and nutrient-rich (Lyne *et al*. 2006 in DSEWPaC 2012). The high productivity of the region is believed to be led by topographically induced water movements through the canyons and the action of internal waves in these canyons as well as around islands and reefs. The canyons are therefore thought to be linked to small and periodic upwellings that enhance this biological productivity (DEWHA 2008c). The Canyons linking the Argo Abyssal Plain and Scott Plateau are likely to be important features due to their historical association with sperm whale aggregations (DSEWPaC 2012).

4.5.7 *Pinnacles of the Bonaparte Basin*

The Pinnacles of the Bonaparte basin lie on the mid-outer shelf in the western Joseph Bonaparte Gulf, providing areas of hard substrate in an otherwise soft sediment environment and so are important for sessile species. Rising steeply from depths of about 80 m some pinnacles emerge to within 30 m of the water surface, allowing light dependent organisms to thrive. Pinnacles that rise to within 45 m water depth support more biodiversity. Communities include sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers (Brewer *et al*. 2007, Nichol *et al*. 2013). The pinnacles are also recognised as a biodiversity hotspot for sponges as they are home to more sponge species and different communities than the surrounding seafloor (NERP MBH 2014). Surveys undertaken in 2012 suggest the area supports a wide range of high-order pelagic animals with 32 species

observed, including 11 shark species, black marlin, barracuda, olive ridley turtle, sea snakes and orcas. Demersal fish communities were found to occur in larger and more diverse populations on the shallower, less turbid banks and pinnacles (Nichol *et al*. 2013). Marine turtles including flatback, loggerhead and olive ridley are known to forage around the pinnacles (Donovan *et al*. 2008; Whiting *et al*. 2007), and flatback turtles feed on squid eggs laid on the hard substrate of the pinnacles (M Guinea, pers. comm., 2009).

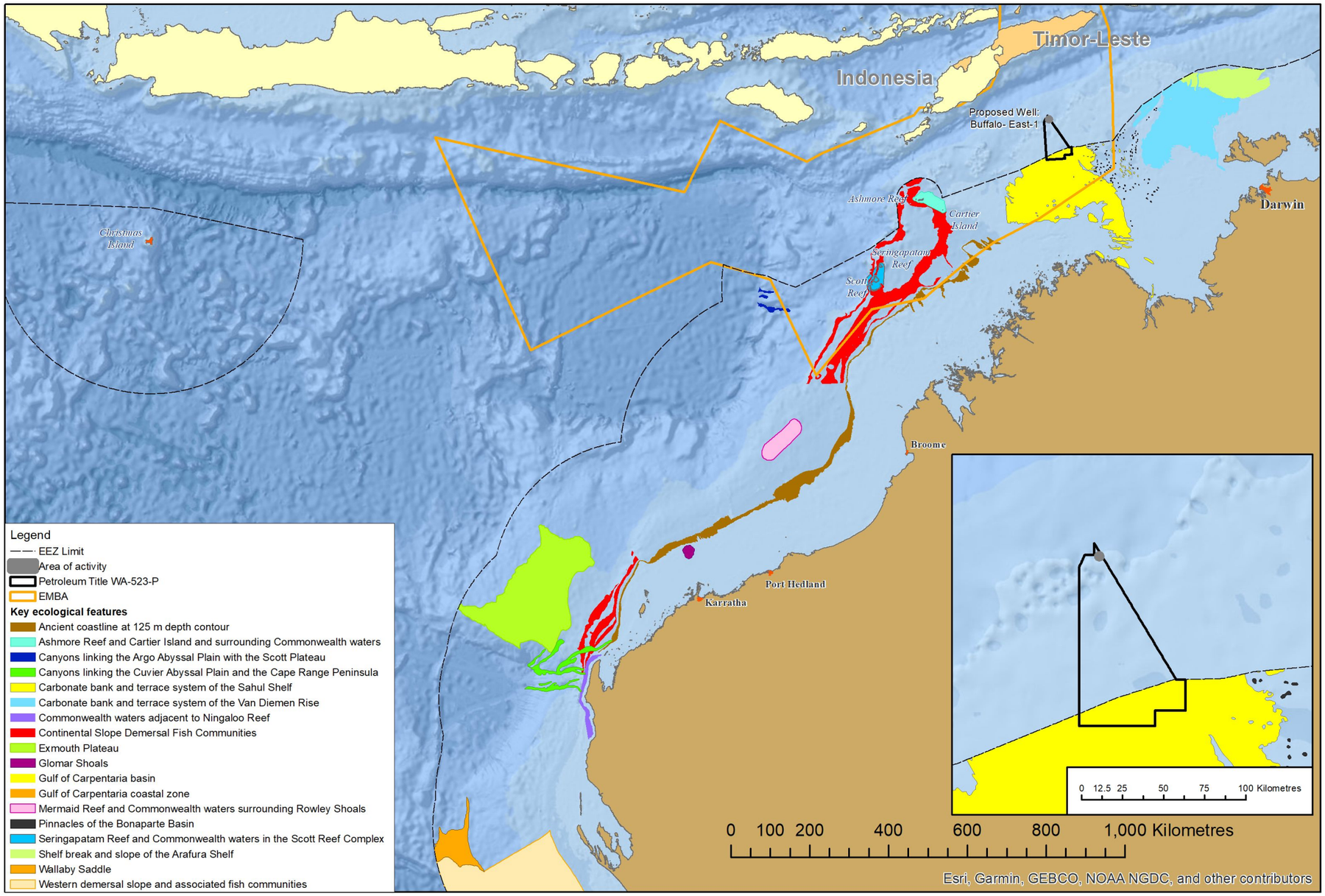


Figure 4-4: KEFs within the EMBA

4.6 Wetlands of International Importance

4.6.1 *Ashmore Reef National Nature Reserve*

See **Table 4-6**.

4.6.2 *The Dales*

Located on Christmas Island, the Dales RAMSAR site is located within the Christmas Island National Park, with the western boundary of the site extending to 50 m seaward from the low water mark (including a narrow, shallow reef). The Dales is a system of seven watercourses that contain a number of wetland types. It also exhibits unusual water-related limestone deposition features, including a 'flowstone' formation that is usually found underground. The combination of this variety of habitats and the presence of permanent surface water provides a habitat which supports a wide diversity of endemic and threatened species (Director of National Parks 2014).

Migrating red crabs pass through the area on their annual breeding migration and the area supports a resident population of red crabs and other terrestrial crabs including the robber crab. The site provides critical habitat for blue crabs that are dependent upon the freshwater streams for their reproductive cycle. The Dales supports a diverse community of tree species and epiphytes. At Hugh's Dale, and in parts of Anderson Dale and Sydney's Dale, there are mono-specific stands of Tahitian chestnut (*Inocarpus fagifer*) and the rare epiphytic ribbon fern (*Ophioglossum pendulum*). The endemic arenga palm (*Arenga listeri*) and endemic Ridley's orchid (*Brachypeza archytas*) are common in The Dales. *Terminalia catappa* grows to an unusually large size on Christmas Island and several large specimens occur in The Dales. A number of endemic fauna species occur within The Dales including the Abbott's booby, blue crabs and forest birds. Christmas Island's only native freshwater fish, the brown gudgeon (*Eleotris fusca*) is also found in the streams at The Dales (Director of National Parks 2014).

4.7 Marine Fauna (Protected Species)

The PMST search identified 41 Listed Threatened Species (LTS) and 55 Listed Migratory Species (LMS) as having the potential to occur within the EMBA.

As part of the desktop searches, an assessment was undertaken to identify if these species have the potential to occur in the EMBA and those species are summarised in **Table 4-8**. Sensitive habitat areas such as an aggregation, resting or feeding or known migratory routes for these species are shown as BIAs.

Table 4-8: Environmental Values and Sensitivities – EPBC Listed Threatened and Migratory Fauna within the EMBA

Value/Sensitivity Common Name (Scientific Name)	*EPBC Act* Status CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory	WC Act Status OPF = Other Protected Fauna P1 = Priority V = Vulnerable S = Schedule LC = Least Concern	Conservation Advice	Recovery Plan	Threat Abatement Plan	Operational Area presence[2]	BIAs, Particular Values or Sensitivities within EMBA	Potential impacts	Relevant Events
Protected Species and Communities: Marine Mammals									
Humpback Whale (*Megaptera novaeangliae*)	V,M		✓ Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee, 2015c)	Ceased 2015	✓ Marine debris	✓	Species or species habitat likely to occur within area	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna
Blue whale (*Balaenoptera musculus*) Including Pygmy Blue Whale	E,M	E (S2)	No	✓ Conservation management plan for the blue whale: *A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999* 2015-2025 (Commonwealth of Australia, 2015a)	✓ Marine debris	✓ Pygmy Blue Whale Distribution BIA	Species or species habitat likely to occur within area Migration route known to overlap EMBA.	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine
Sei Whale (*Balaenoptera borealis*)	V, M	E (S2)	✓ Conservation advice *Balaenoptera borealis* sei whale (Threatened Species Scientific Committee, 2015a)	Ceased in 2015	✓ Marine debris	✓ Transient individuals may occur	Species or species habitat likely to occur within area	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna
Fin Whale (*Baleenoptera physalus*)	V, M	E (S2)	✓ Conservation advice *Balaenoptera physalus* fin whale (Threatened Species Scientific Committee, 2015b)	Ceased 2015	✓ Marine debris	✓ Transient individuals may occur	Species or species habitat likely to occur within area	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna
Bryde's Whale (*Balaenoptera edeni*)	M			No		✓ Transient individuals may occur	Species or species habitat may occur within area	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna

[2] Determined from an EPBC search of the Buffalo Operational Area

Value/Sensitivity Common Name (Scientific Name)	*EPBC Act* Status CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory	WC Act Status OPF = Other Protected Fauna P1 = Priority V = Vulnerable S = Schedule LC = Least Concern	Conservation Advice	Recovery Plan	Threat Abatement Plan	Operational Area presence[2]	BIAs, Particular Values or Sensitivities within EMBA	Potential impacts	Relevant Events
Orca, Killer Whale (*Orcinus orca*)	M			No		✓ Transient individuals may occur	Species or species habitat may occur within area	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna
Sperm Whale (*Physeter macrocephalus*)	M	V		No		✓ Transient individuals may occur	Species or species habitat may occur within area	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*)	M			No		✓	Species or species habitat may occur within area	Noise Vessels Pollution	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna
Irrawaddy Dolphin (*Orcaella brevirostris*)	M	P4							Hydrocarbon Release
Dugong (*Dugong dugon*)	M	OS (S7)			✓ Marine debris		Breeding known to occur within area		Hydrocarbon Release
Protected Species and Communities: Marine Reptiles									
Loggerhead Turtle (*Caretta caretta*)	E,M	E S2		✓ Recovery plan for marine turtles in Australia (DoEE 2017)	✓ Marine debris	✓	Species or species habitat may occur within area Foraging, feeding or related behaviour known to occur within area.	Marine debris Vessel interaction Light	Artificial Light Interaction with Marine Fauna Loss of well control
Green Turtle (*Chelonia mydas*)	V,M	V S3		✓ Recovery plan for marine turtles in Australia (DoEE, 2017)	✓ Marine debris	✓	Foraging, feeding or related behaviour known to occur within area.	Marine debris Vessel interaction Light	Artificial Light Interaction with Marine Fauna Loss of well control
Leatherback Turtle (*Dermochelys coriacea*)	E,M	V S3	✓ Approved conservation advice for *Dermochelys coriacea* (Leatherback Turtle) (Threatened Species Scientific Committee, 2008a)	✓ Recovery plan for marine turtles in Australia (DoEE, 2017)	✓ Marine debris	✓	Foraging, feeding or related behaviour likely to occur within area.	Marine debris Vessel interaction Light	Artificial Light Interaction with Marine Fauna Loss of well control

Value/Sensitivity Common Name (Scientific Name)	*EPBC Act* Status CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory	WC Act Status OPF = Other Protected Fauna P1 = Priority V = Vulnerable S = Schedule LC = Least Concern	Conservation Advice	Recovery Plan	Threat Abatement Plan	Operational Area presence[2]	BIAs, Particular Values or Sensitivities within EMBA	Potential impacts	Relevant Events
Hawksbill Turtle (*Eretmochelys imbricata*)	V,M	V S3		✓ Recovery plan for marine turtles in Australia (DoEE, 2017)		✓	Foraging, feeding or related behaviour known to occur within area	Marine debris Vessel interaction Light	Artificial Light Interaction with Marine Fauna Loss of well control
Olive Ridley Turtle (*Lepidochelys olivacea*)	E, M					✓	Foraging, feeding or related behaviour likely to occur within area	Marine debris Vessel interaction Light	Artificial Light Interaction with Marine Fauna Loss of well control
Flatback Turtle (*Natator depressus*)	V, M	V S3		✓ Recovery plan for marine turtles in Australia (DoEE, 2017)		✓	Foraging, feeding or related behaviour known to occur within area	Light Vessel interaction	Artificial Light Interaction with Marine Fauna Loss of well control
Short-nosed Seasnake (*Aipysurus apraefrontalis*)	CE	CE (S1)					Species or species habitat known to occur within area		Hydrocarbon Release
Leaf scaled Seasnake (*Aipysurus foliosquama*)	CE	CE (S1)					Species or species habitat may occur within area		Hydrocarbon Release
Protected Species and Communities: Fish and Sharks									
Whale Shark (*Rhincodon typus*)	V,M	OPF (S7)	Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015d)	Ceased 2010			Foraging, feeding or related behaviour known to occur within area	Habitat disturbance	Operational Discharges Loss of well control Non-hydrocarbon Release (Solid and Liquid) Noise Emissions Interaction with Marine Fauna
Narrow/Knifetooth Sawfish (*Anoxypristis cuspidata*)	M			✓ Sawfish and river shark multispecies recovery plan (Commonwealth of Australia, 2015b)		✓	Species or species habitat may occur within area		Hydrocarbon Release
Great White Shark (*Carcharodon carcharias*)	V,M	V (S3)	No	✓ Recovery plan for the white shark (*Carcharodon carcharias*) (DSEWPaC 2013c)	✓ Marine debris	✓	Species or species habitat may occur within area		Hydrocarbon Release

Value/Sensitivity Common Name (Scientific Name)	*EPBC Act* Status CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory	WC Act Status OPF = Other Protected Fauna P1 = Priority V = Vulnerable S = Schedule LC = Least Concern	Conservation Advice	Recovery Plan	Threat Abatement Plan	Operational Area presence[2]	BIAs, Particular Values or Sensitivities within EMBA	Potential impacts	Relevant Events
Green Sawfish (*Pristis zijsron*)	V		✓ Approved conservation advice for green sawfish (Threatened Species Scientific Committee, 2008b)	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia, 2015b)			Species or species habitat may occur within area		Hydrocarbon Release
Shortfin Mako (*Isurus oxyrinchus*)	M		No	No			Species or species habitat likely to occur within area		Hydrocarbon Release
Longfin Mako (*Isurus paucus*)	M		No	No			Species or species habitat likely to occur within area		Hydrocarbon Release
Giant Manta Ray (*Manta birostris*)	M		No	No			Species or species habitat known to occur within area		Hydrocarbon Release
Freshwater sawfish (*Pristis pristis*)	V, M	P	✓ Approved Conservation Advice *for Pristis pristis* (largetooth sawfish)				Species or species habitat known to occur within area		Hydrocarbon Release
Northern River Shark (*Glyphis garricki*)	E	P	✓ *Approved Conservation Advice for Glyphis garricki* (northern river shark)				Species or species habitat may occur within area		Hydrocarbon Release
Speartooth Shark (*Glyphis glyphis*)	CE		✓ *Approved Conservation Advice for Glyphis glyphis* (speartooth shark)				Species or species habitat may occur within area		Hydrocarbon Release
Reef Manta Ray (*Manta alfredi*)	M						Species or species habitat known to occur within area		Hydrocarbon Release
Protected Species and Communities: Marine Birds									
Red Knot (*Calidris canutus*)	E, M	V S3	✓ Conservation advice *Calidris canutus* red knot (Threatened Species Scientific Committee, 2016a)	No		Species or species habitat may occur within area	Species or species habitat may occur within area	Habitat loss/disturbance	Hydrocarbon Release
Curlew Sandpiper (*Calidris ferruginea*)	CE, M	V S3	✓ Conservation advice *Calidris ferruginea* curlew sandpiper (Threatened Species Scientific Committee, 2015f)	No		Species or species habitat may occur within area	Species or species habitat may occur within area	Loss wetlands Human disturbance Habitat loss Pollution	Hydrocarbon Release

Value/Sensitivity Common Name (Scientific Name)	*EPBC Act* Status CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory	WC Act Status OPF = Other Protected Fauna P1 = Priority V = Vulnerable S = Schedule LC = Least Concern	Conservation Advice	Recovery Plan	Threat Abatement Plan	Operational Area presence[2]	BIAs, Particular Values or Sensitivities within EMBA	Potential impacts	Relevant Events
Eastern Curlew (*Numenius madagascariensis*)	CE, M	V S3	✓ Conservation advice *Numenius madagascariensis* (eastern curlew)	No		Species or species habitat may occur within area	Species or species habitat may occur within area	Loss wetlands Human disturbance Habitat loss Pollution	Hydrocarbon Release
Common Noddy (*Anous stolidus*)	M	LC		No		Species or species habitat may occur within area	Species or species habitat may occur within area		Hydrocarbon Release
Streaked Shearwater (*Calonectris leucomelas*)	M	LC		No		Species or species habitat may occur within area	Species or species habitat may occur within area		Hydrocarbon Release
Lesser Frigatebird (*Fregata ariel*)	M	LC		No		Species or species habitat may occur within area	Species or species habitat may occur within area		Hydrocarbon Release
Great Frigatebird (*Fregata minor*)	M	LC		No		Species or species habitat may occur within area	Species or species habitat may occur within area		Hydrocarbon Release
Common Sandpiper (*Actitis hypoleucos*)	M	LC	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia, 2015c)	No		Species or species habitat may occur within area	Species or species habitat may occur within area		Hydrocarbon Release
Sharp-tailed Sandpiper (*Calidris acuminata*)	M	LC	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia, 2015c)	No		Species or species habitat may occur within area	Species or species habitat may occur within area		Hydrocarbon Release
Pectoral Sandpiper (*Calidris melanotos*)	M	LC		No		Species or species habitat may occur within area	Species or species habitat may occur within area		Hydrocarbon Release
Australian Lesser Noddy (*Anous tenuirostris melanops*)	V						Breeding known to occur within area		Hydrocarbon Release
Christmas Island Frigatebird, Andrew's Frigatebird (*Fregata andrewsi*)	V, M						Breeding known to occur within area		Hydrocarbon Release
Christmas Island Hawk-Owl (*Ninox natalis*)	V						Species or species habitat likely to occur within area		Hydrocarbon Release

Value/Sensitivity Common Name (Scientific Name)	*EPBC Act* Status CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory	WC Act Status OPF = Other Protected Fauna P1 = Priority V = Vulnerable S = Schedule LC = Least Concern	Conservation Advice	Recovery Plan	Threat Abatement Plan	Operational Area presence[2]	BIAs, Particular Values or Sensitivities within EMBA	Potential impacts	Relevant Events
Abbott's Booby (*Papasula abbotti*)	E, M						Breeding likely to occur within area		Hydrocarbon Release
White tailed Tropicbird (Christmas Island) (*Phaethon lepturus fulvus*)	E, M						Breeding likely to occur within area		Hydrocarbon Release
Bar-tailed Godwit (*Limosa lapponica bauera*)	V	V	✓ Conservation Advice *Limosa lapponica baueri* Bar-tailed godwit (western Alaskan)				Species or species habitat may to occur within area		Hydrocarbon Release
Northern Siberian Bar-tailed Godwit (*Limosa lapponica menzbieri*)	CE	V	✓ Conservation Advice *Limosa lapponica menzbieri Bar-tailed godwit* (northern Siberian)				Species or species habitat may to occur within area		Hydrocarbon Release
Caspian Tern (*Hydropropne caspia*)	M						Breeding known to occur within area		Hydrocarbon Release
Bridled Tern (*Onychoprion anaethetus*)	M						Breeding known to occur within area		Hydrocarbon Release
White-tailed Tropicbird (*Phaethon lepturus)*	M						Breeding known to occur within area		Hydrocarbon Release
Red-tailed tropicbird (*Phaethon rubricauda*)	M						Breeding known to occur within area		Hydrocarbon Release
Roseate Tern (*Sterna dougallii*)	M						Breeding known to occur within area		Hydrocarbon Release
Little Tern (*Sternula albifrons*)	M						Congregation or aggregation known to occur within area		Hydrocarbon Release
Masked Booby (*Sula dactylatra*)	M						Breeding known to occur within area		Hydrocarbon Release
Brown Booby (*Sula leucogaster*)	M						Breeding known to occur within area		Hydrocarbon Release -

Value/Sensitivity Common Name (Scientific Name)	*EPBC Act* Status CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory	WC Act Status OPF = Other Protected Fauna P1 = Priority V = Vulnerable S = Schedule LC = Least Concern	Conservation Advice	Recovery Plan	Threat Abatement Plan	Operational Area presence[2]	BIAs, Particular Values or Sensitivities within EMBA	Potential impacts	Relevant Events
Red-footed Booby (*Sula sula*)	M						Breeding known to occur within area		Hydrocarbon Release
Wedge-tailed Shearwater (*Ardenna pacifica*)	M				✓ Long-line fishing, feral cats, marine debris, red fox		Breeding known to occur within area		Hydrocarbon Release
Streaked Shearwater (*Calonectris leucomelas*)	M						Species or species habitat known to occur within area		Hydrocarbon Release
Oriental Reed-Warbler (*Acrocephalus orientalis*)	M						Species or species habitat known to occur within area		Hydrocarbon Release
Common Sandpiper (*Actitis hypoleucos*)	M						Species or species habitat known to occur within area		Hydrocarbon Release
Sharp-tailed Sandpiper (*Calidris acuminata*)	M						Species or species habitat known to occur within area		Hydrocarbon Release
Pectoral Sandpiper (*Calidris melanotos*)	M						Species or species habitat known to occur within area		Hydrocarbon Release
Crested Tern (*Thalasseus bergii*)	M						Breeding known to occur within area		Hydrocarbon Release

4.7.1 *Windows of Sensitivity*

It is important to understand the seasonal windows in which key marine fauna (or critical activities, such as breeding and migration) are present. The seasonal presence of the key marine fauna species identified in the EMBA is presented in **Table 4-9**.

Table 4-9: Seasonal Presence of Key Marine Fauna Relevant to the Operational Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Key Ecosystems and Biological Resources												
Coral: Spawning												
Seagrass: Flowering and Fruiting												
Plankton: Concentrations												
Fish Spawning												
Southern Bluefin Tuna: Spawning												
Goldband Snapper: Spawning												
Red Emperor: Spawning												
Elasmobranchs												
Whale Shark: Foraging												
Great White Shark												
Narrow Sawfish												
Marine Reptiles												
Flatback Turtle: Nesting												
Green Turtle: Nesting (Ashmore and Cartier)												
Hawksbill Turtle: Nesting												
Leatherback Turtle: Nesting												
Loggerhead Turtle: Nesting												
Olive Ridley Turtle: Nesting												
Marine Mammals												
Dugong: Calving / breeding												
Pygmy Blue Whale: Northern migration												
Pygmy Blue Whale: Southern migration												
Humpback Whale: Calving / breeding												
Avifauna												
Seabirds: Breeding												
Shorebirds: aggregation/breeding												
Migratory seabird – streaked shearwater												
Curlew sandpiper - presence												
Eastern curlew - presence												
Common noddy – presence												
Greater Frigatebird – breeding												

Lesser frigatebird – breeding												

4.8 Socioeconomic Values in the EMBA

Table 4-10 presents the socioeconomic environmental values and sensitivities (cultural and socio-economic) within the EMBA and include all relevant matters of national environmental significance (NES) protected under the *EPBC Act*.

The Australian and Indonesian governments signed a memorandum of understanding (MoU), in 1974 (DSEWPaC 2012), which permits fishing by Indonesian and Timorese fishers, using traditional fishing methods only, in an area of Australian waters in the Timor Sea. The MoU area, which has become known as the MoU box, covers Scott Reef and surrounds, Seringapatam Reef, Browse Island, Ashmore Reef, Cartier Island and various banks and shoals, covering an approximate area of 50,000 km^2. The MoU Box overlaps the EMBA.

The MoU requires fishers to use traditional, sail-powered fishing vessels and non-motorised equipment, and prohibits them from taking protected species, such as turtles, dugongs and clams. Fishers target a range of animals, including sea cucumbers (bêche-de-mer), trochus (top shell snail), reef fish and sharks. Indonesian fishing effort is high at Scott Reef. Peak fishing season is typically between August and October, with fishers departing the region at the onset of the northwest monsoon season.

Table 4-10: Socioeconomic Values and Sensitivities within the Operational Area and EMBA

Value/ Sensitivity	Description	Operational Area Presence
World Heritage Properties	Sites accepted to the World Heritage listing are only inscribed if considered to represent the best examples of the world's cultural and natural heritage. There are no World Heritage properties that intersect with the Operational area or EMBA.	None
Shipping	The Operational Area is not located on a major international shipping route. Support vessels servicing the nearby infrastructure do pass through the Operational area (AMSA, 2014).	✓
Commercial Fishing	The NWSTF is the only active fishery in the region and fishes at low levels. The Western Tuna and Billfish Commercial Fishery is permitted to operate in the Operational area/EMBA area but there is no current effort. Operational area outside state waters.	No current effort
Recreational Fishing	Remoteness of Operational area limits recreational fishing usage.	Limited
Indigenous Fishing	Traditional Australian indigenous fishing activities are concentrated within 3 nm of the NT/WA coastline (DPIF 2015). Indonesian/Timor Leste indigenous fishing occurs in the vicinity of Sahul Bank and Echo Shoals and boats may pass through the Operational area to reach these fishing grounds.	Transit only
Defence	No declared defence areas in Operational area.	-
Oil and Gas	Various petroleum exploration and production activities have been undertaken within the Timor Sea, including some within close proximity of the operational Area. The nearest production activities to the Operational area include the Laminara and Correlina platforms, located 7.1 km and ~15 km away, respectively.	-
Tourism	No regular tourism activity occurs in the Operational area due to its remoteness.	-
Cultural Heritage	No known sites of shipwrecks or Aboriginal Heritage significance within the Operational area.	-

5 CONSULTATION

CVN is supportive of ensuring adequate and open information with relevant persons and its investors. Its website (www.carnarvon.com.au) has been developed to ensure all projects have current and comprehensive information covering location and development plans of its permits, including Buffalo. The contact details provided on the website allow for self-reporting of interest in projects.

Consultation has been undertaken with relevant persons for planned activities (i.e. Operational area only) with additional consultation triggered for the broader EMBA in the event of an unplanned event.

As a minimum for each of the relevant persons (planned event) listed below, a link to an information sheet was either emailed or posted. This information sheet was developed with Subregulation 11A(2) and associated guidance in mind to ensure it adequately described the activity – including:

- Location map (coordinates);
- Key distances;
- Activity description;
- Environment, including water depth;
- Key risks associated with the activities; and,
- Contact details.

In many cases, such as a regulatory role of an unplanned event, the information sheet was also sent for information/relationship building purposes.

A list of identified relevant persons is outlined in **Table 5-1**.

Table 5-1: Relevant Persons Identified for Consultation

Relevant Persons
Department of Defence (ADF Airspace and Australian Navy)
Australian Hydrographic Service
Department of Industry, Innovation and Science
Department of Foreign Affairs and Trade
Department of Environment and Energy
Department of Agriculture and Water Resources
Australian Maritime Safety Authority
Western Australian Department of Mines, Industry Regulation and Safety
Australian Marine Oil Spill Centre (AMOSC)
Oil Spill Response (OSRL)
Hon Josh Frydenberg - Minister for Environment & Energy
Senator the Hon Matt Canavan - Minister for Resources and Northern Australia
Hon Greg Hunt - Minister for Industry, Innovation & Science
Department of the Chief Minister (NT)
Northern Territory Environment Protection Authority

Relevant Persons
Australian Fisheries Management Authority (AFMA)
Australian Petroleum Production and Exploration Association (APPEA)
Northern Oil and Gas Australia (NOGA)
PTTEP
Equinor
BHP
ConocoPhillips
INPEX
Chevron Australia
Eni
Commonwealth Fisheries Association (CFA)
Department of Infrastructure, Planning and Logistics (NT)
Department of Primary Industry and Resources (NT)
Department of Environment and Natural Resources (NT)
Amateur Fisherman's Association of the NT
Tiwi Land Council
Parks Australia - Australia Marine Parks
NT Seafood Council
Tourism Top End
Tourism NT
Australian Border Force (formerly Australian Customs and Border Protection Service)
Autoridade Nacional do Petróleo e Minerais (ANPM)

A number of responses were received in response to consultation. Marine users, such as the fishing industry and tour operators, have raised no specific concern with the planned petroleum activities or planned impacts. All comments received prior to submission of the EP have been assessed, responded to and closed out with the relevant stakeholder. **Table 5-2** below provides a summary of the responses received to stakeholder consultation and CVN's assessment of the comment.

Table 5-2: Assessment of Merit

Relevant person	Relevant person Concern, Objection or Claim	Carnarvon Assessment of Merit	Carnarvon Response
Australian Maritime	Request for future correspondence to be sent to updated email contact	Comment noted and action taken.	Stakeholder database updated

Relevant person	Relevant person Concern, Objection or Claim	Carnarvon Assessment of Merit	Carnarvon Response
Safety Authority	Shipping traffic plot shows area clear of major international shipping routes but frequented by Offshore support vessels operating at nearby Laminaria-Corallina development.	Information noted and risk assessment updated	Considered during ENVID. Refer to Interference with other users.
	Drilling vessel/MODU to notify AMSA's JRCC 24-48 hrs prior to operations commencing	Action to be taken	Updated as action in Section 4.5 of EP
	Australian Hydrographic Office to be contacted no less than 4 weeks prior to operations commencing for the promulgation of related notices to mariners.	Action to be taken	Updated as action in Section 4.5 of EP

5.1 Ongoing Consultation

Ongoing consultation activities build upon CVN's consultation for the EP. The Consultation Strategy outlines the processes that will be followed to ensure a standard approach to interacting with relevant persons during the life of the EP, including revision of relevant persons list and process for dealing with feedback during this period. This includes commitments such as annual updates placed on Carnarvon's website and email notification to relevant persons and notification prior to commencement of government agencies to allow notifications or review of actions. Should relevant persons request additional information or raise concerns on any activity, CVN commits to assess, respond and address any comments raised. In addition, Carnarvon will undertake additional triggered consultation should an unplanned event occur.

6 ENVIRONMENTAL RISK ASSESSMENT

6.1 Risk Assessment

As required by Regulation 13(5) of the Environment Regulations, this section of the EP provides an outline of CVN's Environmental Risk Assessment (ERA) to evaluate impacts and risks due to an activity, and the outcomes of the impact and risk assessment undertaken for the proposed drilling activities. The key steps used for the risk assessment are shown in **Figure 6-1**.

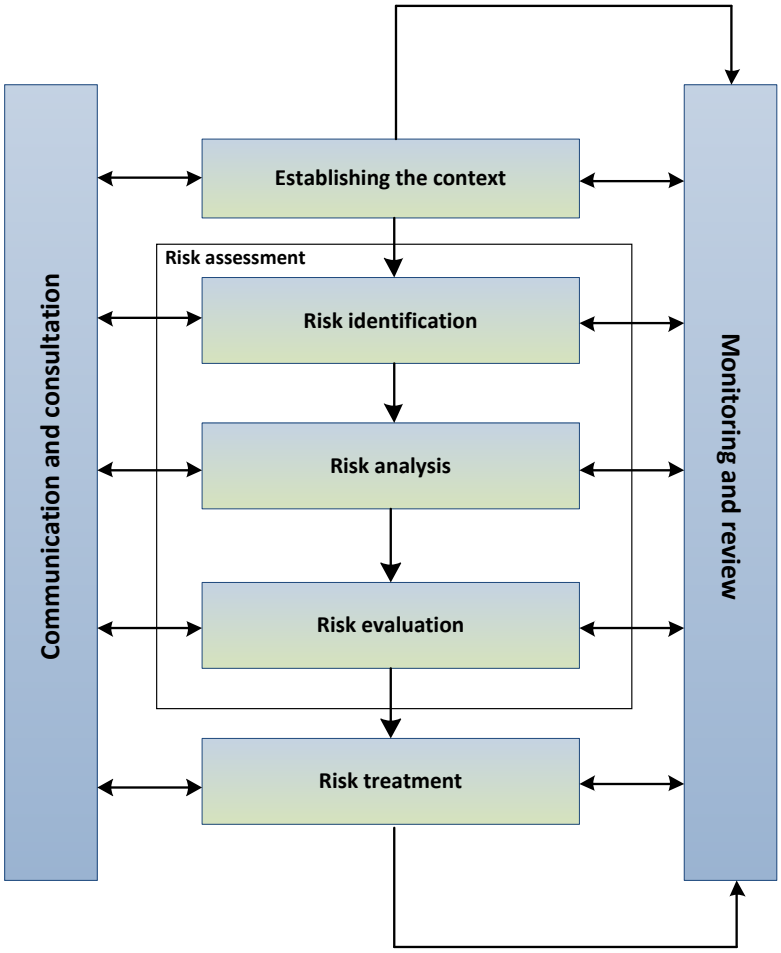


Figure 6-1: Key Steps used for Risk Assessment

A consequence assessment is determined taking into consideration the duration and extent of the impact, receptor recovery time and effect of the impact at a population, ecosystem or industry level. **Table 6-1** provides the environmental and social consequence category descriptions applied. Where there is uncertainty regarding the selection of the consequence category due to data, assumptions or cumulative impacts used within the risk assessment or evaluation, Carnarvon's Risk and Governance Standard (CVN ENV PRC 0004) states that a the next highest consequence category will be selected. This may move the overall risk ranking which will require consideration and/or adoption of additional, alternative and improve control measures to manage risks and impacts to ALARP and Acceptable levels.

Table 6-1: Consequence Categories

Severity Categories		Description
5	Critical	Significant environmental or heritage damage. Large scale <10km long term (decades) impact Widespread degradation to the quality or availability of habitats and/or fauna requiring significant long-term restoration effort Major oil spill over a wide area leading to campaigns and major stakeholders' concerns Long-term (>5 year) decrease in the availability or quality of a resource affecting usage
4	Major	Major environmental damage. Large scale: greater than 10 km. Long term (years to decades) impact: - Decrease in the medium-term (<5 years) availability or quality of a resource affecting usage - Local or regional stakeholders' concerns leading to complaints
3	Moderate	Moderate effects on environment. Limited scale (1-10 km) Short term impact recovery in months to years: - No lasting effects or persistent effects are highly localised - Minor change in habitats or species - Short-medium term decrease in the availability or quality of a resource, noticed by users
2	Minor	Minor environmental damage. Limited scale less than 1km. Recovery in weeks to months. Potential mortality to fauna Short-term or localised decrease in the availability or quality of a resource, likely to be noticed by users
1	Slight	Slight effect; recovery in days to weeks; potential disturbance/injury to habitat/ fauna Effects unlikely to be discernible or measurable Short-term or localised decrease in the availability or quality of a resource, not affecting usage

A likelihood assessment is also undertaken for unplanned events, this considers the frequency of events in industry and within the company. Likelihood descriptions for environmental impacts are described in **Table 6-2**. Likelihood categories are not assigned to planned events.

Table 6-2: Likelihood Categories (Environment)

Likelihood Category		Description	Probability
1	Rare	Unheard of in industry	Consequence occurs once in ten years
2	Unlikely	Has occurred once or twice in industry	Consequence occurs once in five years
3	Possible	Has occurred many times in industry, but not in the company	Consequence occurs once a year
4	Likely	Has occurred once or twice in company or similar operation in industry	Consequence occurs monthly
5	Almost Certain	Has occurred frequently in the company or similar operation in industry	Consequence occurs weekly

A risk ranking is determined for unplanned event by taking the likelihood and consequence ratings. The risk levels determined in the risk matrix fall into one of four categories as described in **Table 6-3.**

Table 6-3: Risk Ranking Descriptions (Environment)

Category	Description	Risk Reduction Action
Red	Unacceptable or intolerable Risk	Risk Reduction Action
Orange	Acceptable risk (ALARP)	Requires further control measures to be in place
Yellow	Acceptable risk (ALARP)	The control measures are deemed to be managing risks and impacts to acceptable levels if the residual risk ranking falls into the orange category, if the selected impact falls below the predefined ecologically acceptable levels, and ALARP has been demonstrated through the consideration and adoption of further additional, alternate and/or improved options.
Green	Low and acceptable risk	The control measures are deemed to be managing risks and impacts to acceptable levels if the residual risk ranking falls into the yellow category, if the selected impact falls below the predefined ecologically acceptable levels, and Carnarvon has considered alternative, additional and/or improved options aligned with company or industry good practice.

6.1.1 *Control Measures*

Following the determination of the consequence assessment for planned impacts, and the inherent risk ranking for unplanned impacts, control measures are implemented. These control measures may be standard controls across the company or industry, or may be specific to the location of the activity. The control measures may be systems, procedures, items of equipment or persons that will be used to reduce environmental impacts and risks. Their effectiveness is discussed in the risk workshop and collectively agreed on. The 'Hierarchy of Controls' is a system used in industry to minimise or eliminate exposure to hazards. The hierarchy of controls is, in order of effectiveness:

- Elimination;
- Substitution;
- Engineering controls; and
- Administrative controls.

The control measures implemented must reduce the impacts and risks of the activity on the environment and demonstrate that the impact or risk is reduced to ALARP and acceptable levels. Once the controls have been evaluated and agreed upon, the consequence and/or likelihood is then re-evaluated whilst considering the controls in place. A residual risk ranking is then presented in the EP.

6.1.2 *Environmental Performance Measurement*

Environmental performance must be measurable during the activity so the titleholder can demonstrate that impacts and risks have been reduced to ALARP and Acceptable levels.

6.1.3 *Environmental Performance Outcomes*

An environmental performance outcome (EPO) is a measurable level of performance required for the management of environmental aspects of an activity to ensure that the environmental impacts and risks will be of an acceptable level. Environmental performance outcomes should ensure that ongoing environmental performance will meet, or be better than, the acceptable levels defined in the EP. An EPO also sets the level at which an incident becomes a recordable incident. EPOs are presented for each identified planned and

unplanned event, and some will be relevant for multiple identified impacts and risks. Every EPO must have measurement criteria demonstrated in the EP to ensure performance can be measured.

6.1.4 *Environmental Performance Standards*

Environmental performance standards (EPS) are the parameters against which control measures are assessed to ensure that the control measures consistently perform to reduce impacts to ALARP and acceptable levels. The EPS is a statement of performance required of a control measure, and an EPO also sets the level at which an incident becomes a recordable incident. Any control measure that is required to reduce an impact or risk to an acceptable level or ALARP requires an EPS; but an EPS may relate to multiple control measures or vice versa.

6.1.5 *Measurement Criteria*

Measurement criteria must be provided for every EPO and EPS identified. These document the ways in which the levels of performance can be measured to determine whether the outcomes have been met during the activity. More than one measurement criteria may apply for each identified EPO or EPS.

6.1.6 *ALARP Evaluation*

CVN's ALARP evaluation considers a range of options for the identified risks and impacts for the activity outlined in the EP. This approach considers alternative, additional, and improved options to manage these risks and impacts and reduce them to as low as reasonably practical.

CVN has developed its ALARP methodology using a semi-quantitative approach using industry best-practice guidance. This approach provides an initial screening of identified options against the consequence rankings in CVN's Corporate Risk Matrix.

Where the risk or impact has already been assessed as Green, CVN may identify alternative, additional or improved options for consideration to align with company or industry expectations.

CVN's hydrocarbon spill response ALARP process is aligned with guidance provided by NOPSEMA in Guideline N-04750-GL1687 (2016) and NOPSEMA Guideline 'Environment Plan Decision Making' (GL1721). The response planning need is based on the risk assessment conducted in the EP. The risk assessment identifies the type of oil, volume of release, duration of release, predicted fate, weathering and the EMBA (along with other requirements such as time to impact and predicted volumes ashore).

6.1.7 *Acceptability*

Carnarvon have considered acceptability in the context of NOPSEMA Guideline – Environment Plan Decision Making (GL1721-Rev5) and in accordance with sub-regulation 10A(c).

Acceptable level definition considered internal and external factors including the uniqueness of, and/or the level of protection assigned to the environment, its sensitivity to pressures introduced by the activity, and the proximity of activities to sensitive receptors. Feedback from relevant persons was also a key consideration.

Carnarvon has based their assessment of the acceptable level of change to these values on the "Technical guidance for protecting the quality of Western Australia's Marine Environment" (EPA 2016). Using this they have selected two levels of Ecosystem Protection (**Table 6-4**):

1. A **Moderate** level of protection for Operational area and wider permit area where vessels may discharge operational discharges (off Big Bank) ; and
2. A **High** level of ecological protection over Big Bank.

The EPA guidelines set limits of acceptable change for these two levels of protection for ecosystem processes, abundance and biomass of marine life and the quality of water, biota and sediment. These limits of Acceptable change have been used as the basis of Carnarvons ecological acceptable change for the selected values. A

different basis of acceptable level of change was used for marine fauna where the MNES definition of significant impact for the different levels of protection represented a more meaningful and specific objective (**Table -6.4**).

Table 6-4: Limits of Acceptable Change

Ecosystem Integrity element	Level of Protection (LEP) limits of acceptable change	
	High LEP	Moderate LEP
Ecosystem processes	Ecosystem processes are maintained within the limits of natural variation (no detectable change) (EPA WA 2016)	Small changes in rates, but not types of ecosystem processes (EPA WA 2016)
Abundance and biomass	Abundances and biomasses of marine life vary within natural limits (no detectable change) (EPA WA 2016)	Small changes in abundances and/or biomasses of marine life (EPA WA 2016
Quality of water, biota and sedimemt	Small detectable changes beyond limits of natural variation but no resultant effect on bioto (EPA WA 2016)	Moderate change in rates, beyond limits of natural variation but not to exceed specified criteria. (EPA WA 2016)
MNES	No significant impact to ANY marine fauna as defined by MNES guidelines (DoE 2013).	No significant impact to ANY marine fauna as defined by MNES guidelines (DoE 2013).

The EPO's specific to this Activity have been set based on the WA EPA and MNES frameworks to ensure environmental impacts will not exceed these acceptable levels. Noting Carnarvon has applied the precautionary principle to set EPOs below the acceptable level. A summary of value derived EPOs from this process are shown in **Table 6-5**.

Table 6-5: Value Derived EPOs for Planned Events

	Acceptable level basis	EPOs
EPO1	WA EPA 2016	No change to habitats or water quality outside Operational Area
EPO2	WA EPA 2016	Impacts from activity on Habitat D is recovered to at least 95 percentile of previous abundance levels within 12 months after cessation of drilling or prior to any additional drilling activity at the site.
EPO3	WA EAP 2016	Impacts from activity on water quality is contained to within the Operational Area and recovered to at least 95 percentile background water quality levels prior to any additional drilling activity at the site.
EPO4	DoE 2013	No breach of MNES significant impact criteria relating to ANY marine fauna as defined by MNES guidelines (DoE 2013).
EPO5	NWQMS and Industry best practice	Relevant persons are kept informed of activities
There are no specific EPOs set for the following social values (Fishing and aquaculture, recreation and aesthetics, industrial water supply; or Cultural and spiritual as assessed by NWQMS), based on the following justification; • Very low levels of fishing in the region (No current commercial Australian fishing, but low/sporadic levels of indigenous Indonesian/Timor fishers)		

- No tourism activities are known to take place specifically within the Operational area due to distance offshore.
- There are no known sites of Indigenous or European cultural or heritage significance within the Operational area.

There is a need however to make sure all relevant persons are informed of activity so an EPO was set for this.

By protecting the underlying ecosystem values through these EPOs other values identified in **Section 3** will be maintained to an acceptable level.

Acceptability (Unplanned events)

The Acceptability of an unplanned events is associated with the potential impact of the event if it was to occur. By applying the Carnarvon Risk Matrix Acceptability criteria any aspect who's consequence was 'yellow' or above was identified as requiring an EPO, in addition to the EPOs for planned events

Table 6-6: Activity Derived EPOs for Unplanned Events

	Acceptable level basis	EPOs
EPO5	NWQMS and Industry best practice	Relevant persons are kept informed of activities.
EPO6	Industry best practice and MNES guidelines	No marine megafauna death caused by vessel strike in the Operational Area
EPO7	Industry best practice CVN Acceptability Matrix (Table 6-7)	No establishment of IMS
EPO8	Industry best practice CVN Acceptability Matrix (Table 6-7)	No long-term environmental impact from discharges, dropped objects or emissions.
EPO9	Industry best practice CVN Acceptability Matrix (Table 6-7)	No loss of well control for the duration of the activity
EPO10	Industry best practice CVN Acceptability Matrix (Table 6-7)	To effectively and efficiently implement the spill response to facilitate ecosystem processes recovery.
EPO11	Industry best practice CVN Acceptability Matrix (Table 6-7)	To effectively and efficiently monitor the potential environmental impact resulting from an oil spill and spill response.

CVN acceptability framework

The environmental EPOs sit within the larger CVN acceptability framework which considers a broader suite of considerations to ensure the acceptability of the Activity. This range of criteria have been considered when evaluating the acceptability of environmental impacts and risks associated with the activity. It is this full suite of criteria which the proposal is evaluated against to ensure the overall acceptability of the project.

Table 6-7: Carnarvon Acceptability Criteria

Objective	Criteria
Environmentally Sustainable Development (ESD) Principles a) Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations (b) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (c) The principle of inter-generational equity - that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations (d) The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making (e) Improved valuation, pricing and incentive mechanisms should be promoted	Does the proposed impact or risk comply with the APPEA Principles of Conduct (APPEA 2003), which includes that ESD principles be integrated into company decision-making.
Environmental context: o Level of protection The operational area is defined as a CMA which stipulates impacts must not: • Result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity; social amenity or human health • Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected o Spatial scale o Uniqueness	Level of protection; CMA criteria are met Spatial scale (<1km and recovery in 12 months as per CVN Acceptability Matrix for <moderate impact) Uniqueness; represented locally and regionally The EPO's are met.
Laws and standards	Is the impact or risk being managed in accordance with existing Australian or international laws or standards, such as EPBC Policy Statements, MARPOL, AMSA Marine Orders, Marine Notices etc.?
Management System and policy compliance	Is the proposed management of the impact or risk aligned with the Carnarvon HSE Policy and Business Management System (BMS)?

Objective	Criteria
Residual Risk Ranking	Is the residual risk ranking within the green/ category? A consequence from a planned event is ranked as 1, or 2; or a risk of impact from an unplanned event is ranked less than 12? Is the residual risk ranking within the yellow/orange category? A consequence from a planned event is ranked as >3 ; or a risk of impact from an unplanned event is ranked less than 12?
Industry best practice	Is the impact or risk being managed in line with industry best practice, such as APPEA Code of Environmental Practice, IAGC guidelines etc.?
Social acceptability	Have stakeholders raised any concerns about activity impacts or risks, and if so, are measures in place to manage those concerns? Commonwealth marine environment is considered a higher order impact. Accordingly, consultation with relevant persons is an important part of establishing context for defining an acceptable level and successfully demonstrating it will be met.

7 SUMMARY OF ENVIRONMENTAL RISK AND IMPACTS

A summary of the Aspects associated with this activity are provided in **Table 7-1**.

Table 7-1: Summary of Activity Risks

Planned	Unplanned
Habitat Disturbance	Interaction with Marine Fauna
Interference with other users	Interaction with Marine Habitats
Artificial Light	Non-hydrocarbon Release (Liquid)
Atmospheric Emissions	Non-hydrocarbon Release (Solid)
Operational Discharges	Introduced Marine Species
Drilling Discharges	Hydrocarbon Spill (Minor)
Noise Emissions	Hydrocarbon Spill (Diesel)
Spill Response	Loss of well control

7.1.1 *Evaluation of the Risk or Impacts to Receptors*

The extent of actual or potential impacts from each planned or unplanned Aspect was evaluated using, where required, modelling (e.g. hydrocarbon spills and drill cuttings), consultation feedback from potentially affected parties (**Section 5**) and scientific reports. The duration of the event was also assessed including the potential duration of any impacts should they occur. Impact thresholds for different critical life stages were also identified where relevant (such as migration or nesting periods) to determine the potential impacts. A summary of the receptors assessed is provided in **Table 7-2**.

Table 7-2: Summary of Receptors Assessed During Risk Workshop

Physical and Biological Receptors	Socio Economic and Cultural Receptors
Marine mammals	World Heritage Properties
Marine reptiles	Commonwealth Heritage Places
Fish (inc. sharks and rays)	Commonwealth Marine Areas
Birds (sea and migratory)	Commonwealth Land
Shoals and banks (including Big Bank)	European and Indigenous Heritage
Offshore reefs and islands	Marine Archaeology
Australian Marine Parks	Commercial Fisheries
Key Ecological Features	Traditional Indigenous Fishing
Water quality	Tourism and Recreation
Sediment quality	Military / Defence
Air quality	Ports and Commercial Shipping
Oceanography	Offshore Petroleum Exploration and Operations
Benthic infauna	
Plankton	

Physical and Biological Receptors	Socio Economic and Cultural Receptors
Indonesian and Timor Leste coastlines	

A summary of the Aspect/Receptor interaction is also shown in **Table 7-3**.

Full detail of the risk assessment for each aspect is contained in **Appendix A**.

Table 7-3: Aspect Receptor Interaction Summary

EP Section	Aspect	Source of Impact	Environmental and Socio-economic Values and Sensitivities																	
			A Physical Env- Big Bank)	B Marine sediment	C Water quality	D Air quality	E Benthic Habitats	F Benthic infauna	G Protected Species - BIA	H Marine Mammals	I Marine Reptiles	J Sharks, Fish and Ray	K Marine Birds	L Protected and Significant Areas	M Offshore reefs and Islands	N International Waters	O Socio - economic	Consequence (residual)	Likelihood	Residual Risk Ranking
		Planned Activity -																		
6.1	Physical presence (seabed disturbance)	Tow line Spudding Laying anchor and chains																1	n/a	2
6.2	Physical presence (Interference with other users)	Vessel/MODU movement																1	n/a	1
6.3	Artificial Light	MODU and vessel operations																1	n/a	1
6.4	Atmospheric emissions	MODU and vessel operations																1	n/a	1

EP Section	Aspect	Source of Impact	Environmental and Socio-economic Values and Sensitivities																	
			A Physical Env- Big Bank)	B Marine sediment	C Water quality	D Air quality	E Benthic Habitats	F Benthic infauna	G Protected Species - BIA	H Marine Mammals	I Marine Reptiles	J Sharks, Fish and Ray	K Marine Birds	L Protected and Significant Areas	M Offshore reefs and Islands	N International Waters	O Socio - economic	Consequence (residual)	Likelihood	Residual Risk Ranking
6.5	Operational discharges	MODU and vessel operations																1	n/a	2
6.6	Drilling discharges	Drilling																2	n/a	3
6.7	Noise emissions	Drilling (VSP) MODU and vessel operations																2	n/a	2
6.8	Spill response	Spill response																2	n/a	2
		Unplanned activities – Use of MODU, and support vessels																		
7.1	Interaction with other marine fauna	MODU and vessel operations																2	2	4

EP Section	Aspect	Source of Impact	Environmental and Socio-economic Values and Sensitivities																	
			A Physical Env- Big Bank)	B Marine sediment	C Water quality	D Air quality	E Benthic Habitats	F Benthic infauna	G Protected Species - BIA	H Marine Mammals	I Marine Reptiles	J Sharks, Fish and Ray	K Marine Birds	L Protected and Significant Areas	M Offshore reefs and Islands	N International Waters	O Socio - economic	Consequence (residual)	Likelihood	Residual Risk Ranking
7.2	Habitat disturbance	MODU and vessel operations																2	2	4
7.3	Accidental release – Non hazardous waste (liquid)	MODU and vessel operations																1	2	2
7.4	Accidental release of hazardous waste (Solid)	MODU and vessel operations																1	3	3
7.5	Introduction of invasive marine species	MODU and vessel operations																4	1	4

EP Section	Aspect	Source of Impact	Environmental and Socio-economic Values and Sensitivities															Consequence (residual)	Likelihood	Residual Risk Ranking
			A Physical Env- Big Bank)	B Marine sediment	C Water quality	D Air quality	E Benthic Habitats	F Benthic infauna	G Protected Species - BIA	H Marine Mammals	I Marine Reptiles	J Sharks, Fish and Ray	K Marine Birds	L Protected and Significant Areas	M Offshore reefs and Islands	N International Waters	O Socio - economic			
7.6	Minor spills Accidental release – diesel spill during transfer operations	MODU and vessel operations																1	3	3
7.7	Support vessel collision- accidental release	MODU and vessel operations																2	3	6
7.8	Loss of well control	Drilling																5	2	10

The output of the ENVID (Risk Assessment) is documented in the Buffalo Drilling Impact and Risk Register and is summarised in **Table 7-4**.

Table 7-4: Summary of Pre-treatment and Residual Rankings

Aspect	Pre-treatment Ranking	Residual Ranking
Planned Events		
Physical presence (seabed disturbance)		
Physical presence (Interference with other users)		
Artificial Light		
Atmospheric emissions		
Operational discharges		
Drilling discharges		
Noise emissions		
Cumulative impacts		
Spill response		
Unplanned events		
Interaction with marine fauna		
Habitat disturbance		
Accidental release – Non- hazardous waste (liquid)		
Accidental release of hazardous waste (Solid)		
Introduction of invasive marine species		
Minor spills Accidental release – diesel spill during transfer operations		
Support vessel collision- accidental release		
Loss of well control		

8 ONGOING MONITORING OF ENVIRONMENTAL PERFORMANCE

8.1 Performance Management Systems

Carnarvon Petroleum is responsible for ensuring that the drilling campaign is managed in accordance with its Business Management System (BMS). The implementation strategy outlines standards, processes, roles and responsibilities as well as training and competency requirements for all personnel (Carnarvon and contractors) in relation to implementing identified control measures, management of change and non-conformance, emergency and oil spill response, and monitoring, auditing, and reporting.

Ten Elements establish a structure to organise the various components of the BMS. Each of the ten Elements includes an overview, a purpose statement and a set of Expectations that define the system's intended outcomes.

1. Commitment and accountability
2. Policies, Standards and Objectives
3. Organisation, Resources and Capability
4. Stakeholders and Customers
5. Risk Assessment and Control
6. Asset Design and Integrity
7. Plans and Procedures
8. Execturion of Activities
9. Monitoring, Reporting and Learning
10. Assurance, Review and Improvement

Carnarvon's BMS (Element 10) establishes requirements for audit programs that assess the adequacy and effectiveness of HSE systems, process and controls. Carnarvon implements and maintains a program for initiating, planning, execute, review and close-out of HSE audits carried out across all areas of the business. An environmental auditing program will be implemented for the drilling campaign.

In accordance with Carnarvon' BMS (Element 9), processes for measuring and monitoring HSE performance, evaluating the achievement of HSE goals and objectives, identifying opportunities for improvement and providing assurance of compliance have been developed.

Processes are in place to measure and monitor project operations and activities, as per the Carnarvon Project Management Procedure.

Carnarvon and the MODU contractor will monitor and review HSE performance for the duration of the drilling campaign. For specific monitoring activities related to the management of environmental risks identified within the EP, information will be collected through set internal reporting processes.

Any opportunities for improvements identified through the process will be evaluated via a Management of Change process prior to the EP, procedures or processes being modified.

8.1.1 *Environmental Audits and Review*

Environmental performance auditing and review programs will be completed to:

- Demonstrate compliance with regulatory requirements, approval commitments and conditions within this EP;
- Confirm impacts and risks are being effectively managed and continuously reduced to ALARP and Acceptable levels;

- Confirm relevant standards and procedures are being followed with appropriate records maintained;
- Monitor, review and evaluate the effectiveness of Carnarvon's BMS; and
- Verify a senior management review of performance via consideration of the audit reports.

8.1.2 *Environmental Audits*

Carnarvon's BMS (Element 10) establishes requirements for audit programs that assess the adequacy and effectiveness of HSE systems, process and controls. Carnarvon implements and maintains a program for initiating, planning, execute, review and close-out of HSE audits carried out across all areas of the business.

The auditing process consists of a three tier auditing hierarchy:

- Tier 1 – workplace/site inspections (workplace hazard identification and control);
- Tier 2 – internal audits (BMS policies and procedures); and
- Tier 3 – external audits (corporate, regulatory bodies and other external bodies such as contractors).

An environmental auditing program will be implemented for the drilling campaign and will include the key elements and frequencies outlined in **Table 8-1**.

Table 8-1: Buffalo Drilling EP Auditing and Review Program Summary

Audit type	Description	Scope	Frequency
Tier 1	Pre-use chemical selection audit	Review compliance with chemical selection and use procedures including handling, storage and documentation	Prior to acceptance of chemicals on the MODU
Tier 1	Containment and performance checklist for the MODU	Site inspection of mud pits, bunds, chemical and hydrocarbon storage areas, drill floor, deck and bilge drainage and waste segregation	Every 2 weeks
Tier 2	Internal environmental compliance audit	Audit of MODU contractor BMS , which will include an audit of implementation of the requirements of the EP, specifically performance against the EPOs, EPSs and MC	As per Audit Schedule (i.e. minimum of annually)
Tier 3	NOPSEMA audits	Regulatory compliance	Unscheduled (i.e. on notification by NOPSEMA)
Management review	Steering Committee performance reviews	Management team mid-year and annual review of HSE performance	Mid-year/annually
Incident investigation review	Review in line with Carnarvon procedures for incident reporting and investigation	The objective of the incident investigation is to establish the root cause(s) of an incident and to raise and close-out corrective actions to prevent recurrence.	Following an incident or training exercise

Tier 1 and Tier 2 HSE audits and follow-up actions are conducted in accordance with Carnarvon Auditing and Inspection Procedure. The audits will be documented, and corrective actions tracked to completion in accordance with this procedure.

A corrective action plan is developed in consultation with senior management and other relevant action owners. Audit findings and agreed audit follow-up actions are entered into an action tracking system, and tracked through to closure by Carnarvon. Key performance indicators are in place to track and report the status of actions arising from incidents and audits.

The results of monitoring and auditing are regularly reported to the senior management team via the BMS steering committee to ensure that action items are addressed.

Carnarvon will undertake internal audits of compliance against this EP with the outcomes of these audits included in the annual report submitted to NOPSEMA.

8.1.2.1 Environmental Review

Carnarvon' BMS (Element 10) establishes review requirements to verify there is a functioning and systematic process in place so that HSE risks are identified and managed in order to achieve the Company goals and objectives.

Carnarvon implements a documented annual HSE review process for the review of the BMS. The reviews are conducted by defined groups, teams, or committees (including Steering Committees), with results reported to, and reviewed by, Senior Management.

The review process considers applicable BMS data and outputs and includes a consideration of:

- The extent to which objectives and targets have been met in light of changing circumstances and commitment to continuous improvement;
- The environmental performance of the organisation;
- Follow-up actions from previous management reviews;
- Results of internal audits and evaluations of compliance with legal and other requirements;
- Communications from external stakeholders, including complaints;
- Incidents and the status of corrective and preventive actions from investigations and audits;
- Significant issues from risk assessments including critical control performance;
- Resource allocation for system implementation and maintenance; and
- Recommendations for improvement.

The outcomes and decisions made in these reviews are distributed to appropriate management and planning teams to facilitate a cycle of continuous improvement. This ensures that the 'adjust' phase of the Carnarvon BMS process may feed into the 'plan' phase, closing the loop on the plan, do, assess, and adjust cycle of continuous improvement.

The Annual HSE review is also an opportunity to ensure new information is incorporated into the EP and will consider the following:

- Existing information in relation to any component of the receiving environment described in this EP including, but not limited to, biologically important areas, KEFs, and threatened species;
- Available scientific literature;
- New issues raised by stakeholders;
- Relevance of existing and identification of new stakeholders; and
- Australian Marine Park status (including any changes in status) and relevant IUCN principles.

The results of the review and any identified improvements or recommendations will be incorporated into processes and procedures used for the operation, or the EP, to facilitate continuous improvement in environmental performance.

In the event that new information (audits, inspections, reviews etc.) suggests risks and impacts are no longer reduced to acceptable levels, or controls are no longer effective in reducing the risks and impacts to ALARP and acceptable levels, then the process for identification of further controls through a risk assessment will follow that of the risk assessment methodology for this EP.

Any opportunities for improvements identified through the risk assessment (i.e. new controls adopted) will be evaluated via a Management of Change process prior to the EP, procedures or processes being modified.

8.1.2.2 Management of Non-conformance Investigation and Corrective Action

Through the Carnarvon BMS (Element 10), Carnarvon implements a systematic approach so that all incidents and near misses are consistently, methodically and effectively investigated, as appropriate to their risk or potential severity.

All incidents including near misses are reported, investigated in a timely manner and analysed to identify corrective actions/preventive measures to prevent recurrence and continuously improve HSE performance. Incident investigations are documented using a database to track actions through to close out.

Non-conformances may be identified through audits, observations or incident reports. Actions required to address non-conforming incidents (including those associated with drills, tests and exercises) and to prevent the escalation of further impacts will be appropriate to the nature and scale of the event. All HSE hazards and incidents are reported in accordance with the Carnarvon Incident Reporting and Investigation Procedure. Root cause analysis of incidents is performed to determine the cause and aid identification of appropriate corrective actions. Monitoring and measurement is a Carnarvon BMS element (Element 9) subject to BMS auditing procedures.

8.1.2.3 Management of Change

Carnarvon has a management of change process as core process of the BMS (CVN-MOC-PRC-0007). This process ensures there is a structured and consistent approach to recognise, identify, action and implement significant change to activities.

Significant changes to the drilling campaign operations include:

- Any material change to the 'engineering intent' or the 'well strategy, e.g. change of drilling approach or major variation to the original plan for processing of drilling cuttings;
- Change in the scope of the drilling campaign that affects the 'well strategy';
- Change of MODU contractor or well control equipment; and
- Any process change that is deemed to increase a risk above existing residual risk levels.

Significant changes are reviewed and must demonstrate compliance with Carnarvon standards and recommended practices. Significant changes which deviate from the approved Well Program require a formal management of change procedure, which is subject to the same internal review and approval process as the original.

A risk assessment may also be completed to determine if there is an increased risk of releasing hydrocarbons to the marine environment. In all cases, where a potential release to the marine environment has been identified, assessment of implementing additional risk control measures to lower the potential risk to ALARP will be undertaken. Any significant changes to the drilling campaign may necessitate amendment to the EP and FSRP, as appropriate to the level of change.

8.1.2.4 Environment Plan Maintenance and Revision

A revised EP will be submitted to NOPSEMA under Regulation 17 of the OPGGS (E) Regulations if any changes occur to this EP due to:

- A new activity;
- A significant modification or new stage of activity that is not provided for in the approved EP;
- Significant new or increased environmental impact or risk; and
- Changes in titleholder that results in a change in the manner in which the environmental impacts and risks of the activity are managed.

NOPSEMA will assess the revised EP and all relevant documents under Regulation 21 of the OPGGS (E) Regulations. While the revision is being assessed any activities adequately addressed under the existing accepted EP can still occur.

The EP may be revised in line with Carnarvon management of change process but may not be resubmitted to NOPSEMA if it does not trigger Regulation 17 of the OPGGS (E) Regulations.

8.2 Reporting

Carnarvon has in place, well-established incident notification, reporting and investigation procedures which require all employees and contractors to report all incidents to their supervisor. All HSE hazards and incidents are reported in accordance with the Carnarvon Incident Reporting and Investigation Procedure. Carnarvon maintains a database to track incidents and ensure actions are tracked through to close out. Environmental incidents are reported to relevant Government authorities as required. With respect to recordable incidents, the environmental management system contains EPOs, EPSs and MC to ensure the desired EPSs are maintained for the duration of the drilling campaign.

Table 8-2 below contains a summary of internal and external routine reporting that will be completed for the duration of the drilling campaign.

Table 8-2: Summary of Routine Reporting

Report	Frequency	Contents
Internal routine reporting		
OVID inspection report	Prior to commencement	Summary of the findings of the support vessel inspection which assesses compliance with relevant Australian and Carnarvon requirements.
Pre-start MODU/ vessel contractor audit(s)	Prior to commencement	Confirmation of compliance with Contractor Management Process for various matters outlined in Section 8 of this EP relating to operational procedures and processes.
Daily drilling report	Daily	Performance information on drilling activities, health, safety and environment, mud, chemical and diesel use as well as current and planned activities.
Daily drilling meeting	Daily	Daily meetings between the OIM, Drilling Superintendent, engineering, and HSE personnel used to transfer information, discuss incidents, agree plans for activities and develop plans for issue resolution.

Report	Frequency	Contents
Drilling HSE meeting	Weekly	Weekly, dedicated HSE meetings are held with the offshore and Perth-based management (including MODU contractor management) and advisers to address targeted health, safety and environment incidents and initiatives. Minutes of these meetings are produced and distributed as appropriate.
After action report for exercises or drills	As per exercise or drill schedule	These reports are completed following an exercise or drill. They generally report on what worked well, opportunities for improvement and corrective actions to address opportunities for improvement.
Post-incident debrief report	As per spill	Post-incident debrief reports provide key information pertaining to the event that occurred. This may include details of the spill, resources, response actions, and lessons learnt.
Monthly maintenance report	Monthly	The monthly maintenance report records assurance checks of essential equipment on the MODU and is derived from the MODU equipment maintenance system.
External routine reporting		
Monthly recordable incident report (to NOPSEMA)	Monthly, by the 15th of each month	Details of recordable incidents that have occurred during the drilling campaign for previous month (if applicable).
Environmental performance report (to NOPSEMA)	Annually, with the first report submitted within 12 months of the commencement of the drilling campaign covered by this EP	In accordance with the OPGGS (E) Regulations (Regulation 14(2a, b; 26C)) the report will address compliance with environmental performance outcomes and standards outlined in Section 8 of this EP.
Start and end reports (to NOPSEMA)	Start report: No less than 10 days prior to commencement of the drilling campaign covered by this EP End Report: No more than 10 days after the completion of the drilling campaign covered by this EP	In accordance with the OPGGS (E) Regulation 29, Carnarvon will notify NOPSEMA of the commencement of the drilling campaign and the completion of the drilling campaign at least 10 days before the activity commences and within 10 days of the drilling campaign completion.

9 HYDROCARBON SPILL RESPONSE ARRANGEMENTS

9.1 Response methodology

Whilst a significant spill during the activity is unlikely, should such an event occur, the First Strike Plan(s) (contained in the Buffalo Drilling OPEP) provides initial response guidance to the activity/area.

The Carnarvon First-Strike Response Plan (FSRP) as part of the Oil Pollution Emergency Plan (OPEP), follows a common initial response methodology aligned to the Australian National Arrangements and based on the IPIECA Incident Management System (IPIECA & IOGP, Report 517, 2014).

The First Strike Plan(s) provides immediate actions required to commence a response based on the scenarios identified in the risk assessment. The rig and support vessels will have SOPEPs/SMPEPs in accordance with the requirements of relevant Marine Orders. These plans outline responsibilities, procedures and resources available in the event of a minor hydrocarbon or chemical spill from vessel activities. The First Strike Plan(s) are intended to work in conjunction with the SOPEPs/SMPEPs, if hydrocarbons are released to the marine environment.

The FSRP provides further information required to support response efforts in the unlikely event of an unplanned release of hydrocarbons including guidance on response strategies and resources available.

The IMP details actions to be taken for an escalating incident, describes arrangements and reporting relationships for command, control and coordination, and provides interfaces to specialist response groups, Government agencies and other external bodies.

A consultation strategy has been developed, focusing on consultation between Carnarvon and the relevant regulatory entities, and industry groups. A program of engagement with stakeholders is in place to ensure that the role of each agency is agreed and clearly defined in the FSRP and IMP.

9.2 Protection Priorities

The Priorities for Protection for oil spill response were determined with consideration of the consequence assessment, probability of contact, together with floating oil minimum time to contact for oil spill response prioritization purpose.

The following locations were identified as Priorities for Protection (for oil spill response planning):

- Browse Island;
- Cartier Island; and
- Christmas Island.

These locations were identified as locations where spill response strategies (as described in the FSRP) would be applied. The worst-case single modelled run was identified by selecting the greatest volume of oil ashore to these combined Priority for Protection areas. Then each Priority for Protection area was analysed separately to identify the worst-case loading and the shortest time-frame to impact. In both instances, the impacts to all receptors were analysed so that sufficient resources could be identified to address impacts..

Although outside Australian jurisdiction, the international waters around Timor Leste, and Indonesian Islands were also risk assessed as part of the EMBA, and response requirements determined due to the high density rural communities, Marine Parks and important coastal habitats including mangroves, wetland and turtle nesting beaches. Other sensitive receptors which were locations or receptors that fell within the EMBA were also identified as potential considerations for Scientific Monitoring. This included:

- The Big Bank Shoals;

- Australian Marine Parks; Ashmore AMP, Kimberley AMP;
- KEFs;
- Breeding or lifestyle stages on any BIA;
- International waters (Indonesia and Timor Leste); and
- Socio economic values (fisheries) that may be impacted in the event of a spill.

For the purposes of spill response preparedness strategies, it is not necessary for all Protection Priorities to have specific operational or tactical response plans in place. For example, wholly submerged Protection Priorities may only be contacted by entrained oil, and the response will largely be the implementation of scientific monitoring to assess impact and recovery. Protection Priorities with emergent features can have response actions prepared.

9.3 Response strategies

The available response strategies were assessed to determine which strategies would be implemented for each spill event. The assessment determined if the response strategy would be effective (viable) and if it would have a net environmental benefit (based on a Net Environmental Benefit Analysis (NEBA)) if implemented. A justification and description of the strategies is provided in **Table 9-1**.

Table 9-1 Selected Response Strategies by Worst case Scenario Oil Type

	Diesel Spill	Loss of Well Control
Predicted outcomes	The Group II hydrocarbon is expected to evaporate and spread rapidly with no shoreline impact.	The Group I oil is expected to evaporate and spread rapidly. Shoreline impact is expected.
Source control		
Identified as suitable?	No	Yes
NEBA considerations	Spill of diesel will be instantaneous and source control will be limited to what the vessel can achieve whilst responding to the incident. I.e. vessels may shut off pumps or transfer fuel to another fuel tank. As the activities are limited to the vessel response they have not been explored further within the FSRP.	Regaining control of a well may require a relief well to achieve the desired result. The use of a sub-sea capping stack to regain the control of a well is not feasible for Buffalo wells.
Monitoring, evaluation and surveillance		
Identified as suitable?	Yes	Yes
NEBA considerations	All spills will be monitored and evaluated to assess the natural biodegradation of the hydrocarbons and ensure situational awareness of the spill is maintained by emergency response teams.	
Surface dispersant application		
Identified as suitable?	No	Yes
NEBA considerations	Marine diesel is not a persistent hydrocarbon; it has a high natural dispersion and	Group I light oils are not persistent hydrocarbons; they have a high natural dispersion and evaporation rate due to the

	Diesel Spill	Loss of Well Control
	evaporation rate due to the high percentage of volatile components within the oil. Modelling for this scenario predicts that approximately 70% of the diesel will have evaporated after 1 day and the majority of the remaining 30% will become entrained in the water column. A small increase in sea state (wave and wind action) can assist natural biodegradation through entraining diesel in the water column. Shoreline impact is not predicted.	high percentage of volatile components within the oil. Oil mass balances of several worst-case deterministic simulations show that ~90% of the released oil is predicted to be lost to evaporation (i.e. volatilisation to the atmosphere). For the ~11% residual oil, surface dispersant will be field tested and applied if deemed to be providing a net environmental benefit.
Mechanical dispersion		
Identified as suitable?	**No**	**No**
NEBA considerations	Diesel spreads and evaporates rapidly. Mechanical dispersion may inhibit the rate of evaporation and could cause the oil to emulsify.	This strategy would have limited effectiveness for a highly volatile Group I spill with a low persistent fraction, in scenarios where wave action will deliver similar benefits. This strategy would have little practical effects on reducing the impacts on the marine environment.
Containment and recovery		
Identified as suitable?	**No**	**Yes**
NEBA considerations	An instantaneous spill of diesel will spread and evaporate rapidly due to the high proportion of volatile components within the oil and will not be of a sufficient thickness to provide for effective containment and recovery operations.	If the MES data informing the NEBA demonstrates a tangible, positive outcome to collect the residual oil, there is the potential to undertake this response activity.
Shoreline protection and deflection		
Identified as suitable?	**No**	**Yes**
NEBA considerations	A diesel spill of this scale is not expected to impact shorelines and as such the deployment of protection booms will not be required.	Due to the very thin surface slicks from Group I spills, very low rates of recovery would be expected. However, if a tangible, positive outcome could be demonstrated a protect and deflect operation may be possible.
Shoreline clean-up		
Identified as suitable?	**No**	**Yes**
NEBA considerations	Shoreline impacts are not anticipated and as such shoreline clean-up is not required.	If the MES and SCAT data informing the NEBA demonstrates a tangible, positive

	Diesel Spill	Loss of Well Control
		outcome, there is the potential to undertake this response activity.
Oiled wildlife response		
Identified as suitable?	Yes	Yes
NEBA considerations	Surveillance for oiled wildlife will be conducted as per the Operational and Scientific Monitoring Plan (OSMP). Oiled wildlife response (OWR) will be carried out as required.	
In-situ burning		
Identified as suitable?	No	No
NEBA considerations	Diesel evaporates rapidly and is not suitable for in-situ burning.	The reservoir oil evaporates rapidly and is not suitable for in-situ burning.
Scientific monitoring		
Identified as suitable?	Yes	Yes
NEBA considerations	All spills will be monitored and evaluated to assess the natural biodegradation of the hydrocarbons and ensure situational awareness of the spill is maintained by Carnarvon emergency response teams. However, only longer-term scientific monitoring plans are likely to be triggered for LOWC.	

9.4 Response Resources

Oil spill response equipment and resources are a combination of:

- Carnarvon;
- OSRL (Associate Membership in place);
- PTEPP (MOU in place);
- Contractors;
- AMSA (with consideration of not guaranteed response for all components); and
- WWC (MOU in place).

Under the Wildlife Conservation Act 1950, DBCA is the jurisdictional authority responsible for ensuring a minimum standard of treatment, protection and destruction of oil-affected wildlife. In this instance, DBCA, the DoT and Carnarvon will work together to coordinate the OWR.

When triggered, arrangements are in place for resources to be contracted to initiate operational and scientific monitoring plans to effectively and efficiently monitor the potential environmental impact resulting from an oil spill or spill response activities.

Emergency Management and Response training is mandatory for specific personnel, such as the Carnarvon IMT and CMT. Carnarvon maintains competent and trained response personnel to ensure a capability can be delivered throughout the drilling campaign.

9.5 Response Drills, Exercise and Audits

As required by Regulation 14 (8A) of the OPGGS (E) Regulations, Carnarvon will test these arrangements in order to confirm capability. Exercises will be either desktop exercises or field-based spill response deployment exercises.

The following exercises and drills that will be conducted to specifically test response preparedness outlined within the scope of the IMP:

- Prior to commencement of the drilling campaign the IMT will undertake an exercise of the response arrangements;
- One drill carried out on board the MODU to practice and review the Buffalo Drilling FSRP;
- One IMT Full- scale exercise conducted annually that is specific to the drilling campaign; and
- Annual Functional exercise in the CMT and IMT Training Program (related to Carnarvon operations, i.e. may not be specific to this drilling campaign).

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APPENDIX A: ENVIRONMENTAL RISK ASSESSMENT

PLANNED EVENTS

HABITAT DISTURBANCE

Source of Impact

Sources of habitat disturbance of the seabed as a result of routine activities, leading to damage to benthic habitat and associated marine flora and fauna may result from:

- RMR equipment (up to 5 m2);
- Tow line in contact with the seabed;
- Extension of jack-up legs (cans) to the seabed (spudding); and
- Laying anchor and chains (contingency anchors for jack-up).

The 'spud cans' of the legs of the jack-up that will attach the rig to seafloor are estimated conservatively to have a surface area of 260 m^2 per leg, equating to a maximum footprint of the Drilling rig of 780 m^2 for each well (up to three). Should the well require re-spud, then the rig may need to shift 50 m, and reposition, potentially lifting the jack-up legs and re-extending them.

Although anchors are not often used from the jack-up, they may be utilised during cyclone or emergency preparations and may extend up to 1 km from the drilling rig. If used, the extent of disturbance to the seafloor will be limited to the area immediately under the anchors as well as disturbance associated with the anchor chain/lines that rest on the seabed. A maximum of four anchors may be employed.

Whilst the rig is moving into location to spud, the tow line of the support vessel may come in contact with the seafloor. The estimated length of tow line that might be in contact with the seafloor is 250 m.

The RMR equipment (pump) may be placed on the seabed below the Jackup. It has a small area of impact which is 2.2 m x 2 m.

Environmental Values Potentially Impacted							
Physical Environment					Fauna		Other
Physical Environment (Big Bank)	Marine Sediment	Water Quality	Benthic Habitats	Benthic Infauna	Marine Reptiles	Sharks, Fish and Rays	Socio-economic

Potential disturbance to benthic habitats from: tow lines, spudding of the MODU or laying anchor and chains may result in:

- The mortality of any flora and sessile fauna within the disturbance footprint and potentially the mortality of benthic infauna associated with the habitat. Following habitat disturbance, the soft sediment will be left disturbed, but will remain a viable habitat that would be expected to recolonise with benthic species within weeks to months following removal of the disturbance.
- Through disturbance to benthic habitats there may be disturbance to sediment, and a short-term decrease in water quality due to increased turbidity.
- Marine turtles and other non-significant species (fish) may be impacted due to a temporary disturbance to feeding habitat.

Evaluation		
Consequence	Likelihood	Ranking
2	n/a	2 (Minor)

Summary of control measures	
CM-1	Rig Move Procedure
CM-2	Marine Operations Management Plan
CM-3	Pre-spud surveys
CM-4	Big Bank Habitat Map based site selection
CM-5	No temporary storage of equipment on seabed
CM-6	Pre-jack survey

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Water Quality	The disturbance to sediments from the positioning of the jackup rig and placement of RMR equipment can increase turbidity in the water column and causes a reduction in the penetration of light available for photosynthesising benthic organisms (see below). Although the background levels of turbidity in the Operational area are likely to be low (~0.2 NTU), the shoals and banks in the region experience natural, episodic elevations of turbidity during storm events, that far exceed the concentrations of TSS or sedimentation from seabed disturbances. Although such events are shorter in duration, their intensity is much greater and could persist for an equivalent amount of time in the case that several storms were to pass in quick succession. The species that occur in these environments are likely to be resilient to these turbidity increases (Heyward et al. 2017). Effects unlikely to be discernible or measurable, and not too different from conditions during a storm event. As such this consequence was ranked as Slight: Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna.
Benthic Habitat	The spudding of the drilling rig and RMR equipment will disturb approximately 780 m2 (jack up) and approx. 5 m2 (RMR pump) of benthic habitat in the vicinity of the drill centre, which is expected to be Habitat D, dominated by rubble and sparse macro algae (including Halimeda sp.) (Section 4.3). This will also result in the mortality of any sessile fauna within this footprint and potentially the mortality of benthic infauna associated with the habitat. Impacts from potential anchor drag, or tow lines would also be within Habitat D and but will remain a viable habitat that would be expected to recolonise quickly with benthic species following removal of the disturbance. The presence of 'sand waves/ripples' in the area during previous surveys (Heyward et al. 1997), indicates a benthic environment subject to periods of strong wave energy. It is likely that the benthic infauna and epifauna that inhabit these areas on Big Bank are those that tolerate episodic disturbance or are able to rapidly recolonise after periods disturbance. This is supported by the recent survey by GeoOceans (2018), that reported no obvious sign of previous spudding in the last drilling location. This area had been returned to normal and recolonised (GeoOceans 2018). A similar recovery would be expected from the proposed activity. However, there may be a cumulative impacts from habitat disturbance from three wells in the same location that may result in a longer recovery time (weeks to months), albeit they are likely to be over 12 months apart. Halimeda sp. are fast growing, able to double their biomass in a matter of weeks and can rapidly propagate through vegetative cloning (Heyward et al. 1997, Drew 1983). Halimeda communities have also been found to recover from severe storm disturbance within six months (Williams 1988). As such this consequence was ranked as Minor: Minor environmental damage. Limited scale less than 1 km. Recovery in weeks to months and potential mortality to fauna (infauna).

Fauna	Turbidity increases from seabed disturbance may also cause localised impact to the waters through which marine reptiles may transit. Marine reptiles were also recorded in the survey by GeoOceans (2018) and are expected to forage on Big Bank. However, the Operational area does not intersect any Habitat Critical for the Survival of marine turtles, with the closest nesting area being >350 km away (green turtle nesting area at Cartier Island; and important foraging ground south west of the permit area. Any loss of potential habitat for marine turtles and other marine fauna from seabed disturbance is negligible, and species are likely to forage at other location on Big Bank and also on nearby shoals that provide similar habitat/foraging areas. Fish abundance and diversity in the rubble/turfing macroalgae habitat of the potential area of impact from seabed disturbance is low, consisting mainly of smaller species, such as hawkfishes (Heyward et al. 1997, GeoOceans 2018). Impacts to these demersal fish that live within 5 to 10 m of the seabed are not predicted, given the fish are mobile. The potential impact on habitat for other resident species such a fish is also expected to be temporary, and only impact a very small percentage of the total Habitat D available on Big Bank. Changes in water quality from seabed disturbance may result in behavioural effects to sharks, fish and rays in close proximity to the Drilling Rig location, with recovery measured within hours to days. As such, the worst case consequence ranking for Physical Presence given was 1 (Slight): Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna; Effects unlikely to be discernible or measurable.
Socio-economic	No socio economic impacts are expected as a result of habitat disturbance within the Operational area. The opportunity to comment on the acceptability of impacts from habitat disturbance was encouraged through the distribution of an information sheet. This information sheet noted that the activity would be undertaken in an area dominated by 'macro-algae and rubble' and what management measures would be implemented to mitigate impacts. The following Commonwealth government agencies were targeted by email in July 2018: • Department of Industry, Innovation and Science; • Department of Agriculture and Water Resources; • Minister for Environment & Energy; • Australian Fisheries Management Authority (AFMA); • Parks Australia - Australia Marine Parks; and • Australian Border Force (formerly Australian Customs and Border Protection Service). Given the location of the potential impacts to the Halimeda sp. in Commonwealth waters it would be anticipated if there were any concerns it would be these agencies that would respond. No concerns were raised by any of the above organisations with regard to the potential impact of drilling.

ALARP Statement
No alternative to use of a Drilling Rig or supply vessels.As part of the ALARP assessment additional controls were adopted to reduce potential impacts from habitat disturbance (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in impact levels. With implementation of the existing management measures, it is considered the risk associated with habitat disturbance are reduced to ALARP
Demonstration of Acceptability
All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with habitat disturbance ACCEPTABLE.

INTERFERENCE WITH OTHER USERS

Source of impact

Interference with other users of the sea through undertaking the drilling activities. This aspect provides for the Drilling Rig and support vessels being continuously present at sea surface for the duration of the Activity (including RMR skip and ship activities), and the associated navigational exclusion zone for support vessels while on location.

Environmental Values Potentially Impacted					
Socio- economic				Fauna	Other
Commercial Fishing	Petroleum Activities	Shipping	Indigenous Fishing	n/a	n/a

The potential impacts for this aspect is restricted to transit of the MODU and support vessels (including RMR skip and ship activities) while operating within the Operational area. Any potential interruptions to users of the sea will be limited to the Operational area.

The presence of the MODU and support vessels may be an obstacle for shipping traffic in the region and may disrupt commercial fishing operations. These impacts can include a loss of access to the area. Potential impacts to commercial and recreational fishers include temporary loss of fishing area, and a potential inconvenience to fishing practices.

Most indigenous (Aboriginal and Torres Strait Islander) fishing activity occurs close to communities and outstations, inland or near WA and NT coastal waters. As the Buffalo field is located closer (~170 km) to Indonesia/Timor Leste coastline than the Australian coastline, it is considered likely that the area is utilised by Indonesian/Timor Leste indigenous fishers.

Evaluation		
Consequence	Likelihood	Ranking
1	n/a	1 (Slight)

Summary of control measures	
CM-1	Rig Move Procedure
CM-7	Implementation of Navigational legislation
CM-35	Carnarvon Petroleum Consultation of Relevant Persons Procedure
CM-4	Benthic Habitat Map based site selection

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Socio-economic	Any impact to commercial industries within or surrounding the Operational area (e.g. commercial fisheries and ecotourism operators) is expected to be Slight. The 500 m exclusion zone is small in comparison to the overall permitted area and minimal to no fishing effort has occurred recently in the area. Stakeholder consultation with Commonwealth Commercial Fishing representatives has been undertaken with no issues raised.

	Indonesian/Timorese indigenous fishing is known to occur in the vicinity of Sahul Bank and Echo Shoals, and as a result boats may pass through the Operational area to reach these fishing grounds. During the recent habitat mapping survey conducted at Big Bank by GeoOceans (2018), a single Indonesian/Timorese fishing vessel was observed anchoring overnight on Big Bank plateau. The 500 m exclusion zone is only a small area relative to the size of Big Bank and fisherman are able to avoid this area and fish at other locations on Big Bank. Navigational lighting will ensure the drilling rig and vessels are easily identifiable by vessels. Potential impacts are considered Slight- effects unlikely to be discernible or measurable. Petroleum exploration has been active in the Timor Sea since the 1980s, with several commercial discoveries since that time. The closest facility to the Operational area is Laminara and Correlina - Northern Endeavour (NOGA) approximately 8 km to the north west. The proposed activity is not expected to result in any significant impacts to NOGA offshore petroleum exploration and operations (Slight). Stakeholder consultation with NOGA representatives has been undertaken with no issues raised. The Operational area is located in an open ocean environment. The nearest Australian commercial port is Darwin (500 km) and the nearest Indonesian commercial port is Kupang (~300 km). During consultation (Section 5) AMSA noted that the drilling location was in a heavy shipping traffic area, however it and the disposal site are not on a major shipping route. However, with the controls in place, effects to shipping traffic are not expected to be discernible or measurable resulting in an overall consequence of 1 (Slight). The 500 m exclusion zone is only a small area and ships are able to avoid this area . The Operational area is located in an open ocean environment well removed from population centres, and any visual impacts from the Drilling Rig are also are expected not to be discernible (Slight).
ALARP Statement	
No alternative to use of a Drilling rig or supply vessels. The exclusion zone is a safety requirement. As part of the ALARP assessment additional controls were adopted to reduce potential impacts to other users (see above) no additional controls considered as not technically feasible, or grossly disproportionate for this type of activity were rejected. With implementation of the existing management controls, it is considered the risk associated with interference with other users are reduced to ALARP.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with interference with others ACCEPTABLE.	

ARTIFICIAL LIGHT

Source of Impact

During the Activity, safety lighting on the MODU and support vessels and equipment (2 small camera lights on RMR) will generate light emissions that may potentially affect marine fauna behaviour. Lighting typically consists of bright white (metal halide, halogen, fluorescent) lights.

Direct light spill on surface waters will be limited to the area directly adjacent to the MODU and support vessels as they operate within the Operational area.

Depending on weather conditions, MODU lighting (particularly at night-time) will be visible at distances of ~20 km, with intensity attenuating with distance. Light from support vessels are visible over shorter distances since their lights are closer to the sea surface and are usually less of them, compared to MODU lighting.

Environmental Values Potentially Impacted				
Physical Environment	Fauna			
Physical Env (Big Bank)	Marine Mammals	Marine Reptiles	Fish, Sharks and Rays	Marine Birds

Continuous lighting in the same location for an extended period of time may result in alterations to normal marine fauna behaviour. Sensitive receptors that may be impacted include fish at surface, marine turtles, mammals and seabirds.

Fish

The response of fish to light emissions varies according to species and habitat. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al. 2001).

Lindquist et al. (2005) concluded from a study that artificial lighting associated with a MODU resulted in an increased abundance of clupeids (herring and sardines) and engraulids (anchovies); these species are known to be highly photopositive. Shaw et al. (2002), in a similar light trap study, noted that juvenile tuna (Scombridae) and jack (Carangidae), which are highly predatory, may have been preying upon higher than usual concentrations of zooplankton that were attracted to a MODU's light field.

Marine Turtles

The most significant risk posed to marine turtles from artificial lighting is the potential disorientation of hatchlings following their emergence from nests. Hatchlings use the light of the oceanic horizon to orientate themselves towards the sea when making their way into the water for the first time; the oceanic horizon is almost always brighter than the elevated landward horizon (EPA 2010). Hatchling behaviour may therefore be affected when exposed to an artificial light source at certain intensities and distributions, potentially leading to disorientation when attempting to migrate to the ocean.

Artificial lighting may also impact on nesting behaviour of adult turtles, which have a preference for non-illuminated beaches (EPA 2010).

Seabirds

Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around illuminated offshore infrastructure (Marquenie et al. 2008) and that lighting can attract birds from large catchment areas (Wiese et al. 2001). Birds may either be attracted by the light source itself or indirectly as structures in deep water environments tend to attract marine life at all tropic levels, creating food sources and providing artificial shelter for seabirds (Surman 2002).

Birds not only see well but their vision includes sensitivity across the visible spectrum and down into the ultra-violet. Light can both attract and disorientate birds (Rich & Longcore 2004), and is particularly detrimental to juveniles.

Since hundreds of species of birds migrate during dark hours, artificial light pollution can slow their migration and lead to mortality when they collide with buildings and other structures near bright lights. Birds are attracted by flares from offshore infrastructure and can be injured or killed by heat or collision.

Shearwaters are highly active at night time. Research has demonstrated they are highly sensitive to artificial lights. Shearwaters have been known to feed on bioluminescent squids, causing juveniles to confuse artificial lights for a source of food (Klomp & Furness 1992; Montevecchi 2006).

Artificial lights are a documented source of significant mortality of shearwaters in Hawaii (Telfer et al. 1987; Ainley et al. 1997), Réunion Island (Jouanin & Gill 1967; Jouanin 1987; Le Corre et al. 1996, 1999), the Canary Islands (Rodríguez & Rodríguez 2009), and the Azores (Aubrecht et al. 2010).

The light sources associated with the MODU and support vessels may also provide enhanced capability for seabirds to forage at night.

Other Marine Fauna

There is no evidence to suggest that artificial light sources adversely affect the migratory, feeding or breeding behaviours of cetaceans. Cetaceans predominantly utilise acoustic senses to monitor their environment rather than visual cues (Simmonds et al. 2004), therefore impacts are thought to be unlikely

Evaluation		
Consequence	Likelihood	Ranking
1	n/a	1 (Slight)

Summary of control measures	
CM-7	Implementation of Navigational legislation
CM-4	Benthic Habitat Map based site selection

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Protected Fauna (turtles)	The impacts of lighting to the receiving environment are well understood and the consequence is expected to be short term. Turtles may pass through the Operational area, however the potential impacts are considered low for the following reasons: Big Bank is not known as a significant feeding, or aggregation areas for marine reptiles; Direct light is not predicted to be visible at any of the nearest emergent receptors of Ashmore Reef, Cartier Island or Browse Island, which are the primary receptors of interest for turtle nesting/interesting; The location of the Operational area in relation to the nearest BIA for turtle nesting/internesting is approximately ~330 km away, significantly greater than the EPA's estimated light influence distance of approximately 1.5 km (EPA 2010). As such, impacts are not expected on turtles at nesting beaches (inter/nesting adults or emerging hatchlings); and Light from a supply vessel will not be directly seen from any reefs/islands).

	The worst case consequence ranking for Artificial light ranking on marine turtles was 1 (Slight): Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna as effects unlikely to be discernible or measurable.
Protected Fauna (Birds)	Research indicates that seabirds may be attracted to artificial light and could potentially collide with infrastructure. In general, the impacts are considered to be dependent on weather conditions. During clear weather conditions, well-lit offshore structures have minimal or no impact on avifauna. Offshore structures can actually provide additional roosting sites for species flying through the area. During conditions of persistent light rain fog or mist, the reflectance of light from offshore structures is increased, compounding the disorientation effects of avifauna and potentially resulting in high mortalities due to collision with structures. The likelihood and frequency of such events leading to significant mortalities are considered low as such events are unusual and generally localised. The Operational area does not contain any significant feeding, breeding or aggregation areas for birds. However, there is a potential for a limited number of individuals to be impacted by light emissions who may transit the Operational Area Transient bird species may see the MODU up to 20 km away however this is likely to equate to no brighter than a full moon any further than 5 km away (Pendolely 2005). The scale of the impacts is expected to be restricted to behavioural effects. Direct light is not predicted to be visible at any of the nearest emergent receptors and BIA of Ashmore Reef, Cartier Island or Browse Island, which provide key habitat for seabirds and migratory shorebird nesting/staging. The worst case consequence ranking for Artificial light given was 1 (Slight): Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna as effects unlikely to be discernible or measurable.
Other Fauna	The potential consequences of artificial light to other fauna in the operational area are unlikely to be discernible or measurable to several common fish species that are resident in the area.
Big Bank	Given the submerged nature of the shoals with no emergent features, the potential impact of light (to benthic habitats) from the proposed Activity is assessed to be Slight.
ALARP Statement	
No alternative to use of a Drilling Rig or supply vessels.There are no safe alternatives to the use of artificial lighting on the Drilling Rig and vessels. Artificial lighting is required on a 24 hour basis for navigational safety in the area and additional light is required to allow the activity to proceed safely on a 24 hour basis for occupational health and safety reasons. As part of the ALARP assessment additional controls were adopted to reduce potential impacts from habitat disturbance (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in impact levels. With implementation of the existing management measures it is considered the risk associated with Artificial light are reduced to ALARP as per the criteria in Section 6.1.6.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with Artifical light ACCEPTABLE.	

ATMOSPHERIC EMISSIONS

Sources of Impact

The use of fuel (specifically marine-grade diesel) to power MODU and vessel engines, generators and mobile and fixed plant and equipment will result in emissions of greenhouse gases (GHG) such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), along with non-GHG such as sulphur oxides (SOx) and nitrous oxides (NOx). The RMR equipment is electrically run and existing power generation capacity is expected to be sufficient, with no additional generators required.

Vessels/MODU may utilise ozone-depleting substances (ODS) in closed-system rechargeable refrigeration systems.

Atmospheric emissions are predicted to dissipate to concentrations that pose limited potential impact to receptors within the Operational Area.

Environmental Values Potentially Impacted	
Physical Environment	Fauna
Air Quality	Birds

Air emissions through the release of ODS and use of fuel (specifically marine-grade diesel) to power MODU, vessel, and helicopter engines, generators and mobile and fixed plant and equipment may result in a temporary, localised reduction of air quality in the environment immediately surrounding the discharge point.

The emissions may contain greenhouse gases (GHG) such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), along with non-GHG such as sulphur oxides (SOx) and nitrous oxides (NOx).

A decline in air quality has the potential to impact on avifauna species using or transiting the area.

Evaluation		
Consequence	Likelihood	Ranking
1	n/a	1 (Slight)

Summary of control measures	
CM-8	MARPOL Regulation 14 – Sulphur content of fuel Marine Orders Part 97 – Marine pollution prevention — air pollution
CM-9	MARPOL Annex VI Marine Order 97 (Marine pollution prevention – Air pollution)
CM-10	Planned maintenance procedure

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Birds	Three listed threatened birds and seven listed migratory birds were identified by the EPBC Protected matters search as potentially occurring or having habitat in the Operational area). No emergent land exists in the shoals or surrounding offshore areas in the vicinity of the Operational area that would be impacted by air emissions to support breeding populations of seabirds or migratory shorebirds. The nearest islands in the vicinity, that support a large number of seabirds and migratory shorebirds are Cartier Island and Ashmore Reef (BIA for listed bird species, which are located ~355 km and ~378 km, respectively, from the Operational area.

	Considering the location of the development in the open ocean, the minor deterioration in local air quality due to emissions (NOx, SOx, VOC and CO) during activities will only have a short term, localised impact on transient marine birds. There is not expected to be any disturbance to populations. The worst case consequence ranking for air emissions on marine birds was 1 (Slight): Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna. Effects unlikely to be discernible or measurable.
Air Quality	Minor deterioration in local air quality due to emissions (NOx, SOx, VOC and CO) during activities. Contribution to the incremental build-up of greenhouse gas in the atmosphere. Considering the location of the Activity in the open ocean, which is well-removed from the nearest residential or sensitive populations, it is considered that atmospheric emissions will only result in localised and short term impacts to ambient air quality at a local and regional scale. The worst case consequence ranking for air emissions on air quality was 1 (Slight): Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna. Effects unlikely to be discernible or measurable.

ALARP Statement
Power generation through combustion of fossil fuels is essential to undertaking the Activity to run work vessels and power the MODU. Practical and reliable alternative fuel types and power sources for the MODU, helicopters and support vessels have not been identified. Disposing of cuttings in deep water at the disposal location will increase the vessel activity and generate more emissions, however the impact from this was considered less significant that the environmental benefit of not discharging cuttings on Big Bank. As part of the ALARP assessment additional controls were adopted to reduce potential impacts from Atmospheric emissions (see above) no additional controls considered as not technically feasible, or grossly disproportionate for this type of activity were rejected. With implementation of the existing management controls it is considered the risk associated with Atmospheric emissions are reduced to ALARP as per the criteria in Section 6.1.6.
Demonstration of Acceptability
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with from Atmospheric Emissions ACCEPTABLE.

OPERATIONAL DISCHARGES

Sources of Impact

During the Activity, the use of a MODU and vessels will result in routine discharges to sea of the following: Food waste, treated sewage, grey water, desalination and cooling water, bilge (oily) water and deck drainage. Discharges will occur at the sea surface and are dependent on the number of people on board as to the volumes discharged.

Vessels and MODUs typically generate between 5-15 m3 of waste water (sewage and grey water) per day (NERA 2018), depending on the number of persons on board. During this activity, this could equate to 1,575 m3 of sewage and greywater discharged during the drilling of all three wells (assuming 35 days per well). Putrescible waste will consist of approximately 1 L of food waste per person per day.

Bilge water and deck drainage will be in minimal quantities and discharged intermittently throughout the activity. Brine and cooling water discharges will be dependent on the number of people on board, equipment and fresh water requirements.

A Operational discharges from the MODU will occur at the drilling location foreach well (within the defined operational area) on Big Bank. Some discharges from vessels will be undertaken off Big Bank where practicable as outlined below. For these the vessels will move >1 km from Big Bank prior to discharging oily water, sewage and food waste.

Discharge	Vessels	MODU
Oily water	Discharge >1km off Big Bank	Discharge on Big Bank
Sewage and food waste	Discharge >1km off Big Bank	Discharge on Big Bank
Cooling water	May discharge on Big Bank	Discharge on Big Bank
Brine	May discharge on Big Bank	Discharge on Big Bank
Deck drainage	May discharge on Big Bank	Discharge on Big Bank

Environmental Values Potentially Impacted						
Physical Environment			Fauna			
Water Quality	Benthic Habitats	Protected Species BIA	Marine Mammals	Marine Reptiles	Sharks, Fish and Rays	Marine Birds

The potential area of impact of each of the operational discharges are described below with evidence from previous studies. The resultingchanges in water quality (temperature, nutrient loading and salinity changes) may have potential impacts on pelagic fauna as described below.

Sewage , food waste and grey water

Given that sewage discharges from vessels and MODUs are at or near the surface, and are buoyant discharges, the receptors with the potential to be impacted are also those within or on surface waters (NERA 2018). Therefore, impacts at the seabed (sediment) or to the benthic habitats of Big Bank is not expected as the water depths in the operational area are >25 m. . Multiple studies undertaken in industry (NERA 2018) have found that potential impacts from the discharges of sewage in surface waters are dispersed within 500 m of the source.

Monitoring of sewage discharges has demonstrated that a 10 m3 sewage discharge over 24 hrs from a stationary source in shallow water, reduced to approximately 1% of its original concentration within 50 m of the discharge

location (Woodside 2008). In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were rapidly diluted or nutrients rapidly metabolised and no elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station. Although only a 10 m3 discharge, this study provides some confidence to the defined mixing zone boundary and further supports the dispersion of these types of effluent in offshore waters where tidal currents will influence the discharge and that it is unlikely that operational discharges will affect the benthic habitats in the vicinity of the discharge locations.

Based on the evidence above, the potential area of impact is predicted to remain within < a 1 km radius of the discharge location The volumes discharged in the NERA (2018) studies are much higher than those considered for this activity (>125,000 m3 per day), and dilutions must be met within 50 m of the discharge point; the composition of these residential/industrial/commercial outfalls is expected to contain higher concentrations and toxicity of contaminants than those found in discharges from offshore support vessels and MODUs. Despite the higher toxicity levels of these types of discharges, the dilution concentrations are routinely achieved, as evidenced through ongoing monitoring (NERA 2018).

Deck drainage and bilge water

RPS (2017, cited in Equinor 2019) modelled the dispersion and dilution of wastewater discharges from ConocoPhillips' Barossa facilities. During the highest flow rate conditions (during commissioning) the facility was to discharge 96 m3/day of water at ambient temperature (approximately 25°C). The wastewater was diluted by a factor of 100 within 5 m of the discharge point and was diluted to 1:5,000 within 55 m. Modelling by RPS (2017) of deck and bilge water indicates that upon discharge, the small volumes of hydrocarbons and other chemicals will be diluted by several orders of magnitude within tens of metres from the discharge point.

Cooling water and brine

After discharge into the marine environment, the heated water plume of cooling water discharged will be rapidly dispersed and diluted through diffusion, convection in water, flow of fluids of variable density, evaporation, radiation and convection in the air (IPPC 2001). The temperature drop in the warm water plume principally comes from the mixing and not from atmospheric heat losses at the surface of the water (IPPC 2001).

RPS modelled the dispersion and mixing of a cooling water stream from an offshore oil and gas installation in northern Australia and showed that the plume of water heated to 45 °C and discharged at a flow rate of 288,000 m3/day mixed to within 3 °C of ambient temperature within 12 m of the discharge point (Equinor, 2019). The maximum horizontal distance the plume moved was about 65 m.

Modelling of continuous waste water discharges (including cooling water) undertaken by Woodside for its Torosa South-1 drilling campaign in the Scott Reef complex found that discharge water temperature decreases quickly as it mixes with the receiving waters, with the discharge water temperature being less than 1°C above background levels within 100 m (horizontally) of the discharge point, and will be within background levels within 10 m vertically (Woodside 2008).

Brine (desalination water) will result in water with a higher saline content than seawater being released to sea, it may be mixed with other discharge streams to reduce salinity prior to discharge. Similar to cooling water, the plume of discharged water will be rapidly dispersed and diluted through physical processes in the marine environment. Chemicals may be present in either of these discharges for scale and corrosion management purposes.

Based on the above studies, it is considered reasonable to predict that potential impacts from these types of discharges would also be contained within a 1 km radius of the source and rapidly diluted. Discharges will occur from the MODU at the drilling location, and from vessels both at the drilling location and >1km away from Big Bank itself. The potential receptors within the discharge location are expected to be similar give the environment in the area and the potential impacts restricted to pelagic fauna and water quality.

Impacts to Water Quality

Eutrophication

Discharge of food waste and sewage can cause eutrophication in the surrounding waters resulting in changes to plankton in the immediate area which could subsequently impact on fish and planktonic feeders. In a study of sewage discharge in deep ocean waters, Friligos (1985) reported no appreciable differences in the inorganic nutrient levels between the outfall area and background concentrations suggesting rapid uptake of nutrients and/or rapid dispersion in the surrounding waters. Similar studies (Parnell 2003) concluded similar results with rapid dispersion and dilution within hours of discharge. Nutrients from discharge of sewage are highly unlikely to accumulate or lead to eutrophication due to the highly dispersive environment.

Salinity and Temperature Changes

The desalination of seawater results in a discharge of brine with a slightly elevated salinity (around 10% higher than seawater). On discharge to the sea, the desalination brine, being of greater density than seawater, will sink and disperse in the currents. On average, seawater has a salt concentration of 35,000 ppm. The volume of the discharge is dependent on the requirement for fresh (or potable) water and the number of people on board vessels and the MODU.

Most marine species are able to tolerate short-term fluctuations in salinity in the order of 20–30% (Walker and McComb 1990), and it is expected that most pelagic species would be able to tolerate short-term exposure to the slight increase in salinity caused by the discharged brine. Chemicals discharged within these waste water streams could have toxicological effects on marine fauna in high concentrations, but are expected to be dispersed and diluted rapidly close to the discharge point.

Cooling water will be discharged at a temperature above ambient seawater temperature. Upon discharge, it will be subjected to turbulent mixing and transfer of heat to the surrounding waters. In the sea, the warm water plume is rapidly mixed by currents that prevent any stratification caused by the difference in density between the warm water and cold water; this may be assisted by the rise of the warmer, less dense water from the discharge point.

Given the relatively short duration of the activity, low volume of cooling water and desalination discharges, open water surrounding the MODU and vessels, salinity and temperature impacts on water quality is expected to be low and short-term.

Change in Water Quality Impacts to Marine Fauna

The changes in water quality described above may impact marine mammals, marine reptiles, fish at surface, seabirds and plankton. Given the surface discharges, there is not considered to be potential for significant impacts at the seabed or to the Big Bank shoals.

Plankton may be exposed to thermal shock from the change in water temperature, and mortality from effects of chemicals within the plume of cooling water and brine discharges, this localised effect would persist for the duration of the activity as cooling water and brine is regularly discharged. Mortality of plankton is therefore expected within the discharge plume but is not expected any further than 100m away based on studies discussed above. Larger marine fauna including protected species passing through the area will be likely to actively avoid entrainment within the localised plume of heated and chemically treated water, therefore impacts are expected to be at a behavioural level only in the vicinity of the discharges from vessels and MODU, and return to normal within 100m of the discharge. It is not expected that any chronic or acute effects would be experienced by other marine fauna. Similar responses are expected from discharges of hypersaline water (brine).

The discharges of sewage and food waste are not considered to result in measurable ecological effects given the small potential area of impact and the mixing that will occur upon discharge. The temporary effects on water quality may impact on plankton and result in mortality within <1km of the discharge location, which is not considered to result in a population level impact of plankton given their rapid life cycles. As discussed above, larger marine fauna may be attracted to the sewage and food waste discharges, and therefore a behavioural impact is expected, but toxicological effects are not expected given the low levels of toxicity, rapid dilution and dispersion and temporary nature of the discharges which are treated to meet legislative requirements.

Oily water discharged from vessels and the MODU (vessels will not discharge oily water on Big Bank) could result in turbidity and toxic effects on marine organisms from hydrocarbons and other contaminants. Deck drainage

from rainfall or wash-down operations would discharge to the marine environment. The deck drainage would contain particulate matter and residual chemicals such as cleaning chemicals, oil and grease.

Such small volumes of oil and chemicals will be rapidly eliminated through microbial degradation, evaporation and photo-oxidation. The potential impacts are limited to the drilling operations period. Given the small volumes periodically discharged into the surface waters, only surface biota such as immobile fish embryo, larvae and plankton, and mobile pelagic fish and transient reptiles, cetaceans and seabirds in the immediate vicinity of the discharge point will be exposed. The small volumes and low concentrations of oily water and deck drainage are not expected to induce acute or chronic toxicity impacts to marine fauna through ingestion or absorption through the skin. Water quality is expected to rapidly return to its original state following the cessation of discharges, which are infrequent and intermittent during the activity.

Evaluation		
Consequence	Likelihood	Ranking
2	n/a	2 (Minor)

Summary of control measures	
CM-14	Waste Management Plan compliant with Marine Orders Part 95 – Marine pollution prevention — garbage
CM-11	Oily Water Treatment system compliant with Marine Orders Part 91 – Marine pollution prevention — oil
CM-13a	Sewage treatment system compliant with Marine Orders Part 96 – Marine pollution prevention — sewage
CM-10	Planned maintenance procedure
CM-16	Inductions
CM-15	Chemical Selection Procedure
CM-12	No Oily Water Discharges from vessels on Big Bank
CM13b	No sewerage discharges from vessels on Big Bank
CM-17	Active Deck Drain Management - Closed drain system to prevent deck drainage discharged overboard
CM-4	Benthic Habitat Map based site selection
CM 86A	Adaptive management Framework A for drilling and operational discharges.

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Water Quality	Planned discharges associated with the activity will be small and intermittent, with volumes dependent on a range of variables. Impacts to water quality will be experienced in the discharge mixing zone which will be localised and limited to the top few metres of the water column and will occur only as long as the discharges occur (i.e. no sustained impacts). The buoyant plumes will not affect benthic and epibenthic communities. Currents and mixing within the Operational area and discharge location (for vessels discharging sewage, food waste and oily water) is expected to be strong. As such, recovery of water quality and receptors is expected within hours of the discharges ceasing. However, given the duration of the activity (>35 days per well), and the potential

	area of impact would be within 1 km of the discharge, impacts to water quality were assessed as a Minor: Minor environmental damage. Limited scale less than 1 km. Recovery in weeks to months.
Protected fauna Other fauna	Operational discharges in the same release location may result in temporary water quality perturbations and alteration to marine fauna behaviour. Sensitive receptors that may be impacted include marine mammals, marine turtles, seasnakes, pelagic fish and sharks at surface, plankton and seabirds. The impacts from these discharges within 1km of the discharge location are not expected to result in significant impacts to these fauna. Mortality of planktonic organisms that may be entrained within the discharge "plume" may be expected, but this will not result in impacts at population levels and plankton populations are expected to rapidly recover due to their rapid life cycle of reproduction and recruitment. Other marine fauna potentially affected by the discharges is likely to be at behavioural levels only and therefore temporary and only within <1km of the discharge location and not result in mortality or toxic effects to fauna. The Blue Pygmy whale BIA (distribution) overlaps the Operational area, as a result, individuals may pass through the area during the activity. Similarly, discharges may also cause localised impact to the offshore waters through which marine reptiles may transit. Recent surveys undertaken (GeoOceans 2018) recorded two marine turtles and two sea snakes during the three-day survey comprising 50 towed camera transects. However, discharges will not contact any regionally significant (BIA) feeding, breeding or aggregation areas for marine reptiles, with the closest nesting area for turtles being 355 km away (green turtle nesting area at Cartier Island; and important foraging ground southwest of the permit area. Due to the nature of the discharges and the Operational area being located in the open ocean (high degree of dispersion due to currents and mixing), and temporary (35 days) if discharges were to cause a disturbance to fauna individuals, they would be behavioural minor, localised and temporary in nature (i.e. contact as they transit through the area). Furthermore, the area of potential impact from operational discharges will be contained to within the Operational area or will be at least 1km from Big Bank (selected vessel discharges). This only represents <10% of the total of Big Bank plateau and any sea snakes that might be resident will be able to avoid this area. Fish abundance and diversity in the rubble/turfing macroalgae habitat of the Operational area is low, consisting mainly of smaller species, such as hawkfishes (Heyward et al. 1997, GeoOceans 2018). Impacts to these demersal fish that live within 5 to 10 m of the seabed are not predicted, given operational discharges are expected to remain in the surface waters. Site-attached species would most likely be associated with the reef habitats on the eastern and western ends of Big Bank where the operational discharges are not expected to reach. Pelagic fish may move through the Operational area, but any impacts are expected to be temporary. Plankton communities have a naturally patchy distribution in both space and time (ITOPF 2011). They are known to have naturally high mortality rates (primarily through predation), however in favourable conditions (e.g. supply of nutrients), plankton populations can rapidly increase. Any potential change in phytoplankton or zooplankton abundance and composition is expected to be localised, typically returning to background conditions within tens to a few hundred metres of the discharge location (e.g. Abdellatif 1993; Axelrad et al. 1981; Parnell 2003 all in NERA 2018). Seabirds may be attracted to the discharge location (mainly of sewage or putrescible waste) due to the changes in behaviour elicited by the discharge that may result in additional fish activity at the surface. Seabirds may feed on these fish, and be exposed to the operational discharge. However, any impacts are expected to be slight.

	No decrease in the local population or significant disruption to feeding or breeding cycles is expected from the planned operational discharges given the low volumes, low toxicity and low numbers of fauna that may be present in the Operational area. Planned operational discharges are therefore not expected to significantly impact marine fauna within the receiving environment nor compromise the objectives of Recovery Plans for threatened and migratory marine fauna (see below). Impacts to water quality and marine fauna were assessed as a worst-case consequence of "Slight": Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna; Effects unlikely to be discernible or measurable.
Socio-economic	Any impacts to fish/species targeted by traditional fishers as a result of operational discharges are also only expected to be behavioural and should not impact on fishing. It has been noted that the Big Bank area is transited by traditional fishers on their way to other shoals rather than a primary fishing destination. Given the low toxicity levels of the impacts, the discharges are not expected to continue up the food chain due to the localised nature of the discharge, rapid dispersion and dilution in open waters and limited fishing activity that occurs in the area. No impacts to commercial fish stocks are predicted given the localised nature of the impact. Consultation with Commonwealth Commercial fishing industry representatives has been undertaken and no issues were raised. Consideration of Impacts to socio-economic values were assessed as a worst-case consequence of Slight: Short-term or localised decrease in the availability or quality of a resource, not affecting usage.

ALARP Statement
No alternative to use of a Drilling Rig or OSV. As part of the ALARP assessment additional controls were adopted to reduce potential impacts from operational discharges but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in impact levels, which are already considered to be Minor. Some discharges will occur >1km from Big Bank and others will occur on Big Bank (all at the surface). However, the impacts to fauna at any discharge location do not differ, but by undertaking the precautionary principle, CVN have elected to adopt additional controls to manage discharges on Big Bank to reduce any potential cumulative imapcts where feasible. Containment and transfer is considered viable for drilling discharges given the volumes expected throughout the drilling programme and the ability to easily capture the drilling fluids via RMR. The potential impacts from drilling discharges are considered of a greater nature and scale than those of operational discharges, and also result in impacts to the benthic habitats of Big Bank. Given the buoyancy of the operational discharges and the acceptable level of impact expected, the containment of these wastes is not considered ALARP compared to drilling discharges and described further below this table. The controls implemented are consistent with standard industry practice and the MARPOL standard is internationally accepted and used industry wide. With implementation of the existing management measures it is considered the risk associated with. Operational discharges are reduced to ALARP.

Demonstration of Acceptability
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with operational discharges ACCEPTABLE

DRILLING DISCHARGES

Sources of Impact

To drill the proposed Buffalo East wells, drilling fluids (comprising water and drilling fluid solid additives), and cement will be required. Lost circulation material (LCM) may also be pumped downhole at times. These materials maybe lost to the geological formation, remain downhole, exit the well at the seabed or be contained for deepwater disposal off Big Bank.

Drilled solids (or cuttings) in the form of 'rock' and to a lesser degree hardened cement will be generated during the process. Cuttings will exit the well at the seabed prior to installation of RMR equipment and the Blow-out Preventer package (and riser), or be collected on the drilling rig and transferred to a PSV for a surface discharge at a disposal location off Big Bank.

The cuttings released at the seabed on Big Bank (54.5m3) from the top open hole sections will be be a calcarenite deposit (a category of limestone). This limestone will be composed predominantly of sand sized calcareous grains (predominantly broken up coral skeleton and shells), that are cemented together with a calcareous cement, resulting in a hard ground of limestone.

Both cuttings and WBM will be discharged at the disposal location from the remaining intervals sections of the well.

Provision for the associated bulk discharges of water-based drilling fluids (150 m^3), brine (50 m^3) at the disposal location in the modelling.

Wet cement discharges on Big Bank will be relatively minor and primarily associated with cement unit tank and pipe flushing and cleaning. Venting of dry cement (up to 20 m3) bentonite (up to 34 m^3) and barite (up to 35 m^3) results in particles being suspended in the air and then subsequent settling on the surface of the water, which contributes minor volumes of TSS to the water column.

Environmental Value Potentially Impacted							
Physical Environment					Fauna		Other
Physical Environment (Big Bank)	Marine Sediment	Water Quality	Benthic Habitats	Benthic Infauna	Marine Reptiles	Other demersal fish	Socio-economic

Drilling discharges could impact sensitive environmental receptors through reduction of water quality (increased turbidity, reduced light available for photosynthesis and toxicological effects), smothering (sediment deposition and toxicological effects) and disturbance to marine fauna.

Impacts to water quality and pelagic receptors from increased turbidity

When drilled solids (cuttings), drilling fluids (muds) cement and vented dry bulk products (e.g. bentonite and barite) are discharged to the sea surface, the larger particles and flocculated solids settle quickly to the seabed. The remaining mass of the mud solids consisting of fine-grained, un-flocculated clay-sized particles and a portion of the soluble components of the mud form a suspended plume that drifts with prevailing currents away from the discharge source and is diluted rapidly in the receiving waters (Neff 2005). The increase in suspended sediments in the water column causes a reduction in the penetration of light available for photosynthesising benthic organisms. This reduction in water quality (e.g. increased suspended sediments/turbidity) can also impact on organisms present in the water column, including fish, mammals, marine reptiles and seabirds. For example, in high concentrations, suspended sediments can cause abrasion to soft tissues of marine fauna, such as the gills of fish, or can impair vision and affect foraging, hunting and predator avoidance as a result (Wenger et al. 2017).

Additional impacts associated with disposal of brine are discussed in Section 6.5

Impacts to water quality and pelagic receptors from potential toxicity

The discharge of WBM drilling mud and cuttings at the sea surface has not demonstrated significant toxic effects to water column flora and fauna and is highly unlikely (Neff 2005). Boehm et al. (2001) concluded that drilling fluid chemicals diluted rapidly in the water column, and much of the drilling fluid and cuttings solids settled rapidly to the bottom near the drilling rig site, or disposal location.

Impacts to benthic habitats and associated fauna from sedimentation and smothering

Discharge of borehole materials will occur at the well opening on the seafloor, and at sea surface at the disposal location. When drilled solids (cuttings), drilling fluids (muds) and cement are discharged to the sea surface, the larger particles and flocculated solids settle quickly to the seabed. Impacts to benthic communities from the discharge of these drilling materials can in the following ways:

- Smothering and direct burial;
- Clogging of feeding apparatus (for filter feeding organisms);
- Reduction in photosynthesis from reduced light availability;
- Toxicity; and
- Alteration of the benthic substrate.

Of these, smothering and burial by drill cuttings/sediments is considered to have the greatest impacts to benthic communities (Bakke et al. 2013). However, it is often difficult to disentangle the combined influence of the abovementioned impact-pathways in the field as all may contribute to a reduction in the density, biomass and diversity of benthic communities (Bakke et al. 2013; Ellis et al. 2012).

Direct smothering as a result of the seafloor discharges, including cement is expected to cause mortality of any benthic invertebrates directly under the cuttings and disposal pile (Neff 1981; Petrazzuolo 1981, cited in Currie and Isaacs 2005). Bakke et al. (2013) found that a bottom thickness of >3 mm was known to have lethal effects to infauna, with effects to infauna usually occurring within 100 m to 250 m of the drill site. Recovery of benthic communities from burial occurs by recruitment of new colonists from planktonic larvae and immigration from adjacent undisturbed sediments. This begins shortly after completion of drilling and often is well advanced within six to 12 months, with some communities returning to baseline communities within 12 months from the cessation of drilling (Currie and Isaacs 2005; Manoukian et al. 2010). The most common impacts are changes in benthic community structure and decreased species diversity in close proximity to the discharge location (Bakke et al. 2013). Full recovery occurs once concentrations of biodegradable organic matter decrease through microbial biodegradation to the point where surface layers of sediment are oxygenated.

A reduction in light available for photosynthesising benthic organisms is caused by the scattering of light by particles suspended in the water column, thereby reducing light penetration to the sea floor. The reduction in light and hence photosynthesis, as an impact pathway, is only applicable to photosynthesising organisms in the photic zone, which is nominally <50 m depth in the vicinity of Big Bank, with a general absence of these species below this depth which is expected at the disposal location (Heyward et al. 1997).

Benthic fauna that exist within the discharge plume may be subject to clogging of feeding apparatus from increased suspended particles. Bakke et al. (2013) concluded that such exposure will in most cases be short term, episodic or pulse wise depending on plume behaviour. The effects are often caused by physical stress from the particles and may lead to damage of ciliary structures, gill membranes and digestive gland cells (Cranford et al. 1999; Barlow and Kingston 2001; Bechmann et al. 2006 as cited in Trannum et al. 2010). As such, there is often a loss of suspension-feeding species and an increase in deposit-feeding species and polychaetes close to the discharge location (Ellis et al. 2012). Elevated suspended sediments can also cause clogging of filter feeding apparatus of sponges and sea fans.

Toxicity, identified as a reduction in sediment oxygen concentration, organic enrichment, increased barium and increased heavy metal concentrations from drill cuttings, can alter biogeochemical processes and generate hydrogen sulphide and ammonia (Neff 2002). This can lead to community-level changes in the density, biomass and diversity of infaunal assemblages (see reviews by Ellis et al. 2012 and Cordes et al. 2016). In general, the acute toxicity of WBM drilling discharges is low (Neff 1987, as cited in Bakke et al. 2013), with a number of studies

finding no in situ effects of WBM cuttings on sediment macrofauna community structure (see review in Bakke et al. 2013).

A vast amount of literature has documented changes benthic communities due to alterations of the sediment particle size distribution (PSD) and subsequent substrate. The altered PSD reflects both the the grain size and texture of the settled particles from drill cuttings, overlying the undisturbed sediments beneath. Of those effects observed, there is often an increase in opportunistic species and a reduction in overall species diversity (Ellis et al. 2012).

Recovery is dependent on the type of community affected; the physical structure; and persistence of the cuttings pile itself; the presence and nature of any toxic components within the cuttings; and the availability of colonising organisms.

Benthic habitats in the Operational Area on Big Bank that may be affected by drill cuttings and cement are expected to be low sensitivity rubble and Halimeda habitats and regularly exposed to turbid conditions.

The benthic habitats at the disposal location (soft sediment communities) are to likely to be dominated by infaunal communities. These comprise a large number of individual species, with varying tolerances and sensitivities to the disposal of drill cuttings (Rogers 1999; Currie and Isaacs 2005).

Traits such as mobility, feeding mode, morphology and reproductive strategy contribute to the net vulnerability of a particular species to a sedimentation event (Essink 1999). Mobile invertebrates are generally less vulnerable than sessile taxa to sedimentation, as they are able to move to areas with less sediment accumulation or by more efficiently physically removing particles (Fraser et al. 2017). Sessile invertebrates may be particularly vulnerable to sedimentation because they are generally unable to reorientate themselves to mitigate a build-up of particulates. Some sessile taxa, including species of sponges and bivalves, have the capacity to filter or physically remove particles, however this can be metabolically costly and unsustainable (Fraser et al. 2017). The impact of sedimentation on sessile invertebrates depends on a range of additional factors, including the duration of exposure and proximity to disposal location. Morphology plays a critical role since upright morphologies are generally more resistant to burial than encrusting forms (Fraser et al. 2017).

Diet and feeding mode are also important in contributing to species sensitivity to sedimentation and light attenuation, especially in sessile species. Sedimentation can be detrimental for suspension feeding organisms since suspended particles can be mistaken for food (Bell et al. 2015). In addition, the mechanical or abrasive action of suspended sediments may be harmful to suspension feeders, clogging their feeding apparatus and impairing respiratory and excretory function (Sherk 1972). Reproductive strategy and recruitment can also influence tolerance to such impacts, whether it be the number of reproductive episodes (singular or multiple), brooding species versus those with planktonic larval phases (Fraser et al. 2017).

Sensitivity of pelagic fish and other fauna

Pelagic fish are known to have markedly different tolerances to suspended sediment (Wenger et al. 2017). Elevated suspended sediments can impair vision and subsequently affect foraging, hunting and predator avoidance (Wenger et al. 2017). High levels of TSS can also lead to abrasion of soft tissues of some pelagic species (e.g. fish gills; Wenger et al. 2017) and can also cause clogging of filter feeding apparatus of sponges and sea fans. However, transient pelagic species (including marine reptiles and cetaceans) that are present in the vicinity of Big Bank are likely to experience a range of environmental conditions, some of which may be regularly exposed to turbid conditions. Being mobile, these fauna are able to move to clearer waters and therefore avoid more turbid waters, should they choose to do so.

Evaluation		
Consequence	Likelihood	Ranking
3	n/a	3 (Moderate)

Summary of control measures

CM-15	Chemical selection procedure
CM-18	Inventory control procedure
CM-19	Chemical inventory management plan
CM-22	Solid control equipment
CM-21	No SBM drilling fluids
CM-20	Drilling discharge modelling
CM-43	Discharge disposal location
CM-84	No bulk discharges
CM-84	No bulk discharges
CM-84	No bulk discharges
CM-85	RMR transfer procedure
CM-86	Adaptive Management Framework
CM89	RMR for drilling wells (3).
CM43	Disposal of cuttings at disposal lcoation

An Adaptive Monitoring Framework was also adopted to monitor and manage potential impacts and any uncertainty around drill cutting modelling and predicted impacts.

Summary of Potential Impacts to Environmental Values(s) (with accepted control measures in place)	
Receptor	Impact Assessment
Water quality	There are no expected increases in TSS above thresholds on Big Bank as a result of drill cuttings disposal or venting of barite and bentonite associated with the selected Scenario 4. Any elevations in drilling-generated TSS (below the 1 mg/L threshold) would be predicted to occur over very short timeframes (i.e. hours, not days) (GHD 2018). As such, impacts to benthic habitats from increased turbidity are not expected, as the most common benthic habitat is rubble and algae (Halimeda). Halimeda is considered tolerant to higher levels of suspended sediment and have a noted tolerance to lower light levels (Hillis-Colinvaux 1986, cited in Fraser et al. 2017), making it more resistant to the increases in turbidity than other genera with higher light requirements (Fraser et al. 2017). Disposal of cuttings and residual drilling WBM and fluids at the disposal location may cause an increase in turbidity (>1 mg/L) up to 4.6 km from the disposal location. Although the background levels of turbidity in the Operational area and disposal location are likely to be low (~0.2 NTU), the shoals and banks in the region experience natural, episodic elevations of turbidity during storm events, that far exceed the concentrations of TSS generated from drilling activities. Although such events are shorter in duration, their intensity is much greater and could persist for an equivalent amount of time in the case that several storms were to pass in quick succession. The species that occur in these environments, including protected fish, turtles and marine reptiles are likely to be resilient to these turbidity increases (Heyward et al. 2017). As such, impacts to water quality on Big Bank and were considered Slight with effects unlikely to be discernible or measurable. Changes in TSS (and associated impacts to water quality) at the disposal location although also likely to be temporary and episodic – they are expected cover a greater

	spatial scale due to the volume of cuttings discharge, and as such were assessed as Minor with minor environmental damage. Recovery in weeks to months. Short-term or localised decrease in the availability or quality of a resource, likely to be noticed by users.
Benthic Habitat	Direct smothering/burial as a result of the open hole discharges, including cement, on Big Bank is expected to cause mortality of benthic communities (algae, sponges, infauna and epifauna) directly under the cuttings pile. The dispersed cuttings will result in increased sedimentation (>10 mg/m^2/day). The modelling results for Buffalo found this could be expected within 300 m of the drilling location, and up to 850m of soft sediment communities at the disposal location. Bakke et al. (2013) found that a bottom thickness of >3 mm was known to have lethal effects to infauna. The modelling results for the selected option found this was not exceeded around the drilling location, and extended approx. 300m at the disposal location. Big Bank Impacts The predicted area of impact from sedimentation and cement is consistent with both Bakke et al. (2013) and Ellis et al. (2012), who found alterations to benthic community structure are almost always observed within 300 m of the drill site. The area surrounding the well is largely low density turfing macro algae and Halimeda, only sparsely populated by epifauna, typical of 90% of the Big Bank plateau. The open hole cuttings (54 m3) will not contain any WBM and will be be a calcarenite deposit (a category of limestone). This limestone will be composed predominantly of sand sized calcareous grains (predominantly broken up coral skeleton and shells), that are cemented together with a calcareous cement, resulting in a hard ground of limestone. Low levels of sedimentation, are unlikely to inhibit algal growth (Fraser et al. 2017). Experimental simulation of increased sedimentation in the Caribbean also found no changes to Halimeda populations, which resisted the 'burial treatment' (Cruz-Palacios and Tussenbroek 2005), indicating their resilience to such disturbance from sedimentation. The thresholds are also notably conservative, particularly if comparing to INPEX's Environmental Monitoring Program tolerance limits of 15 mm sedimentation (bottom thickness) for coral, filter feeders and macroalgae (INPEX 2012), or the Great Barrier Reef Guideline Sedimentation trigger value of 30 mg/cm2/day (GBRMAP 2010) (which is for much more sensitive coral species). The previous ROV survey conducted in 2001 (Nexen 2003), reported drill cuttings beneath the previous well head platform had raised the seabed one metre above the pre-existing level and that the cutting substrate was devoid of epi-benthos. However, in the most recent survey by GeoOceans (2018), there was no obvious sign of these piles of cuttings piles and macroalgae had colonised the gravel and rubble substrates beneath (GeoOceans 2018). A similar recovery would be expected from the proposed activity. The presence of 'sand waves/ripples' in the area during previous surveys (Heyward et al. 1997), indicates a benthic environment subject to periods of strong wave energy. It is likely that the benthic infauna and epifauna that inhabit these areas on Big Bank are those that tolerate episodic disturbance or are able to rapidly recolonise after periods of high sedimentation and turbidity associated with wave action. Halimeda, in particular, is not only tolerant to disturbance to some extent but it's ability to successfully propagate through vegetative cloning, combined with fast growth rates and low predation rates allows it to rapidly recolonise following disturbance. Williams (1988) found that Halimeda beds recovered to their pre-disturbance abundance within six months of the passing of a destructive cyclonic storm. Halimeda plants that had been buried in sediment from the storm event were observed to regenerate upright thalli within one month from the disturbance (Williams 1988). Fragments broken off from

	one individual by storms, waves or fauna can develop into individual plants under favourable conditions (Heyward et al. 1997). This is consistent with the results from a comparable study by IRCE (2003) in shallow waters (<10 m deep), where the physical impacts at seabed associated with drilling fluid discharge were manifested in a change in composition of in-faunal species and/or abundance in close proximity to the drilling location (i.e. within tens of metres), however, recovery occurred within six months and cuttings mounds were no longer visible (IRCE 2003). Impacts to Habitat D would only represent <0.01% of Big Bank and likely be temporary and recoverable within weeks to months following cessation of discharges. However, due to the uncertainty associated with potential cumulative impacts (for an additional two wells), and paucity of specific research on drilling impacts, Carnarvon have applied the Precautionary Principle and have increased the risk ranking from Minor to Moderate on Big Bank. This is consistent with the pre-defined level of Acceptability. Impacts from sedimentation are not predicted to occur within the filter feeder or coral habitats of Big Bank. In the event of all three wells being drilled, or as a result of other cumulative impacts, there is a possibility of a longer recovery time (months to years) (Section 6.8 - Cumulative impacts). However, this will be monitored (Monitoring Framework, Section 6.6.7; Appendix F) Disposal Location Impacts to the sparsely inhabited benthos in the deeper waters of the disposal location are expected to cause mortality to some of the benthic infauna and epifauna in this area (Section 6.6.1). The habitats in the deep water disposal location do not contain photosynthesising benthic primary producers due to the absence of light at these depths (300 m). As such, impacts from drill cuttings at this location are expected from potential clogging of filter feeding apparatus and abrasion of soft tissues, rather than the reduction in light. The area impacted by increased sedimentation (>3mm) is likely to be very localised at these depths (approx. 300 m) due to the dissipation of particles throughout the water column. The habitats in the deep water location contain very sparse sponge and invertebrate communities (see Section 3.3.3) that may tolerate these levels of sedimentation. While some species may be tolerant of increased sedimentation, impact via burial is expected to some extent. Recovery of benthic communities from burial occurs by recruitment of new colonists from planktonic larvae and immigration from adjacent undisturbed sediments. This tends to commence shortly after completion of drilling/disposal and often is well advanced within six to 12 months. Rapid recolonisation of benthic infauna within the deposited layer at both locations is expected, given the low-to-no toxicity of the material and the ability of these organisms to recolonise. Epifauna and flora associated with the sediment would also be likely to recolonise within weeks to months. Full recovery may not occur until concentrations of biodegradable organic matter decrease through microbial biodegradation to the point where surface layers of sediment are oxygenated. From this, impacts to benthic habitat at the disposal location were considered Minor; minor environmental damage. Recovery in weeks to months. Short-term or localised decrease in the availability or quality of a resource, likely to be noticed by users.
Protected Fauna	Marine Fauna Elevated suspended sediments can impair vision and affect foraging, hunting and predator avoidance as a result (Wenger et al. 2017). High levels of TSS can also lead to abrasion of soft tissues of some pelagic species (e.g. fish gills; Wenger et al. 2017) and can also cause clogging of filter feeding apparatus of sponges and sea fans. However,

	the 1 mg/L threshold defined for hard corals is unlikely to impact physiologically on these marine fauna who are likely to be regularly exposed to turbid conditions. For example, fish, who have markedly different tolerances to suspended sediment, can experience mortality starting at 25 mg/L, while other species are able to withstand concentrations up to 28,000 mg/L (Wenger et al. 2017). Highly transient marine reptiles and cetaceans that may temporarily forage at Big Bank are likely to be unaffected by a 1 mg/L increase in turbidity. These species regularly inhabit the naturally turbid inshore waters of the northwest and northern regions, such as the Kimberley, Joseph Bonaparte Gulf, Darwin coast, Cobourg Peninsular and Gulf of Carpenteria. Turbidity in these macrotidal inshore environments can reach up to 145 NTU during extreme weather events and values exceeding 100 NTU are not uncommon near the seafloor in Darwin Harbour during the wet season (INPEX 2010). A review by Todd et al. (2015) summarised that effects of increased turbidity are often localised with minimal direct impact on marine mammals that inhabit naturally turbid environments. In well-mixed ocean waters, drilling muds and cuttings are diluted by 100-fold within 10 m of the discharge and by 1000-fold after a transport time of about 10 minutes at a distance of about 100 m. As the chemicals selected for use in drilling operations are highly rated (CHARM Gold/Silver or OCNS E/D) or alternatively are risk assessed as environmentally acceptable, their environmental impact to water quality in terms of toxicology, will be insignificant. They are not considered to be toxic to marine fauna or benthic habitats. However, changes in water quality may potentially cause temporary behavioural changes. The sensitive receptors on or adjacent to Big Bank or the disposal location that may show avoidance behaviour due to drilling discharges influencing water quality include pelagic fish, marine turtles, sea snakes, mammals and seabirds. Avoidance behaviour is likely to be temporary, with affected individuals likely to relocate to more preferable areas. The Blue Pygmy whale BIA (distribution) overlaps the Operational area and disposal location, as a result, individuals may pass through the area during the activity. However, due to the nature of WBM discharges and the location being located in the open ocean (high degree of dispersion due to currents and mixing), and temporary (with turbidity levels above 1 mg/L only occurring for a few hours at a time, for a few days (GHD 2018), if discharges were to cause a disturbance to fauna individuals they would be behavioural minor, localised and temporary in nature (i.e. contact as they transit through the area). Turbidity increases may also cause localised impact to the waters through which marine reptiles may transit. Sightings of marine reptiles (two turtles and two sea snakes) were also recorded in the survey by GeoOceans (2018), and are expected to forage on Big Bank. However, the Operational area and disposal location do not intersect any Habitat Critical for the Survival of marine turtles, with the closest nesting area being 355 km away (green turtle nesting area at Cartier Island; and important foraging ground south west of the permit area) Any loss of potential habitat for marine turtles is Slight, and species are likely to forage at nearby shoals that provide similar habitat/foraging areas to that of Big Bank. The area of potential impact from drill cuttings will be contained to within the Operational area and disposal location. The Operational area represents <7% of the total of Big Bank plateau and any protected marine fauna including fish, cetaceans or reptiles that might be resident will be able to avoid this area if they choose to for the duration of the disturbance. The area of impact adjacent to the disposal location is very small (<1%) in comparison to the remaining deepwater belagic habitats regionally (Section 3.3.3). From this, impacts to protected fauna were considered Slight, with recovery in days to weeks; potential disturbance/ injury to habitat/ fauna, effects unlikely to be discernible

	or measurable. This is consistent with the pre defined level of Acceptability (no significant impact as per MNES Guidelines.
Other Fauna	Fish abundance and diversity in the rubble/turfing macroalgae habitat of the potential area of impact is low, consisting mainly of smaller species, such as hawkfishes (Heyward et al. 1997, GeoOceans 2018;. Impacts to these demersal fish that live within 5 to 10 m of the seabed are not predicted, given the fish are mobile and the EMBA from Scenario 4b on Big Bank is small. Site-attached species would most likely be associated with the reef habitats on the eastern and western ends of Big Bank, where the drilling discharges are not expected to reach. Changes in water quality may result in behavioural effects to sharks, fish and rays in close proximity to the drilling location, with recovery measured within hours to days. Plankton communities have a naturally patchy distribution in both space and time (ITOPF 2011). They are known to have naturally high mortality rates (primarily through predation), however in favourable conditions (e.g. supply of nutrients), plankton populations can rapidly increase. Any potential change in phytoplankton or zooplankton abundance and composition as a result of increased turbidity from drilling discharges is expected to be localised, typically returning to background conditions within tens to a few hundred metres of the discharge location (Neff 2005). No decrease in the local population or significant disruption to feeding or breeding cycles is expected from the planned drilling discharges given the relatively small area affected, low toxicity drilling materials and low numbers of fauna that may be present in the Operational area and disposal location. From this, impacts to other fauna were considered Minor.
Socio-economic	No visual amenity impacts are expected. Any impacts to fish targeted by traditional fishers are also only expected to be behavioural and should not impact on fishing. It has been noted that the Big Bank area is transited by traditional fishers on their way to other shoals rather than a primary fishing destination. The opportunity to comment on the acceptability of impacts from drilling was encouraged through the distribution of an information sheet. This information sheet noted that drilling would be undertaken in an area dominated by 'macro-algae and rubble' and what minimal management measures would be implemented to mitigate impacts. The following Commonwealth government agencies were targeted by email in July 2018: • Department of Industry, Innovation and Science; • Department of Agriculture and Water Resources; • Minister for Environment & Energy; • Australian Fisheries Management Authority (AFMA); • Parks Australia - Australia Marine Parks; and • Australian Border Force (formerly Australian Customs and Border Protection Service). Given the location of the Activity in Commonwealth waters it would be anticipated if there were any concerns it would be these agencies that would respond. No concerns were raised by any of the above organisations with regard to the potential impact of drilling. Impacts to social values were considered Slight – not likely to be discernible or measurable.
Commonwealth Marine Environment	Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. Carnarvon consider all of these factors when determining whether an activity is likely to have a

	significant impact on matters of national environmental significance. Using the Matters of National Environmental Significance – Significant impact guidelines 1.1 (CoA 2013). The activity does not contravene the MNES significant impact guideline criteria for; • Critically endangered and vulnerable species; • Migratory species; and • Commonwealth marine environment. As such the activity is considered 'non- significant impact' and acceptable
ALARP summary	
An extensive list of possible controls were considered for the ALARP assessment (see above). A significant number of additional controls above standard practice were adopted to reduce potential impacts to Big Bank (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls the additional effort would not result in significant reductions in risk levels. With implementation of the existing management measures, it is considered the risk associated with drilling discharges are reduced to ALARP.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with drilling discharges ACCEPTABLE.	

NOISE EMISSIONS

Potential sources of impact

During the Activity, underwater noise will be generated during MODU positioning, vessel movements, drilling activities and during VSP. Noise emissions will be temporary and intermittent, as drilling noise will be emitted at various levels for the duration of the activity and VSP noise will be generated in typically 18 hours per well.

Vessels

The vessels will emit noise from propeller cavitation, thrusters, hydrodynamic flow around the hull, and operation of machinery and equipment.

Typically, marine vessels produce low frequency sound (i.e. below 1 kHz) from the operation of machinery on-board; from hydrodynamic flow noise around the hull; and from propeller cavitation, which is typically the dominant source of noise (Ross 1987; 1993 in Skjoldal et al. 2009). Most sounds associated with vessels are broadband, though tones are also associated with the harmonics of the propeller blades (Ross 1987; 1993 in Skjoldal et al. 2009). Usually, the larger the vessel, or the faster a vessel moves, it results in more noise (Richardson et al. 1995). Large commercial vessels (containerships, bulk carriers, vehicle carriers, cargo ships, and tankers) operating at normal operating speeds, can result in noise levels ranging between 177 and 188 dB re 1 µPa m (McKenna et al. 2012).

McCauley et al. (1998) examined the noise from a 64 m, 2,600 tonne rig tender vessel underway. When using bow thrusters and main propellers for holding position in strong currents, maximum noise reached 137 dB re 1µPa at 405 m with levels of 120 dB re 1µPa recorded at 3-4 km. However, when underway, the 120 dB re 1µPa contour ranged from only 250 m -1 km from the vessels.

Recent noise monitoring undertaken in Vancouver indicate that vessels slowing down from 18 knots to 11 knots results in an actual measured level drop of 12.5dB (Vancouver Fraser Port Authority, 2018). Depending on the vessel, source levels can range from less than 160 dB (trawlers) to over 200 dB re 1µPa @1m (super-tankers) (Simmonds et al. 2004).

Sound levels from vessel engines are expected to be higher than those emitted from equipment or machinery on the vessels.

Helicopters

Strong underwater sounds are detectable for only brief periods when a helicopter is directly overhead (Richardson et al. 1995). Sound emitted from helicopter operations is typically below 500 Hz and sound pressure in the water directly below a helicopter is greatest at the sea surface but diminishes quickly with depth. Reports for a Bell 214 (regarded to be one of the noisiest), indicated that noise is audible in the air for four minutes before the helicopter passed over underwater hydrophones. The helicopter was audible underwater for only 38s at 3 m depth and 11s at 8 m depth (Greene 1985a; cited in Richardson et al. 1995). Noise levels reported for Bell 212 helicopter during fly-over is 162 dB re 1µPa and for Sikorsky-61 is 108 dB re 1µPa at 305 m (Simmonds et al. 2004).

Drilling

The MODU will generate noise from the operation of onboard machinery, including diesel engines, mud pump, ventilation fans (and associated exhaust) and electrical generators, and also (during drilling) from the drill string and bit and the use of RMR equipment. Jack-up drill rigs have been measured to produce noise between 0.005 and 1.2 kHz frequencies with a source level of 59 dB re 1 µPa @ 1 m (WDCS 2004); noting that the key source of sound originates from generators and equipment above the water level on the rig. This is considered to present a very low risk of impacts.

McCauley (1998) reported highest underwater noise levels generated by a semi- submersible rig occurred during drilling, reaching around 115-117 dB re 1µPa at distances of 405 m and 125 m respectively. Studies undertaken in the Arctic on different MODU types (semi-submersible, drill ships) indicate that noise levels dropped to 117dB

re 1µPa within 1km of the MODU and are much lower than those for large commercial vessels operating at normal speeds (Austin et al. 2018).

Typically sound sources from drilling activities produce low intensity but continuous sound. However, these noises will contribute to and can exceed ambient noise levels which range from around 90 dB re 1µPa under very calm, low wind conditions, to 120 dB re 1µPa under windy conditions (McCauley 2004). Ambient noise covers the whole acoustic spectrum from below 1Hz to well over 100kHz (Harland et al. 2005) and is commonly defined as background acoustic noise without distinguishable sources (e.g. Wenz 1962; Urick 1983). Sources of this noise commonly includes wind- and wave-driven turbulence, hydrodynamic noise associated with variable tidal flow conditions and rainfall.

Noise emissions generated during RMR activities will be from the machinery on board the MODU. The pump on the seabed is not expected to produce a high level of noise than that generated by the action of drilling.

VSP

Hydrocarbon bearing formations identified during drilling may be evaluated using wireline logging tools and VSP. If this is the case, VSP will be carried out using geophones (receivers) positioned at different levels inside the wellbore and a seismic source near the ocean surface. The seismic source is typically a 3 x 250 cubic inch air gun configuration deployed approximately 5 m below the water surface from the MODU, or potentially a support vessel. In addition to tying well data to seismic data, the VSP also enables the conversion of seismic data to zero-phase data and distinguishes primary reflections from multiples. VSP typically takes in the region of 12 to 18 hours, with approximately 130 shots in total, and is undertaken at the completion of drilling.

VSP generates higher intensity noise than routine drilling operations, with peak output in the order of 195 dB re 1µPa @ 1 m. Modelling of VSP undertaken by Chevron Australia and reported in Chevron (2010) using 3 x 250 cubic inch air guns at a source depth of 5 m recorded an amplitude spectrum peak of 190 dB re 1uPa @ 1m from the source. The results reported demonstrate that the received source level does not exceed 160 dB re 1µPa2.s at a distance of 500 m from the source and 170 dB re 1µPa2.s at 100 m from the source.

Environmental Value Potentially Impacted					
Fauna					Other
Protected Species - BIA	Marine Mammals	Marine Reptiles	Sharks, Fish and Rays	Marine Birds	Socio-economic

Marine mammals

Sound levels sufficient to cause physical injury (defined as the onset of permanent threshold shift, PTS) and sub-lethal responses (such as temporary threshold shift, TTS) have been the subject of many studies. Southall et al. (2007), Finneran and Jenkins (2012) Wood et al. (2012), Finneran (2015) and more recently NMFS (2013, 2018) reviewed available literature to determine noise exposure criteria, determined based on the onset levels of non-recoverable permanent hearing loss (PTS) and temporary hearing threshold shift (TTS) in cetaceans. The NMFS (2018) criteria incorporate the best available science to inform assessment of PTS and TTS. Thresholds for PTS (for impulsive sounds) are between 202 and 230dB (depending on the cetaceans), and thresholds for TTS are between 196 and 224dB. Behavioural responses are typically expected at 160dB (NMFS, 2018).

Scientific literature suggests that impacts from noise and vibrations have the potential to cause behavioural and physiological damage, such as hearing loss to marine mammals (cetaceans). The consequence of such an impact to individuals is much lower than if it were to affect an entire population. However, it is more likely that an individual would be impacted as opposed to an entire population as the Project area does not intersect any known migratory pathways.

A recovery plan for blue, fin and sei whales was developed for the period 2005 to 2010. Subsequently, the Conservation Management Plan (Recovery Plan) for the Blue Whale (B. musculus) (DoE 2015) was developed which identifies key anthropogenic threats that may inhibit the recovery of the blue whale populations in Australian waters, including noise interference. Under the Conservation Management Plan (Recovery Plan)

shipping noise is considered a moderate risk to blue whales, and aircraft noise is considered a moderate risk to pygmy blue whales (DoE 2015). The management plan lists assessing and addressing anthropogenic noise as an action area, highlighting the following areas relevant to the Activity for improved management and understanding of this risk:

- Assessing the effect of anthropogenic noise on blue whale behaviour; and
- Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area.

An approved Conservation Advice for Megaptera novaeangliae (humpback whale) (2015) outlines noise interference, including shipping noise, as a threat. Advice regarding assessing and addressing anthropogenic noise is that, should acoustic impacts on humpback calving, resting, foraging areas, or confined migratory pathways be identified, a noise management plan should be developed. The migration pathway does not overlap the Operational area. Control measures suggested in the advice are assessed below.

Marine Reptiles

Recent surveys undertaken (GeoOceans 2018) recorded sightings of two marine turtles and two sea snakes during the three-day survey comprising 50 towed camera transects at Big Bank. Although these species could not be identified, it can be assumed that turtles and sea snakes may be present during the planned activity, although in very low numbers.

Turtles are sensitive to low frequency sounds with a range between 100-700 Hz. The noise produced from the drilling rig (low-level, low frequency tones), and accompanying support vessels is in the same order of magnitude of noise produced by commercial shipping and as such, is not expected to cause significant disturbance to conservation significant fauna populations. Seasnakes may also be affected, as they are generally associated with reef systems.

Caged green and loggerhead sea turtles increased their swimming activity in response to an approaching airgun when the received SPL was above 166 dB re 1 µPa, and they behaved erratically when the received SPL was approximately 175 dB re 1 µPa (McCauley et al. 2000). Though mortality or potential mortality impacts to turtles from seismic noise exposure has not been reported Popper et al. (2014) provides exposure guidelines of >207 dB PK or >210 dB SELcum.

Based on the limited data regarding noise levels that illicit a behavioural response in turtles, the lower level of 166 dB re 1 µPa level drawn from NSF (2011) is typically applied, both in Australia and by NMFS, as the threshold level at which behavioural disturbance could occur. No studies have been conducted on sea snakes, therefore the thresholds adopted for turtles are also adopted for sea snakes.

The Recovery Plan for Marine Turtles in Australia: 2017-2027 (DoEE 2017) highlights noise interference from anthropogenic activities as a threat to marine turtles. The plan refers to vessel noise and the operation of some oil and gas infrastructure as sources of chronic (continuous) noise in the marine environment, exposure of which may lead to avoidance of important turtle habitat.

There is no significant turtle habitat (BIA) within the Operational area. The closest significant foraging grounds are south-east of the Operational area.

Sharks, Fish and Rays

No known key feeding/ breeding areas occur within the Big Bank, however fish will likely transit the area. Surveys undertaken on the areas of the Big Bank shoals (Heyward et al. 1997; GeoOceans 2018) identified a diversity of small tropical reef fish that are considered site attached (i.e. will be unlikely to transit away from the area), however these were associated with the hard coral habitat at the western and eastern edges of the plateau, and the deeper water filter feeder habitats. Fish diversity was confirmed to be low over the unconsolidated macroalgae-dominated habitats that cover much of the Big Bank plateau, but it is assumed that sharks, fish and rays may transit through the area. One area of filter feeders was identified ~1 km from the proposed Buffalo WHP (GeoOceans 2018).

Although hearing ranges and sensitivities vary substantially between species (e.g. Ladich and Fay 2013), all fish species tested to date can hear (Dale et al. 2015). Sensitivity to sound pressure seems to be functionally correlated in fishes to the presence and absence of gas-filled chambers in the sound transduction system. These enable fishes to detect sound pressure and extend their hearing abilities to lower sound levels and higher frequencies (Ladich and Popper 2004; Braun and Grande 2008). Based on their morphology, Popper et al. (2014) classified fishes into three animal groups comprising:

- Fishes with swim bladders whose hearing does not involve the swim bladder or other gas volumes;
- Fishes whose hearing does involve a swim bladder or other gas volume; and
- Fishes without a swim bladder that can sink and settle on the substrate when inactive.

Thresholds for PTS and recoverable injury are between 207 dB PK and 213 dB PK (depending on the presence or absence of a swim bladder), and the threshold for TTS is 186 dB SELcum (Popper et al. 2014). Given there is no exposure criteria for sharks, the same criteria are adopted, though typically sharks do not possess a swim bladder.

The levels of noise generated by vessels, MODU, machinery and drilling equipment varies but studies undertaken show that these levels are well below those that can cause injury (as described above). Studies on fish exposed to continuous level of noise indicate that fish do not show an acute stress response even though they were exposed to more than twice the duration of intermittent noise during trials (levels of >137 dB re 1 µPa (Nichols et al, 2015), perhaps due to the relative unpredictability of more intermittent noise. Further studies showed that some fish behaviour will change immediately upon being exposed to boat noise (e.g. decrease in distance moved from site), but that behaviour returned to a pre-exposure manner after twenty minutes of continuous exposure (Holmes et al. 2017). Given the continuous noise form machinery, vessels and drilling during the activity, it is considered unlikely that this persistent level of noise, which is below levels that can cause temporary or permanent injury, will result in significant disturbance to fish, particularly given these experiments played the noise in close proximity to the fish rather than at distance which is the situation with this activity given the hard coral habitat is >4 km from the drilling location.

Strong 'startle' responses have been observed in some fish species at received sound levels of 200-205 dB re 1 µPa, indicating that sounds at or above this level may cause more severe behavioural reaction such as avoidance. The most recent relevant study on how the behaviour of fishes exposed to seismic signals changed (at higher source levels than the proposed activity) is the Woodside's Maxima 3D survey at Scott Reef (Woodside 2012a, 2012b; Miller and Cripps 2013). The behavioural observations of free-swimming fish conducted in these studies show that seismic airgun emissions did not cause lethal or sub-lethal effects on fish near the operating array. The findings from research at Scott Reef support those by Wardle et al. (2001), who exposed free ranging marine fish inhabiting an inshore reef to sounds from a seismic source (195-218 dB re 1 µPa PK). The study found that fishes exhibited a startle response to all received levels, but no avoidance behaviour were observed, they showed no signs of moving away from the reef and exposure to the seismic noise did not interrupt a diurnal rhythm of fish gathering at dusk. These observations are relevant to VSP operations only given the level of noise that is likely to be emitted during VSP operations.

Plankton

Noise-induced effects on zooplankton, such as copepods, cladocerans, chaetognaths and euphausiids, have been investigated in a number of sound exposure experiments. Parry et al. (2002) studied the abundance of plankton after exposure to airgun sounds but found no evidence of mortality or changes in catch-rate on a population-level. However, noise exposure guidelines have been published for eggs and larvae (Popper et al. 2014), which are based on pile driving. Mortality could be expected at received levels of >210 dB SELcum or >207 dB PK. This is the same exposure level adopted for fish and sharks. However, it has become industry practice to apply the more recent results from McCauley et al. (2017) of 178 dB re 1 µPa PK-PK but this is based on seismic surveys rather than short duration VSP activities.

Birds

There is the potential for behavioural disturbance to migratory birds. However, noise levels from drilling activities will be below levels where significant disturbance to fauna are expected (Richardson et al. 1995).

It is highly unlikely that noise associated with the activity will impact populations/ communities of birds. Given the remote offshore location of the Operational area, it is more likely that an individual would be impacted as opposed to an entire population as the Project area does not intersect any known migratory pathways and is not in the vicinity of key nesting sites.

Social Impacts

Impacts to fish may result in indirect impacts to fisheries in the Operational area. Commercial fish species spawning biomass and breeding stock are at sustainable levels thus recruitment and recovery would be not be impeded by noise emissions. The only fishery that may be active in the area is the NWSTF, although there is no current effort in the Operational area and therefore no impacts are expected. Indonesian/Timorese indigenous fishing occurs in the vicinity of Sahul Bank and Echo Shoals and boats may pass through the Operational area to reach these fishing grounds. Given the low numbers of large fish observed in recent surveys (GeoOceans 2018), it is unlikely that fishing activity will be affected by fish potentially moving away from the area during the activity due to behavioural disturbance.

Evaluation		
Consequence	Likelihood	Ranking
2	n/a	2 (Minor)

Summary of control measures	
CM-23	VSP Procedure
CM-24	Trained and competent crew
CM-16	Inductions
CM-10	Planned Maintenance Procedure

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
	Noise emitted by vessels, helicopters and during drilling and VSP during the activity will be short in duration (~35 days for vessels, helicopter presence per well and VSP use will be considerably less) and is likely to be reduced to background levels within kilometres to tens of kilometres.
Marine Mammals	Scientific literature on impacts from noise/vibrations on marine mammals indicates that there is potential for a change in fauna behaviour/ movement. Noise levels within the 120 to 160 dB re 1µPa range may cause avoidance or other behavioural effects to cetaceans. Impacts to cetaceans are not considered significant as: MODU noise emissions that are expected are below the thresholds for behavioural impacts, PTS and TTS; Vessel noise is expected to be below the thresholds for behavioural impacts, PTS and TTS given the typical size vessels used during the activity and the slow vessel speeds within the operational area; Helicopter noise will be intermittent during the activity, and below the thresholds for PTS and TTS. Behavioural responses may be elicited and have been noted previously: Reactions of cetaceans to circling aircraft (fixed wing or helicopter) are sometimes conspicuous if the aircraft is below an altitude of 300 m, uncommon at 460 m and generally undetectable at 600 m (NMFS, 2001). Helicopters will only be below these

	levels during landing and take-off which will occur infrequently during the activity and elicit behavioural responses only. Baleen whales sometimes dive or turn away during over-flights, but sensitivity seems to vary depending on the activity of the animals. The effects on cetaceans seem transient, and occasional over-flights probably have no long-term consequences on cetaceans. Observations by Richardson and Malme (1993) indicate that, for bowhead whales, most individuals are unlikely to react significantly to occasional single-pass low-flying helicopters transporting personnel and equipment at altitudes above 150 m. McCauley et al. (2004) noted that the noise profile associated with normal drilling operations (MODU and vessel) might induce a behavioural response in cetaceans, for on average 5 minutes for each event, for a cumulative total of around 10 hrs during a 30 day drilling program. Leatherwood et al. (1982) observed that minke whales responded to helicopters at an altitude of 230 m by changing course or slowly diving. VSP operations conducted over a period of up to 18 hours will result in the thresholds for PTS, TTS and behavioural impacts being exceeded. However, the received levels will decline rapidly from the source and be below thresholds for PTS and TTS within 500 m of the source. Behavioural impacts are expected during VSP activities; and The use of VSP during drilling may impact on conservation significant fauna potentially transiting the area. Scientific literature suggests that impacts from noise and vibrations from VSP have the potential to cause behavioural and physiological damage, such as hearing loss to marine mammals (cetaceans). The consequence of such an impact to individuals is much lower than if it were to affect an entire population. However, it is more likely that an individual would be impacted as opposed to an entire population as the Operational area does not intersect any known migratory pathways. The Blue Pygmy whale BIA (distribution) overlaps the Operational area, as a result, individuals may pass through the area during the activity, and may exhibit avoidance behaviour. However, due to the nature of the noise emissions, and the short duration of the activity any potential disturbances are expected to be localised and temporary (limited to the duration of the activity). The area does not contain any significant feeding, breeding or aggregation areas. Minor (2): Minor environmental damage. Limited scale less than 1 km. Recovery in weeks to months.
Marine Turtles	It is likely that turtles would be able to hear the activities undertaken at distance and would experience some disturbance, however the impacts are not considered significant based on the following: MODU noise emissions that are expected are below the thresholds for behavioural impacts, PTS and TTS; Vessel noise is expected to be below the thresholds for PTS and TTS given the typical size vessels used during the activity and the slow vessel speeds within the operational area, the received levels may result in behavioural impacts, but for a limited duration and will not result in significant impacts; Helicopter noise will be intermittent during the activity, and below the thresholds for behavioural impacts, PTS and TTS; and VSP operations conducted over a period of up to 18 hours will result in the thresholds for PTS, TTS and behavioural impacts being exceeded. However, the received levels will decline rapidly from the source and be below thresholds for PTS and TTS within ~500 m of the source. Behavioural impacts are expected during VSP activities.

	The Operational area does not intersect any Habitat Critical for the Survival of marine turtles (BIAs), with the closest nesting area being 355 km away (green turtle nesting area at Cartier Island; and important foraging ground south west of the permit area. Considering the remote offshore location of the field and the distance to offshore reefs and islands, the likelihood of noise and vibrations causing a significant change in fauna behaviour/movement is considered to be low. The temporal and spatial scale of behavioural response on turtles would likely be short-term and limited to the localised area surrounding the Project. It is expected that transiting turtles will exhibit localised and temporary (for the duration of the activity only) avoidance behaviour in response to elevated underwater noise levels generated from vessels and/or helicopters, drilling or VSP. Consequence assessment of Minor was assigned to turtles given the limited scale less than 1 km. Recovery in weeks to months.
Fish and Sharks	There are no known key feeding/ breeding areas occur within the Big Bank, however fish will likely transit the area. Sufficient information on injury or death to fish from noise/vibration. Impacts to fish and sharks are likely to be behavioural only based on the following: MODU noise emissions that are expected are below the thresholds for behavioural impacts, PTS and TTS; Vessel noise is expected to be below the thresholds for behavioural impacts, PTS and TTS given the typical size vessels used during the activity and the slow vessel speeds within the Operational area; Helicopter noise will be intermittent during the activity, and below the thresholds for PTS and TTS; VSP operations conducted over a period of up to 18 hours will result in the thresholds for PTS, TTS and behavioural impacts being exceeded. However, the received levels will decline rapidly from the source and be below thresholds for PTS and TTS within ~350 m of the source. Behavioural impacts are expected during VSP activities; The hard coral habitats where site attached fish species occur are >4 km from the proposed well locations and therefore not within the area of potential PTS or TTS from VSP; Demersal fish species such as snapper, emperor and cod though not as strong swimmers as pelagic fish species are able to move away from the noise source. Thus PTS and TTS are unlikely with behavioural impacts more likely; Pelagic fish such as mackerel are strong swimmers thus, PTS and TTS are unlikely as they can swim away from a noise source. Impacts are more likely to be behavioural including avoiding or moving away from the area for the period of the VSP activity; No unique species were identified during recent surveys (GeoOceans 2018), and fish diversity was low suggesting the shark, fish and ray species that are likely to occur within the area are well represented within the wider environment. Therefore potential behavioural impacts to fish, sharks and rays from noise emissions are not significant; and The area of potential impact for fish, sharks and rays is a low proportion of the area they are likely to inhabit. Thus, population effects are not likely as there is a significant proportion of the population unaffected and for the. The area of potential PTS or TTS is confined to the immediate area surrounding the VSP noise source and for a very short duration (~18 hours per well). It is expected that fish in close proximity to the VSP will move away from the area during start up as the dominant seabed type is macroalgae where limited fish species are expected. There are no areas of high fish abundance within 350 m of the proposed well locations and therefore site attached fish species are not likely to be impacted by VSP activities.

	Given the short duration of the activities, any behavioural impacts are expected to be temporary and short ranged and are not expected to lead to long term changes in individual behaviour (e.g. migration, breeding) or lead to changes at the population level. Consequence assessment of Minor (2), given the minor environmental damage. Limited scale less than 1km. Recovery in weeks to months. Plankton (fish eggs and larvae) The threshold for mortality to plankton is likely to be exceeded within 100m of the source (based on VSP modelling; Chevron 2010). Any mortality or mortal injury effects to fish eggs and larvae resulting from seismic noise emissions are likely to be inconsequential compared to natural mortality rates of fish eggs and larvae, which are very high (exceeding 50% per day in some species and commonly exceeding 10% per day). For example, in a review of mortality estimates (Houde and Zastrow 1993), a loss of 21.3% per day was calculated. In the more recent McCauley (2017) study, zooplankton mortality rate background levels were 19% thus impacts to zooplankton are likely to be within natural mortality rates and will not have population level impacts to the fish populations of Big Bank.
Birds	There is potential for behavioural disturbance to migratory birds. However, noise levels from drilling activities will be below levels where significant disturbance to fauna are expected (Richardson et al. 1995). Any behavioural impacts will be Slight: with recovery in days to weeks; potential disturbance/injury to habitat/ fauna. Effects unlikely to be discernible or measurable.
Socio-economic	Impacts to fish from noise may result in indirect impacts to fisheries. However, impacts to fisheries are considered Slight largely due to the short duration of the activity (35 days) and that the Operational area is small in comparison to the overall fishing permitted area and that minimal to no fishing effort has occurred recently in the area. Stakeholder consultation with Commonwealth Commercial Fishing representatives has been undertaken with no issues raised. Any impacts to fish/species targeted by traditional fishers as a result of noise emissions are also only expected to be behavioural and should not impact on fishing. It has been noted that the Big Bank area is transited by traditional fishers on their way to other shoals rather than a primary fishing destination. Impacts are expected Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna. Effects unlikely to be discernible or measurable. Short-term or localised decrease in the availability or quality of a resource, not affecting usage".
ALARP Statement	
No alternative to use of a Drill Rig or supply vessels and VSP during well evaluation. As part of the ALARP assessment additional controls were adopted to reduce potential impacts from Noise emissions (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in impact levels. With implementation of the existing management measures it is considered the risk associated with Noise emissions are reduced to ALARP.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with noise emissions as ACCEPTABLE.	

CUMULATIVE IMPACTS

Sources of impact

The potential for cumulative impacts to Big Bank exists due to:

- Impacts that have occurred in the area from previous anthropogenic activities (drilling activities, fishing);
- Adjacent anthropogenic activities;
- Overlap of multiple impact pathways could also result in increase in impact levels (e.g impact on benthic habitats may be from drilling discharges and direct disburbance); or
- Consecutive drilling of 3 wells at the site.

Potential sources of cumulative impacts may occur due to:

- Light (multiple sources of light from rig, vessels, submersible equipment e.g. RMR).
- Noise (multiple sources of noise e.g. vessels, drilling, adjacent anthropogenic activities).
- Seabed disturbance (multiple seabed footprints from Spudcans, RMR equipment and settling of sediments disturbed).
- Decreased water quality (due to overlap in disturbance of sediment, increased turbidity, drilling and operational discharges.

Environmental Values Potentially Impacted							
Physical Environment					Fauna		Other
Physical Environment (Big Bank)	Marine Sediment	Water Quality	Benthic Habitats	Benthic Infauna	Marine Reptiles	Sharks, Fish and Rays	Socio-economic

Environmental values and the pathways they are potentially impacted include:

- Through disturbance to benthic habitats there may be disturbance to sediment, and a short-term decrease in water quality due to increased turbidity.
- The mortality of any flora and sessile fauna within the benthic habitat disturbance footprint and potentially the mortality of benthic infauna associated with the habitat.
- Marine turtles and other non-significant species (fish) may be impacted due to a temporary disturbance to feeding habitat.
- Changes in water quality as a result of drilling and operational discharges may impact plankton and pelagic species including fish, marine reptiles and mammals.
- Light, noise and atmospheric emissions may result in behavioural impacts to marine fauna.

A summary of the cumulative area of impact area is provided below:

Big Bank TOTAL (100%)	Habitat A (1.6%)	Habitat B (1.3%)	Habitat C (8.1%)	Habitat D (89%)
Area 41,280,899 m^2	660,494 m^2	536,652 m^2	3,302472 m^2	36,740,000 m^2
Operational Area is 3,140,000 m2 = 8.5% of Habitat D and 7.6% of total area of Big Bank plateau				
ASPECT	Habitat disturbance	Operational discharges	Drill cuttings	Cumulative

Habitat D (Big Bank)	Jack up approx. 780m^2 per well (0.01% of Big Bank habitat D) Area potentially impacted by emergency anchors would be < 3,140,000 m2 (8.5% of Habitat D and 7.6% of total area of Big Bank	Seabed (benthic habitats not expected to be impacted from operational discharges)	Sedimentation (10g/m^2/day) (worst case footprint) 105000m^2 (3.1% of Habitat D)	Jack up approx. 780m^2 per well (0.01% of Big Bank habitat D). Noting wells will be drilled at same site and same footprint likely to be impacted. Area potentially impacted by cumulative aspects (emergency anchors would be < 3,140,000 m^2) (8.5% of Habitat D and 7.6% of total area of Big Bank
Recovery	Benthic habitat recovery expected in months to year (Moderate).			
Pelagic env on Big Bank	n/a	Pelagic area potentially impacted by cumulative aspects; < 3,140,000 m^2 (7.6% of total pelagic waters over of Big Bank	TSS greater than 1mg/L <1000 m^2 (<0.01%)	Pelagic area potentially impacted by cumulative aspects; < 3,140,000 m^2 (7.6% of total pelagic waters over of Big Bank (operational and drilling discharges)
Recovery	Impacts to pelagic environment and receptors weeks to months (Minor)			
Habitat A, B, C	Zero	Zero	Zero	Zero
Disposal site	n/a	X	311,000 m^2 (Deepwater soft sediment community)	311,000 m^2 (Deepwater soft sediment community)
Recovery	Impacts to pelagic environment and receptors weeks to months (Minor)			
Pelagic disposal site	n/a	<500m area	5, 885,704m^2	5, 885,704m^2 (includes Op discharges)
Recovery	Impacts to pelagic environment and receptors weeks to months (Minor)			

Evaluation		
Consequence	Likelihood	Ranking
3	n/a	3 (Mod)

Summary of control measures	
All	All controls accepted in other Sections.
CM 86B	Adaptive managmement framework for cumulative impacts
CM 90	Time between wells

Summary of Potential Cumulative Impacts to Environmental Values(s) (with control measures in place)	
Water Quality	There will be several sources of disturbance to water quality from activities including from seabed disturbance, drilling discharges and operational discharges. These can all result in increased turbidity in the water column which can causes a reduction in the penetration of light available for photosynthesising benthic organisms (see below). Although the background levels of turbidity in the Operational area are likely to be low (~0.2 NTU), the shoals and banks in the region experience natural, episodic elevations of turbidity during storm events, that far exceed the likely concentrations of TSS or sedimentation from the drilling activity and associated discharges. Although such storm events are shorter in duration, their intensity is much greater and could persist for an equivalent amount of time in the case that several storms were to pass in quick succession. The causes of increased turbidity from the activity are also likely to be episodic and not occur simultaneously for the duration of the activity (35 days). Drill cuttings modelling results found any elevations in drilling-generated TSS above the 1 mg/L threshold is predicted to occur over very short timeframes (i.e. hours, not days) (GHD 2018). Likewise, operational discharges are expected to be intermittent (minutes to hours) and only cause temporary disturbances to water quality. The discharges are expected to be dispersed and diluted rapidly, with concentrations of discharges significantly dropping with distance from the discharge point. Heyward et al. (1997) maintained that the species that occur in these environments are likely to be resilient to these turbidity increases. Currents and mixing within the Operational area is also expected to be strong. As such, cumulative impacts to water quality from the activities were assessed as a Slight: Slight effect; recovery in days to weeks; disturbance/injury to habitat/ fauna. The planned activities are therefore not expected to result in a significant cumulative impact on the water quality in the existing environment of Big Bank given the discharge types and duration of the activities.
Benthic Habitat	The benthic habitat on Big Bank will be impacted by seabed disturbance from the Drilling Rig, RMR equipment and drill cuttings discharges. The area of impact will be contained within the Operational area, which is dominated by rubble and sparse macro algae and is not expected to be permanent. Impacts to benthic habitats may also result in the mortality of any sessile fauna within this footprint and potentially the mortality of benthic infauna associated with the habitat. Apart from a small (<50 m) area where there may be cement on the seabed, the rest of the benthic habitat area impacted by drilling activities is expected to remain a viable habitat that would be expected to recolonise with benthic species within weeks to months following removal of the disturbance. The small footprint associated with RMR pump (2 x 2.5 m) would also be temporarily impacted. As discussed in previous sections, the presence of 'sand waves/ripples' in the area during previous surveys (Heyward et al. 1997, GeoOceans 2018), indicates a benthic environment subject to periods of strong wave energy. It is likely that the benthic infauna and epifauna that inhabit these areas on Big Bank are those that tolerate episodic disturbance or are able to rapidly recolonise after periods of disturbance. This is also supported by the recent survey by GeoOceans (2018), who reported no obvious sign of previous spudding, or drill cuttings discharges on Big Bank. The previous area has been returned to normal and recolonised (GeoOceans 2018). A similar recovery would be expected from the proposed activity. This indicates that the drilling discharges will not be an additive impact from the previous drill cuttings discharges and therefore is not considered a cumulative impact.

	Because of the scientific uncertainty around recovery times, potential cumulative impacts from three wells being drilled, recognising that this is habitat that is used by EPBC species, such as foraging turtles and it being considered a 'higher order impact' Carnarvon have applied the 'Precautionary Principle' (EPBC Act), and taken a conservative approach to the risk assessment. The area impacted by drill cuttings may take 1-2 years to return to normal (if three wells are drilled) the cumulative consequence was ranked as Moderate: with moderate environmental damage. Limited scale less than 1 km. Recovery in months to a year and potential mortality to fauna. Therefore, the planned activities are considered to have a Moderate cumulative impact on the surrounding benthic environment and associated fauna.
Fauna	Marine fauna, including EPBC protected turtles, sharks, fish, rays, sea snakes and marine mammals (including the Blue Pygmy whale BIA (distribution) which overlaps the Operational area, may transit through Big Bank and could be affected by changes in water quality from operational and drilling discharges as well as potential impacts from noise and light. The discharges from the activity are not considered to be toxic to marine fauna. Additionally, these discharges only occur intermittently and for the short duration (35 days per well) of the activity. As there are no significant feeding or breeding grounds for fauna species, with the closest nesting area for turtles being 355 km away (green turtle nesting area at Cartier Island; and important foraging ground south west of the permit area), effects would be to individuals and not impact on populations. Seabirds may be attracted to the discharge location (mainly of sewage or putrescible waste) due to the additional fish activity at the surface. However, the impacts are limited to behavioural impacts only. If discharges were to cause a disturbance to fauna they would be behavioural and minor, localised and temporary in nature (i.e. contact as they transit through the area). Given the temporary nature of these discharges, the effects are not considered to result in a cumulative impact, with fauna behaviour returning to existing levels within hours of each discharge. Noise and light emissions will most likely influence marine mammals and fish. Fish abundance in the Operational area, however, has been reported as low (Heyward et al. 1997, GeoOceans 2018). Site attached species would most likely be associated with the reef habitats on the eastern and western ends of Big Bank where the impacts from noise and light are not expected to be significant. Considering the cumulative impacts of these aspects, there are no decreases in the local population or significant disruption to feeding or breeding cycles expected. Largely due to the nature and short duration of the planned activities, the relatively small area affected, and the low numbers of fauna that may be present in the operational area. Existing impacts to marine fauna from natural episodic events (such as storms and cyclones) that have occurred in the area would likely have resulted in temporary impacts to marine fauna with impacts to individuals, the additional impacts that may occur during the planned activity are not considered to significantly increase the impacts of these natural events. Previous anthropogenic disturbance may have also resulted in temporary disturbance to marine fauna but, as evidenced by recent surveys (GeoOceans 2018), fauna abundance is considered low. Fauna with strong site fidelity are therefore expected to remain within the area of impact from the planned activities given the short duration. As such, the worst case cumulative consequence ranking to marine fauna was determined as Minor (2): Minor environmental damage. Limited scale less than 1 km. Recovery in weeks to months.
Socio-economic	Any impact to socio-economic receptors within or surrounding the Operational area (e.g. commercial fisheries and Indigenous fishers) is expected to be Slight. The 500 m exclusion zone and 1 km buffer area where all planned impacts are expected to occur is only small relative to the size of Big Bank (<10%) and fisherman are able to avoid this area and fish at other locations on Big Bank. Given the previous activity

	occurred >14 years ago (the field was decommissioned in 2004), the environment where socioeconomic activities occur has likely recovered (as evidenced in the recent GeoOceans (2018) surveys). Therefore, the short duration of the planned activities is not considered to result in a significant cumulative impact. Cumulative noise and light impacts would be expected to be minimal due to lack of receptors and location remote from population centres. Stakeholder consultation with Commonwealth Commercial Fishing representatives has been undertaken with no issues raised. Potential impacts are considered Slight- effects unlikely to be discernible or measurable.

ALARP Statement
No alternative to the planned activity as described in previous sections, including additional controls adopted to reduce potential impacts from the Activity. Those controls considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in risk levels and were considered grossly disproportionate. With implementation of the existing management measures, it is considered the risk associated with cumulative impacts to the Big Bank environment are reduced to ALARP.
Demonstration of Acceptability
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with cumulative impacts ACCEPTABLE.

SPILL RESPONSE

Sources of impact

In the event of a hydrocarbon spill, contingency spill response activities will be undertaken to reduce the level of impact to sensitive receptors within the environment. In summary spill response strategies that will be employed in the event of a worse case hydrocarbon spill are:

- Monitoring, evaluation and surveillance
- Source control;
- Dispersant application;
- Containment and Recovery
- Protection and deflection;
- Shoreline clean-up;
- Waste Management;
- Oiled wildlife response; and
- Scientific Monitoring.

The WA-5235-P First Strike Response Plan (FSRP) (BUF-ENV-PLN-0002) provides further detail on how these strategies will be implemented.

While the aim of undertaking these spill response activities is to reduce environmental impacts from the spill, there is the potential for these activities to create additional impacts or to exacerbate existing oil spill impacts. Poorly selected or implemented spill response activities may therefore do more environmental harm than good.

Spill response activities will involve:

- The use of vessels which are required at a minimum to display navigational lighting. Vessels may operate near shoreline areas during spill response activities.
- Spill response activities may also involve onshore operations including the use of vehicles and temporary camps which may require lighting.
- The use of aircraft and vessels which will generate noise both offshore and in proximity to sensitive receptors in coastal areas.
- The use of equipment on coastal areas during clean-up of shorelines (e.g. pumps).
- The use of fuels to power vessel engines, generators and mobile equipment that will result in emissions of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), along with non-GHG such as sulphur oxides (SOx) and nitrous oxides (NOx).

Operational discharges including those routine discharges from vessels used during spill response. In addition, there are specific spill response discharges and waste creation that may occur, including:

- Cleaning of oily equipment/vessels;
- Flushing water for the cleaning of shoreline habitats;
- Sewage/putrescible and municipal waste on vessels; and
- Creation, storage and transport of oily waste and contaminated organics.

Movement and operation of vessels, personnel and equipment on the shoreline areas including the marine/coastal habitats and fauna, which may include those habitats and fauna within protected areas.

Oiled wildlife response activities may involve deliberate disturbance (hazing), capture, handling, cleaning, rehabilitation and release of wildlife.

Environmental Value Potentially Impacted							
Physical Environment					Fauna		Other
Air	Water	Benthic Habitat	Shoreline Habitat	Protected / Significant Areas	Protected Fauna	Other Fauna	Socio-economic

The key environmental hazards associated with the potential spill response strategies are provided together with a description of associated potential impacts to sensitive receptors. Some of these hazards are unique to spill response (e.g. shoreline clean-up, oiled wildlife response). Some hazards common to the drilling activity have also been detailed and re-evaluated on the basis that the environment within which spill response activities take place may be of higher sensitivity than the environment within which the planned drilling activity occurs. Following this principal, hazards associated with the contingency drilling of a relief well by an additional MODU, as part of the source control strategy, have not been re-assessed since they are considered sufficiently evaluated elsewhere in the EP.

Light

Lighting may cause behavioural changes to fish, birds and marine turtles which can have a heightened consequence during key life-cycle activities, for example turtle nesting and hatching. Turtles and birds, which includes threatened and migratory fauna, have been identified as key fauna susceptible to lighting impacts that occur within the EMBA.

Spill response activities which require lighting may take place in protected areas important to turtles and birds, for example at shoreline locations of Browse Islands, Cartier Island, and Indonesian and Timor Leste coasts/islands.

Noise

Underwater noise from the use of vessels may impact marine fauna, such as fish, marine reptiles and marine mammals which may impact key life-cycle process (e.g. spawning, breeding, calving). Underwater noise can also mask communication or echolocation used by cetaceans.

Spill response activities using vessels have the potential to impact fauna in protected areas; this includes the whale migration pathways.

Noise and vibration from terrestrial activities on shorelines also has the potential to cause behavioural disturbance to coastal fauna including protected and migratory species of shorebirds and turtles. Shoreline activities involving the use of noise generating equipment may take place in important nesting areas for turtles and/or roosting/feeding areas for shorebirds; this includes sites at Cartier Island and Browse Island

Atmospheric Emissions

Atmospheric emissions from spill response equipment such as the use of mobile equipment, vessels and vehicles may result in a temporary, localised reduction of air quality in the environment immediately surrounding the emission points.

Operational Discharges

Operational discharges from vessels may create a localised and temporary reduction in marine water quality. Effects include nutrient enrichment, toxicity, turbidity, temperature and salinity increases. However, given vessel use may occur in shallower coastal waters during spill response activities a different set of receptors may be impacted than previously described. Discharge could potentially occur adjacent to marine habitats such as corals, seagrass, macroalgae, and in protected areas, which support a more diverse faunal community, however discharges will still be very localised and temporary.

The decanting of oily water back into the marine environment during containment and recovery activities has the potential to impact marine organisms from the toxic effects from hydrocarbons, however, given the marine

environment is already contaminated with hydrocarbons there is limited potential for an increase in impact, unless the discharge spreads the contamination to a previously uncontaminated area.

Cleaning of oil contaminated equipment, vehicles and vessels, has the potential to spread oil from contaminated areas to those areas not impacted by a spill, potentially spreading the impact area and moving oil into a more sensitive environment.

Flushing of oil from shoreline habitats is a clean-up technique designed to remove oil from the receptor that has been oiled and remobilise back into the marine environment and result in further dispersion of the oil. The process of flushing has the potential to physically damage shoreline receptors such as mangroves and rocky shoreline communities, increase levels of erosion, and create an additional, and potentially higher, level of impact than if the habitat was left to bio-remediate.

Sewage, putrescible and municipal waste will be generated from onshore activities at temporary camps which may include toilet and washing facilities. These wastes have the potential to attract fauna, impact habitats, flora and fauna and reduce the aesthetic value the environment areas, which may be within protected areas. The creation, storage and transport of oily waste and contaminated organics has the potential to spread impacts of oil to areas, habitats and fauna not previously contaminated.

Physical Presence

The use of vessels may disturb benthic habitats in coastal waters including corals, seagrass, macroalgae and mangroves. Impacts to habitats from vessels include damage through the deployment of anchor/chain, nearshore booms and grounding. Vessel use in shallow coastal waters also increases the chance of contact or physical disturbance with marine megafauna such as turtles and dugongs. Booms create a physical barrier on the surface waters that has the potential to injure or entangle passing marine fauna that are either surface breathing or feeding.

Vehicles, equipment and personnel used during shoreline response activities have the potential to damage coastal habitats such as dune vegetation, samphire and mangroves and habitats important to threatened and migratory fauna including nests of turtles and birds and bird roosting/feeding areas. Shoreline clean-up may involve the physical removal of substrates that could cause impact to habitats and coastal hydrodynamics and alter erosion/accretion rates.

Oiled wildlife response may include the hazing, capture, handling, transportation, cleaning and release of wildlife susceptible to oiling such as birds and marine turtles. While oiled wildlife response is aimed at having a net benefit, poor response can potentially create additional stress and exacerbate impacts from oiling, interfering with life-cycle processes, hampering recovery and in the worst instance increasing levels of mortality.

Impacts from invasive marine species released from vessel biofouling include out-competition, predation and interference with other ecosystem processes. In shallow coastal areas, such as areas where vessel-based spill response activities may take place, conditions are likely to be more favourable for invasive marine species.

Impacts from invasive terrestrial species are similar in that the invasive species can out-compete local species (e.g. weeds) and interfere with ecosystem processes. Non-native species may be transported attached to equipment, vehicles and clothing. Such an introduction would be especially detrimental to wilderness areas or protected terrestrial reserves which have a relatively undisturbed flora and fauna community.

The disturbance to marine and coastal natural habitat, as well as the potential for disruption to culturally sensitive areas, which may occur in specially protected areas, may have flow on impacts to socio-economic values and industry (e.g. tourism, fisheries).

Chemical Dispersant Application

The application of chemical dispersants has the aim of enhancing oil dispersion and entrainment into the water column, thereby avoiding or reducing the volume of oil that could reach the shoreline. By entraining oil into the water column, chemical dispersants can aid the natural processes of biodegradation but can also increase impacts to subsea receptors.

While the aim of chemical dispersants is to provide a net benefit to the environment, the use of dispersants has the potential to increase the impact to receptors under the sea surface, including coral, seagrass and macroalgae, by increasing entrained oil and dissolved aromatic hydrocarbon concentration. These sensitive receptors are generally located in shallow coastal areas of the mainland and offshore islands.

Increased entrained and aromatic hydrocarbon concentration may also impact on marine fauna either directly or through impacts to subsea habitats. Direct impacts are most likely to be encountered by filter feeding invertebrates, fish and sharks. Fish and sharks include threatened/migratory species, which may ingest oil or uptake toxic compounds across gill structures. As a result of increased impact to marine fauna and subtidal habitats, including those that represent values of protected areas, socio-economic impacts may be felt through industries such as tourism and commercial fishing.

Disruption to Other Users

The use of vessels in the nearshore and offshore environment may impact on livelihoods and revenue with respect to coastal communities, and industries such as commercial fishing.

Evaluation		
Consequence	Likelihood	Ranking
2	n/a	2 (Minor)

Summary of control measures	
For vessel-based responses will implement control measures to manage impacts associated with vessels	
CM-36	FSRP outlines NEBA, notifications and consultation requirements to ensure net environmental benefit from response.
CM-37	FSRP procedure details IMT Core team members, resource pool and responsibilities.
CM-38	FSRP provides for task description for response activities to ensure lighting is managed.
CM-39	FSRP provides for task description for response activities to manage oily water during response activities
CM-78	Waste Management Plan
CM-41	FSRP details appropriate equipment and sites for response selected during spill response activities to minimise potential impacts from people/ vessel/ equipment presence.
CM-42 CM-79 CM-80	Specialist OWR personnel
CM-54 CM-63 CM-64	FSRP provides for task description for response activities to manage chemical dispersants including No-Go Zone.

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Light	The receptors considered most sensitive to lighting from vessel and shoreline operations are seabirds/shorebirds and marine turtles. Emerging turtle hatchlings on the beaches are particularly sensitive to light spill, however, the potential impact is considered negligible as stated below. Following restrictions on night time operations by spill response vessels, which will demobilise to mooring areas

	offshore with safety lighting only, light impacts from vessels are considered to be Slight. The positioning of temporary camps will be done in consultation with DBCA and any camp lighting will be restricted to minimum directional lighting of a colour that will reduce fauna disturbance. Following these controls, the consequence of shoreline lighting is considered Negligible. These species are likely to be values of the protected area they occur in, and the impact to the protected area from light is also considered Slight.
Noise	The receptor considered most sensitive to vessel noise disturbance are whales which are most vulnerable during their peak activity season as they migrate north/south through the EMBA. Control measures, by means of compliance to Part 8 of EPBC Regulations, will reduce potential impacts from response activities within this area during whale activity seasons. Given the activity will only introduce vessel engine noise, the consequence is considered to be consistent with noise impacts from activities (Minor). With respect to noise from onshore operations (mobile equipment and vehicles), nesting, roosting or feeding birds are considered to be the most sensitive to noise, in particular shorebirds may be aggregating at Ashmore Reef, Cartier Island, and Indonesian/Timorese coastlines. However, the equipment used is not considered to have excessive sound levels and the consequence to birds from noise is expected to be Slight.
Atmospheric	Atmospheric emissions from spill response equipment will be localised and impacts to even the most sensitive fauna, such as birds, are expected to be Slight.
Operational Discharges	Operational discharges from vessels may create a localised and temporary reduction in marine water quality, which has the potential to impact shallow coastal habitats in particular. However, following the adoption of regulatory requirements for vessel discharges, which prevent discharges close to shorelines, discharges will have a Slight impact. Furthermore, washing of vessels and equipment will take place only in defined offshore hot zones preventing impacts to shallow coastal habitats. Onshore, the use of flushing water has the potential to damage sensitive shoreline and intertidal habitats (e.g. mangroves). However low pressure flushing only will be used, preventing further damage to habitats or erosion of sediments. For sensitive habitats the deployment of booms will be considered to retain flushed hydrocarbons, if this presents a net benefit. Following these controls, the use of flushing to clean shorelines and intertidal habitats is seen to have a Slight additional impact. The cleaning of contaminated vehicles and equipment onshore has the potential to spread oily waste and damage habitats if not contained. Decontamination units will be used during the spill response thus containing waste and preventing any secondary contamination. The consequence of cleaning discharges is therefore ranked as Slight. Sewage, putrescible and municipal waste generated onshore will be stored disposed of at approved locations. There will be no discharges of this waste to the marine or coastal environment and the likelihood of an unplanned discharge is considered Unlikely following those controls provided. In the event that those controls failed and secondary contamination or loss of municipal waste occurred the additional consequence to coastal habitat has been assessed as Minor. The Risk ranking for an Unlikely event with a Minor consequence is Low.
Physical Presence	Physical Presence of Nearshore Response Vessels and Spill Equipment The use of vessels and nearshore booms has the potential to disturb benthic habitats, including sensitive habitats in coastal waters such as corals, seagrass,

	macroalgae and mangroves. A review of shoreline and shallow water habitats, bathymetry, and the establishment of demarcated areas for access and anchoring will reduce the level of impact to Slight. Onshore Vehicle Movements, Equipment Use and Camp Set-up The use and movement of vehicles, equipment and personnel during shoreline response activities has the potential to disturb coastal habitats such as dune vegetation, samphire and mangroves, and important habitats of threatened and migratory fauna including nests of turtles and birds and bird roosting areas. A clean-up can also involve physical removal of substrates that could cause impact habitats, fauna and alter coastal hydrodynamics. As with vessel use, an assessment of appropriate vehicles and equipment to reduce habitat damage, along with the establishment of access routes/demarcation zones, and operational restrictions on equipment/vehicles use will limit sensitive habitat damage and damage to important fauna areas. The establishment of temporary camp areas will be done with consultation to DoT, DBCA and with a Heritage Advisor if access is sought to culturally significant areas. Following these controls, the overall resultant consequence to the physical environment and habitat is assessed as Minor, indicating that there may be a detectable reduction in habitat area from response activities (as separate from spill impacts), but recovery will be relatively rapid once spill response activities cease. As with all spill response activities this disturbance will only occur if there is a net benefit to accessing and cleaning shoreline areas. Wildlife Response The main direct disturbance to fauna would be the hazing, capture, handling, transportation, cleaning and release of wildlife susceptible to oiling impacts, such as birds and marine turtles. This would only be done if this intervention were to deliver a net benefit to the species, but may result in a Minor consequence following close adherence to the WA Oiled Wildlife Response Plan and the Pilbara Region Oiled Wildlife Response Plan.
IMS	Invasive Marine Species The mobilisation of vessels, vehicles and equipment into sensitive nearshore and coastal habitats brings the potential for non-indigenous and potentially invasive species, either attached as biofouling, in the case of vessels or as seeds/plant propagules or invasive fauna within equipment and vehicles. The release of such species is an unplanned event which is considered to have a likelihood of Rare following vessel risk assessments (on all international and interstate Australian vessels) and pre-cleaning and quarantine inspections of onshore equipment. Furthermore, no international vessels are anticipated for general spill response activities in the nearshore/coastal environment thus reducing potential for invasive species introduction. The consequence of an outbreak of an invasive marine species is considered Major in the nearshore/coastal environment, which is more conducive to establishment of invasive marine species than deeper offshore waters. Given the UnlikelyRare likelihood the overall Risk Ranking is Medium. The response activities may occur within the Ningaloo and Muiron Islands World Heritage Protected Areas, impacts due to physical presence/disturbances to the key values within these WHA areas are also expected to be Minor with a medium risk of introduction of invasive marine species.
Disturbance to Other Users	The use of vessels in the nearshore and offshore environment and spill response activities at shoreline locations, and within townships, may exclude general public (community villages) and industry use. It should be noted that this is distinct from the socio-economic impact of a spill itself which would have a far greater detrimental impact to industry and recreation. Following the controls adopted it is considered that the additional impact of spill response activities on affected industries would be Minor.

Dispersants	Dispersants The use of dispersants has the potential to increase the impact to receptors under the sea surface, including coral, seagrass and macroalgae, by increasing entrained oil and dissolved aromatic hydrocarbon concentration. These sensitive receptors are generally located in shallow coastal areas of the mainland and offshore islands. However a dispersant 'no go' zone has been defined as the area where no chemical dispersant can be applied under any circumstances. This includes: • Big Bank and the associated 'Big Bank Shoals'; • waters shallower than 20m (LAT); • within exclusion zones for offshore facilities; • within an Australian Marine Park boundary; or • within State waters without approval from the State HMA. This will ensure impacts to benthic habitats in sensitive locations will be Acceptable and ALARP..
AMPs	Response activities (including Scientific Monitoring) may occur within the highly sensitive locations of Cartier Island, Ashmore Reef and Kimberley AMPs. Alternatively, species that may be impacted are also likely to be values of the protected area they occur in. The objectives of the North-west Marine Parks Management Plan (DoNP 2018a) are to provide for: • the protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks in the North-west Network; and • ecologically sustainable use and enjoyment of the natural resources within marine parks in the Northwest Network, where this is consistent with objective (a). A worst case Minor impact (from physical disturbance or noise) on the values of the AMP from spill response activities may also have an impact on the socio-economic values (i.e. the benefit of marine parks for people, businesses and the economy). This may result in a Minor socio-economic impact- damage done with stakeholders/users of the park, and national reputational impact.
ALARP Statement	
No alternative to spill response in the event of a hydrocarbon spill. As part of the ALARP assessment additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls the additional effort would not result in significant reductions in risk levels. With implementation of the existing management measures, it is considered the risk associated with Spill response are reduced to ALARP.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with spill response ACCEPTABLE.	

UNPLANNED EVENTS

INTERACTION WITH MARINE FAUNA

Sources of impact

During the Activity, use of MODU and support vessels has the potential to result in direct impacts to fauna through collision with larger marine fauna (including cetaceans, whale sharks, birds and turtles).

Environmental Value Potentially Impacted				
Physical Environment	Fauna			
Physical Environment (Big Bank)	Marine Mammals	Marine Reptiles	Fish, Sharks and Rays	Marine Birds

Marine Mammals

Cetaceans are naturally inquisitive marine mammals that are often attracted to vessels underway; for example, dolphins commonly 'bow ride' with vessels. There have been recorded instances of cetacean deaths as a result of vessel collisions in Australian waters (e.g. a Bryde's whale in Bass Strait in 1992) (WDCS 2006), though the data collected indicates this is likely to be associated with container ships and fast ferries. Collisions between vessels and cetaceans are most frequent on continental shelf areas where high vessel traffic and cetacean habitat occur simultaneously (WDCS 2006).

The Conservation Management Plan for the Blue Whale (DoE 2015) identifies vessel strike as one of the threats to Blue Whale species.

The reaction of whales to the approach of a ship is quite variable. Some species remain motionless when in the vicinity of a ship 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).

Marine Turtles and Sharks (Whale Sharks)

Other marine fauna like turtles and whale sharks that are present in shallow waters or surface waters are also susceptible to vessel strike due to their proximity to the vessel (hull, propeller or equipment) and their limited ability to avoid vessels.

Whale sharks may be behaviourally vulnerable to boat strike. They spend a significant amount of time feeding in surface waters (DEH 2005; Norman 1999) and scars have been observed on several whale sharks that have likely been caused by boat collision (DEH 2005). There have also been several reports of whale sharks being struck by bows of larger ships in other regions where whale sharks occur (Norman 1999).

Marine Birds

Should individuals of listed or migratory bird species transit through the Operational Area, the worst-case consequence of a bird strike with a helicopter would be localised, with a potentially lethal effect on a single individual with no lasting effect to population or community baseline.Evaluation		
Consequence	Likelihood	Ranking
2	2	4

Summary of control measures	
CM-16	Inductions
CM-4	Benthic Habitat Map based site selection
CM-24	Trained and competent crew
CM-25	Vessel Operating Procedure(s) [Marine Operations Management Plan]
CM-26	Reporting

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Marine Mammals	Four listed threatened and migratory species of cetacean were identified as potentially occurring or having habitat in the Operational area; the sei whale, blue whale, fin whale and humpback whale. However, there are no known key aggregation areas (resting, breeding or feeding) located within or immediately adjacent to the Operational area. The blue pygmy whale BIA (distribution) overlaps the operational area, pygmy blue whales are typically solitary animals or occur in low numbers. Occasional individuals or groups of a number of cetacean species may also be present from time to time. Should a support vessel strike a marine mammal, the worst-case consequence would be a potentially lethal effect on a single individual with no lasting effect to population. With the controls implemented to reduce impacts to marine mammals, and the short duration of the activity any potential disturbances are expected to be Minor (limited to the duration of the activity). Although impacts have been identified within relevant conservation and recovery plans (see below), any impact would be to individuals only. The worst case consequence was assessed as Minor due to the potential mortality to an individual.
Marine Turtles	Six species of listed threatened and migratory marine turtle were identified as potentially occurring in, or relating to, the Operational area; loggerhead, green, leatherback, hawksbill, olive ridley/Pacific ridley and flatback turtles. Marine turtles are predominantly oceanic species except in the nesting season when they come ashore. There are no shorelines in close proximity to the Operational area. However, turtles may transit the offshore waters in proximity to the Operational area and may forage on algae at Big Bank and nearby shoals (noted as BIA foraging for some species). The Operational area does not intersect any Habitat Critical for the Survival of marine turtles, with the closest nesting area being 355 km away (green turtle nesting area at Cartier Island; and important foraging ground south west of the permit area. Vessel strike is an identified impact within relevant conservation and recovery plans, given that marine turtles are known to occur in the region and in the vicinity of the Operational area they are also susceptible to vessel strike. However, with the controls implemented to reduce impacts to marine turtles, and the short duration of the activity any potential disturbances are expected to be localised and temporary (limited to the duration of the activity). Thirteen listed marine species of sea snake were identified in the *EPBC Act* Protected Matters search as potentially occurring in or having habitat within the Operational area The majority of sea snake species are reef dwelling and have small home ranges. However, some species have been observed in remote offshore waters and Tiwi islands and may transit through the Operational area. Vessel strikes are unlikely in the

	Operational Area where vessel are travelling at low speeds. In the event of a vessel strike, it is expected that there would be an impact to individual(s) and as such there would not be a decrease in the population size at either a local or regional scale. The worst case consequence was assessed as **Minor** due to the potential mortality to an individual.
Fish and Sharks	Two listed migratory species of sharks and rays were identified as potentially occurring or having habitat within the Operational area; Narrow/Knifetooth sawfish and the threatened Great white shark neither are likely to be susceptible to vessel strike. There are no known feeding, breeding or aggregation areas for fish, sharks or rays within the Operational area. It possible that whale sharks may transit the Operational area, and they are also susceptible to vessel strike. However, in this event it is expected that there would be an impact to individual(s) and as such there would not be a decrease in the population size at either a local or regional scale. The worst case consequence was assessed as **Minor** due to the potential mortality to an individual.
Birds	Avifauna are expected to display avoidance behaviour in response to helicopter noise. The worst-case consequence was assessed as **Minor** due to the potential mortality to an individual.
Socio-economic	No potential impacts to socio economic values as a result of vessel strike, although threatened species may be a value of a marine park that has social and economic values.
Likelihood Assessment	Given the ability of marine mammals to display avoidance behaviour, and that no key aggregation areas for marine mammals, turtles or whale sharks overlap the Operational area, it is considered unlikely that a lethal fauna strike incident will occur. Given the short term and intermittent helicopter activities and mobile nature of listed or migratory bird species, it is considered rare for a strike incident to occur.
ALARP Statement	
No alternative to use of a Drilling Rig or supply vessels. As part of the ALARP assessment additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls the additional effort would not result in significant reductions in risk levels. With implementation of the existing management measures, it is considered the risk associated with Interaction with marine fauna are reduced to ALARP.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with from Interaction to Marine Fauna (resulting in habitat disturbance) ACCEPTABLE.	

INTERACTION WITH MARINE HABITATS

Sources of impact

MODU movement causing physical damage/disturbance to Big Bank due to adverse weather.

Environmental Value Potentially Impacted				
Physical Environment				Fauna
Physical Environment (Big Bank)	Marine Sediment	Water quality	Benthic Habitats	Benthic Infauna

Potential disturbance to benthic habitats from MODU dragging on Big Bank include:

- Through disturbance to benthic habitats there may be disturbance to sediment, and a short-term decrease in water quality due to increased turbidity.
- Disturbance to Habitat D or C: the habitat will be left disturbed, but will remain a viable habitat that would be expected to recolonise with benthic species within weeks to months following removal of the disturbance.
- Disturbance to Habitat A or B: the habitat will be left disturbed, and may take months to years to recover.
- The mortality of any flora and sessile fauna within the disturbance footprint and potentially the mortality of benthic infauna associated with the habitat.

Marine turtles and other non-significant species (fish) may be impacted due to a temporary disturbance to feeding habitat.

Evaluation		
Consequence	Likelihood	Ranking
2	2	4

Summary of control measures	
CM-27	Cyclone procedure
CM-25	Vessel Operating Procedure(s) [Marine Operations Management Plan]
CM-1	Rig Move Procedure
CM-4	Benthic Habitat Map based site selection

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Water and Sediment Quality	The disturbance to sediments can increase turbidity in the water column and causes a reduction in the penetration of light available for photosynthesising benthic organisms. Although the background levels of turbidity in the Operational area are likely to be low (~0.2 NTU), the shoals and banks in the region experience natural, episodic elevations of turbidity during storm events, that far exceed the concentrations of TSS or sedimentation from seabed disturbances. Although such events are shorter in duration, their intensity is much greater and could persist for an equivalent amount of time in the case that several storms were to pass in quick succession. The species that occur in these environments are likely to be resilient to

	these turbidity increases (Heyward *et al*. 2017). Effects unlikely to be discernible or measurable, and not too different from conditions during a storm event. Impacts to water quality were considered **Slight** with effects unlikely to be discernible or measurable.
Benthic Habitats	Impacts from adverse weather causing damage to benthic habitats would most likely be within habitat D. This habitat is expected to recolonise with benthic species within weeks to months following disturbance. Impacts to benthic communities from habitat disturbance may have the following ways impacts: • Smothering and direct burial; • Clogging of feeding apparatus (for filter feeding organisms); • Reduction in photosynthesis from reduced light availability; and • Alteration of the benthic substrate. Recovery is dependent on the type of community affected; the physical structure; and persistence of the cuttings pile itself; and the availability of colonising organisms. The presence of 'sand waves/ripples' in the area during previous surveys (Heyward *et al*. 1997), indicates a benthic environment subject to periods of strong wave energy. It is likely that the benthic infauna and epifauna that inhabit these areas on Big Bank are those that tolerate episodic disturbance or are able to rapidly recolonise after periods disturbance. Benthic habitats in the Operational area (and over 85% of Big Bank) that may be affected are expected to be low sensitivity (rubble and macro algal) habitat. Impacts to coral habitats will take longer to recover and may result in a consequence of **Minor** given the limited scale (less than 1 km) and **Minor** environmental damage, with recovery in weeks to months.
Marine Fauna	The Operational area does not intersect any Habitat Critical for the Survival of marine turtles, with the closest nesting area being 355 km away (green turtle nesting area at Cartier Island; and important foraging ground 120 km south west of the permit are. Migratory species are likely to forage at nearby shoals that provide similar habitat/foraging areas to that of Big Bank. Fish abundance and diversity in the rubble/turfing macroalgae habitat of the potential area of impact from seabed disturbance is low, consisting mainly of smaller species, such as hawkfishes (Heyward *et al*. 1997, GeoOceans 2018). Impacts to these demersal fish that live within 5 to 10 m of the seabed are not predicted, given the fish are mobile. The potential unplanned impact on habitat for other resident species such a fish would only impact a very small percentage of the total Habitat D available on Big Bank. Changes in water quality from seabed disturbance may result in behavioural effects to sharks, fish and rays in close proximity to the Drilling Rig location, with recovery measured within hours to days. The potential impact on habitat for other resident species such a fish is also expected to be temporary, and only impact a very small percentage of the total Habitat D available on Big Bank. As such the worst case consequence ranking for habitat disturbance to marine fauna was 1 (**Slight**): recovery in days to weeks; potential disturbance/injury to habitat/ fauna. Effects unlikely to be discernible or measurable.
Socio-economic	No potential impacts to socio economic values as a result of MODU moving during adverse weather.
Likelihood Assessment	The likelihood of adverse weather causing impacts to benthic habitats from the MODU moving was considered unlikely (2).
ALARP Statement	

No alternative to use of a Drilling rig or supply vessels.

As part of the ALARP assessment additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls the additional effort would not result in significant reductions in risk levels. With implementation of the existing management measures, it is considered the risk associated with unplanned habitat disturbance from the Drilling rig are reduced to ALARP.

Demonstration of Acceptability

All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with unplanned habitat disturbance ACCEPTABLE.

NON-HYDROCARBON RELEASE (LIQUID)

Source of impact

A non-hydrocarbon release of liquid to the environment has the potential to occur from the following activities:

- MODU/ vessel operations;
- Brine, muds and base fluids – overflow of tanks;
- Brine, muds and cuttings during skip and ship;
- Mechanical failure of equipment;
- Dropped objects;
- Vessel collision; and/or
- Structural failure.

Environmental Value Potentially Impacted							
Physical Environment				Fauna			
Big Bank	Marine Sediment	Water Quality	Benthic Infauna	Marine Reptiles	Sharks, Fish and Rays	Marine Mammals	Birds

The maximum volume of non-hydrocarbon liquid that may be released during routine operations is likely to be small and realistically limited to the volume of individual containers (e.g. IBCs/ drums etc.) stored on-deck (1 m^3). However, it is credible that a hose could part when loading/offloading brine or mud – then the discharge would be approximately 2.5 m^3.

Dilution from most discharges at sea is rapid with 1 in 1,000 dilution occurring within 30 minutes (Costello and Read 1994). It is expected that in the event that spill is not contained on deck, the spill would rapidly disperse and evaporate.

Drill cuttings will be either vacuumed and blown to from the rig to the vessel or mechanically transferred by an auger system. The hose or chute will be custom designed for the rig and support vessel when they are contracted. These are both proven systems that are used to transfer cuttings from rigs to adjacent supply vessels however there is the risk of a hose or other piece of equipment failing, leading to discharge of brine, muds and cuttings to the marine environment. In a worst case only a small volume would be discharged in an unplanned event given the maximum of 40 m3 - 50 m3 in a single tank and presence of personnel who would observe any pipe failures. Drilling discharges could impact sensitive environmental receptors through reduction o water quality (increased turbidity, reduced light available for photosynthesis and toxicological effects), smothering (sediment deposition and toxicological effects) and disturbance to marine fauna.

Water Quality

Marine receptors can be impacted from non-hydrocarbon liquid releases from direct contact with the release (toxicity) or a reduction in water quality (e.g. reduced dissolved oxygen concentrations). The susceptibility of marine receptors to non-hydrocarbon releases will be dependent on the nature of the liquid released, toxicity and other chemical properties such as biodegradation and bioaccumulation potential. The exposure duration is also a consideration in resultant acute and chronic toxicity effects.

Marine Fauna

Liquid discharges may cause minor short-term water quality perturbations (see above) and as a result a possible alteration to marine fauna behaviour. Sensitive receptors on Big Bank that may show avoidance behaviour due to drilling discharges include fish at surface, marine turtles, sea snakes, mammals and seabirds.

Benthic Habitats

Physical environment and habitats can be impacted as a result of smothering (from an accidental spill of mud pits). However, as a result of currents, dilution is expected.

Evaluation		
Consequence	Likelihood	Ranking
1	2	2

Summary of control measures	
CM-14	Waste Management Plan compliant with Marine Orders Part 95 – Marine pollution prevention— garbage.
CM-16	Inductions
CM-10	Planned maintenance procedure
CM-11	Oily water treatment system compliant with Marine Orders Part 91 – Marine pollution prevention — oil.
CM-13	Sewage treatment system compliant with Marine Orders Part 96 – Marine pollution prevention — sewage
CM-30	Oil Pollution Emergency Plan (OPEP): Comprising; FSRP + IMP
CM-31	Vessel spill response plan (SFSRP/SMPEP)
CM-28	Dropped object procedure
CM-4	Benthic Habitat Map based site selection
CM-15	Chemical Selection Procedure
CM-85	RMR Transfer Procedure

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Water Quality	The extent of potential impact associated with this hazard is confined to the Operational area. Rapid dispersion and dilution is expected in the highly dynamic (GHD 2018) receiving environment and a liquid release would have short dispersion duration and a small extent of exposure at concentrations that may result in toxic effects. As such acute toxicity in the water column is not expected and the worst case impact is expected to be short term behavioural impact to fauna (see below). Changes in water quality from seabed disturbance may result in behavioural effects to sharks, fish and rays in close proximity to the Drilling Rig location, with recovery measured within hours to days. RMR activities will be monitored limiting the volume potentially discharged to the environment. As, in the event an accidental discharge, the consequence is considered to be **Slight**. It is expected that there would be an impact to individual(s) with no decrease in the population size at either a local or regional scale. Impacts to water quality were considered **Slight** with effects unlikely to be discernible or measurable.
Benthic Habitat	While unplanned liquid discharges may cause short term reductions in the change in water quality, these spikes are expected to occur for very short durations and as such any affects to benthic habitats are expected to be temporary as the most common benthic habitat is rubble and algae, which would recover quickly if impacted.

Protected Fauna Other Fauna	An unplanned non-hydrocarbon release in the operational area may result in temporary water quality perturbations and alteration to marine fauna behaviour. Sensitive receptors that may be impacted include pelagic fish and sharks at surface, marine turtles and mammals, and seabirds. Given that the activity will be for a limited duration, in offshore waters, and an unplanned release would likely be an on-off, finite release; impacts will be limited to short-term with recovery measures in days to weeks and potential disturbance to fish and seabirds. Planned operational discharges are therefore not expected to significantly impact marine fauna within the receiving environment nor compromise the objectives of Recovery Plans for threatened and migratory marine fauna. Although four cetacean species have been identified as potentially occurring in the operational area, a lack of important habitat for these species within the Operational area indicates that only transient individuals would be expected in lower numbers throughout the Activity. Given that marine turtles and whale sharks are known to occur in the region and in the vicinity of the WA-523 permit they are also susceptible to unplanned non-hydrocarbon releases. As such the worst case consequence ranking for unplanned non-hydrocarbon releases given was; **Slight** due to the potential disturbance to fauna.
Likelihood Assessment	The likelihood of an unplanned liquid release causing impacts to water quality and marine fauna is considered probable (3) based on industry experience.
ALARP Statement	
No alternative to use of a Drill rig or supply vessels generation of liquid wastes and use of liquids (such as chemicals) during the activity that may accidentally be released to sea. As part of the ALARP assessment additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls the additional effort would not result in significant reductions in risk levels, the risk associated with unplanned liquid discharges are reduced to ALARP.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with Accidental liquid discharges ACCEPTABLE.	

NON-HYDROCARBON RELEASE (SOLID)

Sources of impact

A non-hydrocarbon release of solid waste to the environment has the potential to occur from the following activities:

- MODU/ vessel operations;
- Dropped object;
- Accidental discharge of dry bulk; and/ or
- Accidental discharge of waste.

Non-hydrocarbon solid wastes including paper, plastics and packaging and hazardous solid wastes such as batteries, fluorescent tubes, medical wastes and aerosol cans may be released unintentionally to the marine environment. Release of these waste streams may occur as a result of overfull and/or uncovered bins, incorrectly disposed items or spills during transfers of waste and materials between the MODU and support vessels.

Environmental Value Potentially Impacted				
Physical Environment		Fauna		
Physical Environment (Big Bank)	Benthic Habitats	Marine Reptiles	Sharks, Fish, Rays	Marine Mammals

Physical Environment and Marine Fauna

Non-hydrocarbon solid wastes such as plastics have the potential to harm marine fauna through entanglement or ingestion. Marine turtles and seabirds are particularly at risk from entanglement. Marine turtles may mistake plastics for food; once ingested, plastics can damage internal tissues and inhibit physiological processes, which can both result in fatality.

Release of hazardous solid wastes may result in the pollution of the immediate receiving environment, leading to detrimental health impacts to marine flora and fauna. Physiological damage can be through ingestion or absorption may occur to individual fish, cetaceans, marine reptiles or seabirds.

Benthic Habitats (including Big Bank)

Benthic habitats have the potential to be impacted with heavy loads resulting in potential loss of benthic habitats and invertebrate communities within the impact zone.

Evaluation		
Consequence	Likelihood	Ranking
1	3	3

Summary of control measures	
CM-14	Waste Management Plan compliant with Marine Orders Part 95 – Marine pollution prevention — garbage
CM-16	Inductions
CM-10	Planned maintenance procedure
CM-28	Dropped object procedure
CM-85	RMR Transfer Procedure

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Benthic Habitats	In the event of a lost equipment/dropped object, it is expected to result in localised damage to the seabed. The presence of 'sand waves/ripples' in the area during previous surveys (Heyward *et al*. 1997), indicates a benthic environment subject to periods of strong wave energy. It is likely that the benthic infauna and epifauna that inhabit these areas on Big Bank are those that tolerate episodic disturbance or are able to rapidly recolonise after periods disturbance. This is supported by the recent survey by GeoOceans (2018), that reported no obvious sign of previous spudding in the last drilling location. This area had been returned to normal and recolonised (GeoOceans 2018). A similar recovery would be expected from the proposed activity. The area surrounding the well is largely low density turfing macro algae, only sparsely populated by epifauna, typical of 90% of the Big Bank plateau. Impacts to this habitat type would only represent <0.01% of Habitat D and likely be temporary and recoverable within weeks to months following cessation of discharges. Any localised disturbance to benthic habitat is not expected to have an impact to fishes in the immediate vicinity. The extent of the seabed damage will be limited to the size of the dropped object and given the size of standard materials lifted overboard, any impact is expected to be very small. Any impact to seabed through dropped objects would result in a negligible reduction in habitat area/function impacted and the consequence was assessed as **Slight** with recovery in days to weeks.
Protected Fauna Other Fauna	In the event of a non-hydrocarbon release (solids), the quantities would be limited. This waste stream could cause localised impacts to water quality and the benthic environment if the solid can degrade, leading to impacts on localised flora and fauna species. Ingestion of solid wastes could occur in small quantities. Only small volumes of this waste stream would be generated during the activity due to the duration of the activity, as a result, any accidental loss to the environment would be small in size. Any impacts would be restricted to a small number of individuals in the close proximity to the release, if any. As such, there is the potential for short term behavioural impacts only to a small proportion of a local population and not during critical lifecycle activity for cetaceans, marine turtles or fish. Fish abundance and diversity in the rubble/turfing macroalgae habitat of the potential area of impact from seabed disturbance is low, consisting mainly of smaller species, such as hawkfishes (Heyward *et al*. 1997, GeoOceans 2018). Impacts to these demersal fish that live within 5 to 10 m of the seabed are not predicted, given the fish are mobile. The potential unplanned impact on habitat for other resident species such a fish would only impact a very small percentage of the total Habitat D available on Big Bank. Changes in water quality from seabed disturbance may result in behavioural effects to sharks, fish and rays in close proximity to the Drilling Rig location, with recovery measured within hours to days. As such the worst case consequence ranking for unplanned non-hydrocarbon releases (solid) given was **Slight**; with potential disturbance/injury to habitat/ fauna and effects unlikely to be discernible or measurable.
Likelihood Assessment	The likelihood of an unplanned solid release causing impacts to water quality and marine fauna is considered probable (3) based on industry experience.
ALARP Statement	
No alternative to use of a Drilling rig supply vessels and lifting in the field. As part of the ALARP assessment additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in risk levels. the risk associated with unplanned solid discharges are reduced to ALARP.	

Demonstration of Acceptability
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with unplanned solid release ACCEPTABLE.

INTRODUCED MARINE SPECIES

Sources of impact

Introduced Marine Species (IMS) have been introduced and translocated around Australia by a variety of natural and human means including biofouling and ballast water. IMS can be introduced into the operational area and surrounds by vessels carrying IMS on external biological fouling, internal systems (sea chests, seawater systems etc.), on marine equipment (including RMR), or through ballast water exchange.

Environmental Values Potentially Impacted		
Physical Environment		Fauna
Physical Environment (Big Bank)	Benthic Infauna	Sharks, Fish, Rays

IMS are marine plants, animals and algae that have been introduced into a region that is beyond their natural range but have the ability to survive, and possibly thrive. The majority of climatically compatible IMS to the NWS are found in south-east Asian countries.

Some IMS pose a significant risk to environmental values, biodiversity, ecosystem health, human health, fisheries, aquaculture, shipping, ports and tourism (Wells *et al*. 2009). IMSs can cause a variety of adverse effects in a receiving environment, including:

- Over-predation of native flora and fauna;
- Out-competing of native flora and fauna for food;
- Human illness through released toxins;
- Depletion of viable fishing areas and aquaculture stock;
- Reduction of coastal aesthetics; and
- Damage to marine and industrial equipment and infrastructure.

Species of concern are those that are not native to the region; are likely to survive and establish in the region; and are able to spread by human mediated or natural means. Species of concern vary from one region to another depending on various environmental factors such as water temperature, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities.

It is recognised that artificial, disturbed and/or polluted habitats in tropical regions are susceptible to introductions which is why ports are often areas of higher IMS risk (Neil et al. 2005).

Following their establishment, eradication of IMS populations is difficult, limiting management options to ongoing control or impact minimisation. Case studies in Australia indicate that from detection to eradication can take approximately four weeks (Bax 1999). However, this is dependent on the environmental conditions and species. For this reason, increased management requirements have been implemented in recent years by Commonwealth and State regulatory agencies.

Ballast water is responsible for up to 30% of all IMS incursions into Australian waters, however, research indicates that biofouling (the accumulation of aquatic micro-organisms, algae, plants and animals on vessel hulls and submerged surfaces) has been responsible for more foreign marine introductions than ballast water (DAWR 2017).

Under the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (2009), a risk assessment approach is recommended to manage biofouling. Biofouling on vessel hulls and other external niche areas, biofouling on internal niches, biofouling on equipment routinely immersed in water and ballast water exchange all pose a potential risk of introducing IMS into Australia. The potential biofouling risk presented by the vessels will relate to the length of time that the vessel has already been operating in Australian waters or, if they have been operating outside Australian waters, the location/s of the operations it has been undertaking, the length of time spent at these location/s, and whether the vessel has undergone hull inspections, cleaning and application of new anti-foulant coating prior to returning to operate in Australia.

Any vessel or marine infrastructure destined for WA waters from interstate or overseas is required to meet the aquatic biosecurity standards set out under the Fisheries Resources Management Act 1994, including a Marine Biosecurity Inspection for the presence of known and potential IMS to ensure compliance with Regulation 176. No target marine species of concern to Australian waters can be observed during the in-water inspection.

Evaluation		
Consequence	Likelihood	Ranking
2	2	4

Summary of control measures	
CM-16	Inductions
CM-10	Planned maintenance procedure
CM-52	Ballast water management plan implemented on vessels and MODU
CM-53	Anti-foulant system maintained on MODU and vessels
CM-29	Biosecurity Risk Assessment on vessels and MODU and RMR equipment.
CM-85	RMR Transfer Procedure
CM-4	Benthic Habitat Map based site selection

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Benthic Habitat	Ballast water discharge and contaminated ships and equipment (including RMR) may have the potential to introduce IMS. There is the potential that any IMS entering the Operational area would establish on the natural benthic habitat (macroalgal habitat), given the shallower water depths in the area. However, the lack of diversity on the seabed and limited epifauna and in fauna (GeoOceans 2018) is considered unlikely to provide adequate habitat for establishment. In the event that IMS establishes on benthic habitat it could result in an overall change in localised areas to the benthos. In the event that an IMS is introduced into the operational area, given the benthic habitat in the region, there could only be a reduction in the physical environment. The consequence was assessed as Minor, as impacts would be within 1 km of the activity and could result in potential mortality to fauna associated with the benthic habitat.
Protected Fauna Other Fauna	Marine pests are 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 Australia has over 250 established marine pests, and it is estimated that approximately one in six introduced marine species becomes pests (DoE 2015l). In the event that a marine pest is introduced into the operational area, there is the potential for this pest to become established resulting in a localised but medium term impact to the area. There are increased concerns regarding fishery impacts following the introduction of IMPs into Australian waters. Should IMPs be introduced, they have the potential to outcompete and displace native species which may in turn affect the local marine ecosystem, and potentially fisheries operating in the area affected. Fish abundance and diversity in the rubble/turfing macroalgae habitat of the potential area of impact from seabed disturbance is low, consisting mainly of smaller species, such as hawkfishes (Heyward *et al*. 1997, GeoOceans 2018). Impacts to these demersal fish

	that live within 5 to 10 m of the seabed are not predicted, given the fish are mobile. The Operational area does not contain any known critical areas (i.e. feeding, breeding) or highly significant habitat (i.e. coral reef, seagrass) for fish. Larger fauna is unlikely to be significantly affected by a change in the physical environment due to the introduction if IMS as they are transient species (marine mammals, marine reptiles) and the prey availability in the area is not high enough to support critical habitat to these species, hence the low numbers found. The lack of critical areas (coral reefs and filter feeders) in the area of the well location (GeoOceans 2018) further reduces the potential for IMS establishment and subsequent competition with local fauna. As such the worst case consequence ranking for IMS was **Minor**- due to the potential for minor environmental damage. Limited scale less than 1 km. Recovery in weeks to months. Potential mortality to fauna.
Likelihood Assessment	**The likelihood of IMS being introduced and establishing in the operational area was considered unlikely (2).**
ALARP Statement	
No alternative to use of a Drill rig or supply vessels, and the use of ballast water during the activity. As part of the ALARP assessment additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls the additional effort would not result in significant reductions in risk levels, it is considered the risk associated with IMS are reduced to ALARP.	
Demonstration of Acceptability	
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with IMS ACCEPTABLE.	

HYDROCARBON SPILL (MINOR)

Sources of impact

A minor spill of MGO could occur during vessel, helicopter or MODU refuelling resulting in a loss of hydrocarbons to the marine environment at sea surface. Spills during refuelling can occur through several pathways, including fuel hose breaks, coupling failure or tank overfilling.

ROV systems and RMR equipment carry <100 L of hydraulic fluid. Accidental release of hydraulic fluids could occur due to hose failure.

The most credible worst-case spill scenario on board the MODU is considered to be loss of a 160 L container of hydraulic fluid during transfer from a support vessel.

Hydrocarbon spilt volumes due to drop out from flaring and well testing are difficult to estimate. Given the automatic and manual systems in place during flaring, the accidental release of hydrocarbon is expected to be low (<500 L).

The anticipated low volumes are expected to rapidly disperse into the marine environment. Below toxic/ harmful threshold concentrations are expected to occur at short distances from the hydrocarbon release point.

Environmental Values Potentially Impacted						
Physical Environment			Fauna			
Physical Environment (Big Bank)	Water Quality	Benthic Habitats	Seabirds	Marine Reptiles	Sharks, Fish, Rays	Marine Mammals

A reduction of the water quality with potential toxicity effects to marine flora/fauna in the immediate vicinity of the rig could occur.

Hydraulic oils behave similarly to marine diesel when released to the marine environment. Hydraulic oils are medium oils of light to moderate viscosity and have a relatively rapid spreading rate and will dissipate quickly, particularly when high sea states afford rapid mixing.

Based on material safety data sheets, typically, hydraulic fluids are not expected to be toxic as the mineral oil is not expected to cause any chronic effects to aquatic organisms at concentrations <1 mg/L. However, it may cause physical fouling of aquatic organisms.

Evaluation		
Consequence	Likelihood	Ranking
1	3	3

Summary of control measures	
CM-24	Trained and competent crew
CM-4	Benthic Habitat Map based site selection
CM-31	Vessel spill response plan (SOPEP/SMPEP)
CM30 Refer (OSMP) Refer (FSRP (BUF- ENV-PLN- 0002)	Oil Pollution Emergency Plan (OPEP): Comprising; OSMP Framework (Appendix B EP) Emergency response preparedness
CM-32	ROV Inspection Procedures

CM-28	Dropped object procedure
CM-33	Refuelling procedure

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Water Quality	Minor spills associated with the activity will be small, with volumes dependent on a range of variables. Impacts to water quality will be experienced in the discharge mixing zone which will be localised and will occur only as long as the discharges occur (i.e. no sustained impacts). Currents and mixing within the Operational area is expected to be strong so that impacts will be localised and temporary. Impacts to water quality were considered Slight- with effects unlikely to be discernible or measurable and recovery within days to weeks.
Benthic Habitats	Given a surface discharge, impacts to benthic habitats were considered discernible or measurable.
Protected Fauna Other Fauna	Sensitive receptors that may be impacted include pelagic fish and sharks at surface, marine turtles and mammals, and seabirds. The Blue Pygmy whale BIA (distribution) overlaps the Operational area, as a result, individuals may pass through the area during the activity. However, due to the potential nature of the unplanned discharges and the Operational area being located in the open ocean (high degree of dispersion due to currents and mixing), and temporary (over 35 days) if discharges were to cause a disturbance to fauna individuals they would be behavioural minor, localised and temporary in nature (i.e. contact as they transit through the area). Discharges may also cause localised impact to the offshore waters through which marine reptiles may transit. Discharges will not contact any regionally significant (BIA) feeding, breeding or aggregation areas for marine reptiles. Due to the nature of the discharges and the Operational area being located in the open ocean (high degree of dispersion due to currents and mixing), and temporary (over 35 days) if discharges were to cause a disturbance to fauna individuals they would be behavioural minor, localised and temporary in nature (i.e. contact as they transit through the area). As such the worst case consequence ranking to marine fauna was Slight: recovery in days to weeks; potential disturbance/injury to habitat/ fauna. Effects unlikely to be discernible or measurable.
Socio-economic	Any impacts to fish/species targeted by traditional fishers as a result of minor hydrocarbon discharges are also only expected to be behavioural and should not impact on fishing. It has been noted that the Big Bank area is transited by traditional fishers on their way to other shoals rather than a primary fishing destination. Effects to social values were considered unlikely to be discernible or measurable (Slight). Consultation with Commonwealth Commercial fishing industry representatives has been undertaken. No issues were raised.
Likelihood Assessment	The likelihood of a minor hydrocarbon spill in the operational area was considered probable (3) given the experience of industry.
ALARP Statement	
Offshore refuelling is standard industry practice and oil pollution legislation (Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and MARPOL Annex I) has been developed to safeguard against the risk of a hydrocarbon spill occurring during refuelling. Additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected (see controls above). In the instance of rejected controls, the additional effort would not	

result in significant reductions in risk levels. With implementation of the existing management measures, it is considered the risk associated with spills are reduced to ALARP.
Demonstration of Acceptability
Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with minor hydrocarbon spill ACCEPTABLE.

HYDROCARBON SPILL (DIESEL)

Source of impact

There is a possibility of a vessel collision occurring within the operational area between vessels and the MODU, or between a passing 3rd party vessel and vessels. The worst-case environmental incident resulting from a vessel collision is the rupturing of a vessel fuel tank resulting in the release of MGO to the environment. Vessel collision could occur due to factors such as human error, poor navigation, vessel equipment failure or poor weather.

A maximum credible spill volume has been determined based on technical guidance provided by AMSA (AMSA 2015). This guidance states that for a vessel other than an oil tanker, the maximum credible spill from a collision can be determined from the volume of the largest single fuel tank.

In reviewing the general arrangements and fuel tank capacities of typical vessels likely to be utilised for the activities, the largest single fuel tank capacity identified was no greater than 350 m3 of MGO for a support vessel, including vessels associated with RMR.

Based on a review of the Australian Transport Safety Bureau's marine safety database (http://www.atsb.gov.au/publications/safety-investigation-reports.aspx?Mode=Marine), there were 14 collisions in the last 10 years (2008-2018), none of these were vessel to MODU collisions, but the statistics indicate that vessel collisions do occur in Australian waters.

Environmental Value Potentially Impacted					
Physical Environment			Fauna		
Physical Environment (Big Bank)	Water Quality	Benthic Infauna	Marine Reptiles	Sharks, Fish and Rays	Marine Mammals

The accidental discharge of diesel has the potential to cause toxic effects on marine fauna and flora and a localised reduction in water quality.

In the open ocean habitat, where the proposed activity will occur, any spilled diesel would be subject to rapid dispersal, weathering, evaporative losses and dissipation throughout the water column. Adios modelling found ~200 m3 evaporates within the first 24 hours. The diesel may travel approximately 20 km during this time with the remainder travelling approximately 50 km away. The receptors within this EMBA would include adjacent banks/shoals and marine fauna transiting the area.

Potentially affected biota includes seabirds, cetaceans, fish and turtles that may come into contact with a surface diesel slick in the period prior to disappearance of these slicks due to natural dispersion and evaporation.

If surface slicks or entrained diesel were to contact shallow waters or emergent features adjacent to the operational area, including those associated with Big Bank shoals, then a range of benthic habitats and communities could be at risk of impacts. Commercial fishing activities and shipping in the area could also be impacted in the event of a major diesel spill.

Evaluation		
Consequence	Likelihood	Ranking
2	3	6

Summary of control measures	
CM-24	Trained and competent crew
CM-31	Vessel spill response plan (SOPEP/SMPEP)
CM-30	Oil Pollution Emergency Plan (OPEP):

	Comprising; FSRP + IMP
	Refer FSRP – (OSMP; Appendix B of the FSRP)
CM-7	Navigation legislation
CM-35	Carnarvon Petroleum Consultation of Relevant Persons Procedure (JS-70-PR-I-00034)
CM-33	Refuelling procedure
CM 86-C	Adaptive Management Framework (C hydrocarbon spill)

Summary of Potential Impacts to Environmental Values(s) (with control measures in place)	
Water Quality	Spills associated with the activity will be small, with volumes dependent on a range of variables. Impacts to water quality will be experienced in the discharge mixing zone which will be localised and will occur only as long as the discharges occur (i.e. no sustained impacts). Impacts to water quality could result in a temporary change in water quality over the Big Bank shoals resulting in subsequent impacts to marine fauna as discussed below. Currents and mixing within the Operational area is expected to be strong so that impacts will be localised and temporary. Impacts to water quality were considered **Slight** with recovery in days to weeks.
Protected Fauna Other Fauna	Sensitive receptors that may be impacted include pelagic fish and sharks at surface, marine turtles, seasnakes, mammals, and seabirds. The Blue Pygmy whale BIA (distribution) overlaps the Operational area, as a result, individuals may pass through the area during the activity. However, due to the potential nature of the spill and the Operational area being located in the open ocean (high degree of dispersion due to currents and mixing), and temporary (over 35 days) if discharges were to cause a disturbance to fauna individuals they would be behavioural minor, localised and temporary in nature (i.e. contact as they transit through the area). Pelagic fish and sharks could be impacted by a diesel spill due to the potential ingestion and potential toxic effects that could occur as pelagic fish and sharks at surface swim through the area of impact. Recent surveys undertaken on Big Bank (GeoOceans 2018) indicate that fish abundance is low, and of low diversity. Fish associated with the hard coral habitats and deeper waters of the Big Bank shoals are unlikely to be significantly affected by a surface diesel spill due to the distance from the operational area and the distance to these habitat types. However, a change in water quality could potentially affect smaller fish species, impacts are expected to be behavioural only given the size and duration of the potential spill. Seabirds may also be affected if they continue foraging for fish within the area of the spill, and this could lead to coating of feathers. Impacts to fish, sharks and seabirds at surface would be less than those expected from a loss of well control event. Discharges may also cause localised impact to the offshore waters through which marine reptiles may transit. Sightings of marine reptiles (two turtles and two seasnakes) were recorded at Big Bank in the survey by GeoOceans (2018), and are expected to forage on Big Bank. Discharges will not contact any regionally significant (BIA) feeding, breeding or aggregation areas for marine reptiles. Due to the highly evaporative nature of diesel and the Operational area being located in the open ocean (high degree of dispersion due to currents and mixing), if a diesel spill was to occur it would result in a short term and temporary changes to water quality. This would would most likely cause a disturbance to fauna individuals they would be behavioural minor, localised and temporary in nature (i.e. contact as they transit through the area). As

	such the worst case consequence ranking given for a diesel spill was 2, **Minor** - due to the potential mortality to some marine fauna (fish) and small scale of a spill therefore resulting in recovery within weeks to months.
Socio-economic	Any impacts to fish/species targeted by traditional fishers, as a result of minor hydrocarbon discharges are also only expected to be behavioural and should not impact on fishing. It has been noted that the Big Bank area is transited by traditional fishers on their way to other shoals rather than a primary fishing destination. Impacts to social values were considered **Slight** with: • Effects unlikely to be discernible or measurable; and • Short-term or localised decrease in the availability or quality of a resource, not affecting usage. Consultation with Commonwealth Commercial fishing industry representatives has been undertaken. No issues were raised.
Likelihood Assessment	The likelihood of a diesel spill in the operational area was considered probable (3) based on industry experience.

ALARP Statement

Vessels are required to undertake the activity. There are no suitable alternatives to the use of vessels to complete the activity. It is considered that the controls to reduce collision risks that have been proposed and the contingencies in place in the event of the hazard occurring reduce the likelihood and potential impacts from a loss of fuel as a result of a vessel collision to ALARP. In terms of spill response activities CVN will implement oil spill response as specified within the FSRP. The proposed spill response strategies (Spill Response Operations), consider relevant values and include completion of a NEBA in the event of a spill which includes the relevant values and receptors present in the area, including AMPS. A diesel spill would be monitored and impacts evaluated to ensure that potential impacts to sensitive receptors are managed to ALARP. Additional controls were adopted to reduce potential impacts (see above) but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in risk levels. With implementation of the existing management measures, it is considered the risk associated with spills are reduced to ALARP.

Demonstration of Acceptability

Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential environmental impacts and risks associated with diesel spill ACCEPTABLE.

LOSS OF WELL CONTROL

Source of Impact

A loss of well control during drilling may occur due to a number of reasons:

- Shallow gas;
- Well kick;
- Failure to keep the hole full;
- Working over live well;
- Tripping/Swabbing;
- Loss of primary and secondary well control; and
- Failure to keep the correct mud density.

In the event of a loss of well control, hydrocarbons may be released to the marine environment with the most likely release points at either the MODU floor (sea surface) or seabed.

In a loss of well control scenario, large quantities of the hydrocarbon (worse-case oil release 796,124 m3 and gas release 595,907 MScf) may be released to the marine environment until well control can be re-established.

The environmental consequences of a loss of well control are highly variable, dependant on the characteristics of the hydrocarbon released, the dynamics of the receiving environment and the proximity of the release point to sensitive environmental receptors.

Environmental Value Potentially Impacted							
Physical Environment				Fauna			
Physical Environment (Big Bank)	Marine Sediment	Water Quality	Offshore Reefs	Benthic Infauna	Marine reptiles	Fish	Marine Mammals

Surface Oil

Smothering of marine flora, fauna and habitats or ingestion of surface oil by marine fauna. The degree to which impacts could occur will depend upon the level of coating (concentration of oil and/or loading of oil on shorelines) and how fresh the oil is.

Physical shoreline habitats have the potential to be smothered by stranded oil. Persistent weathered hydrocarbons and shoreline fauna can be exposed to toxic effects from ingestion. There are no thresholds identified at which smothering or volume ashore will result in an impact, however those shorelines with the highest load, and those identified as significant threatened or migratory fauna habitat are the most susceptible to impact.

Surface oil occurring in coastal waters (of 1 g/m2) and accumulating on shorelines may also reduce the visual amenity of an area diminishing the natural, historic and indigenous heritage values of a place.

The combined dissolved oil and entrained oil (or droplets) are jointly referred to as the 'total water-accommodated fraction' (total WAF).

Total WAF

Total oil in the water column has the potential to coat benthic and susceptible shoreline habitats and organisms. The phenomena of smothering of submerged benthic habitats and those within tidal zones from water column oil has only been reported where very large oil spill quantities have affected these habitats or very sticky oil slicks have encountered exposed coral surfaces or polyps.

Dissolved WAF

While there is some debate in the scientific literature (Barron et al. 1999), the main component of oil generally thought to be responsible for the majority of toxicity to wildlife are the Dissolved Aromatic Hydrocarbons (DAH) compounds that dissolve into the water column following a spill. Various studies indicate that the toxic effects of aromatic compounds result from the narcosis caused in biological receptors following exposure to low molecular weight aromatics including compounds from the BTEX group and 2−4 ring PAHs (French 2000).

Accumulation of petroleum hydrocarbons by marine organisms is dependent on the bioavailability of the hydrocarbons, the length of exposure, and the organism's capacity for metabolic transformations of specific compounds.

Actual toxicity depends on both concentration and the duration of exposure, being a balance between acute and chronic effects.

Acute Toxicity

Toxicity to wildlife increases with increased length of exposure; marine organisms can typically tolerate high concentrations of toxic hydrocarbons over short durations (French 2000; Pace et al. 1995).

DAHs have a narcotic effect on organisms, resulting from interference with cell function that occurs as hydrocarbons are absorbed across cell membranes (French-McCay 2002). The narcotic effect varies among specific hydrocarbon compounds, with these variations thought to be attributable to the lipid solubility of the compounds. Over periods of hours to a few days, the narcotic effect has been found to be additive, both in severity and the number of different soluble hydrocarbons that are present (French 2000; NRC 2005; Di Toro et al. 2007).

Because the toxicity of DAH to aquatic organisms increases with time of exposure, organisms may be unaffected by brief exposures to a given concentration but affected at long exposures to the same concentration (French-McCay 2002). This is due to the fact that the concentrations of hydrocarbons build up in the tissues of biological receptors from either long-term exposure or repeated exposure to sub-lethal concentrations.

Chronic Toxicity and Accumulation

There is sparse data available on the chronic effects of PAHs in the marine environment. A review of the processes controlling the uptake and persistence of PAH in marine organisms, especially under chronic exposure conditions, highlighted differential mechanisms of uptake, tissue distribution, and elimination (Meador et al. 1995). While vertebrates have a high capacity for metabolising aromatic hydrocarbons including PAHs (through cytochrome P450 1A mediated oxidation), PAHs can accumulate in the body of invertebrates (as they lack a cytochrome P450 1A mediated oxidation system).

Socio-economic Receptors

Socio-economic receptors will be affected by hydrocarbon exposure in three key ways:

1. Loss of Income (e.g. reduction in catch for commercial fisheries);
2. Restriction of access; and
3. Reduction in aesthetic values.

Modelling

Far-field spill modelling was carried out with OSCAR. The model was configured in stochastic mode to simulate a range of environmental conditions. The start dates for the stochastic simulations were staggered approximately fortnightly across the five (5) years of hydrodynamic and wind data. A total of 120 individual 'realisations' made up the full stochastic set for the loss of well control scenario.

For each of the 120 stochastic realisations, OSCAR spatially tracks the surface oil, entrained oil droplets in the water column, dissolved oil and oil on shorelines. To present this large amount of simulated data in a meaningful way, thresholds are applied to each of the hydrocarbon components and OSCAR generates statistical spatial outputs of the instances when (and where) each threshold was exceeded. For example, a threshold of 100 ppb was applied to the dissolved component. As such, the stochastic output from OSCAR will present the area of

impact and associated probabilities (amongst other statistics) for which the concentration of dissolved hydrocarbons exceeded 100 ppb at any model grid cell during any of the realisations.

An analogue oil was selected from SINTEF's oil library through comparisons with Laminaria's bulk properties and distillation curve. The bulk properties of the SINTEF oil Sleipner (IKU) match very well with those of Laminara (**Table 10-1**).

Table 10-1: Comparison of Bulk Crude Properties of Laminaria and the Sintef Oil Sleipner (IKU)

Parameter	Laminaria	SINTEF Sleipner (IKU)
API	61.1	58.4
Wax Content (%)	<5	
Pour Point (%)	<-36	-30
Asphaltene (%)	<0.05	
Viscosity (cSt)	0.9 @ 20°C	0.75 @ 20°C

Importantly, the distillation curve of the Sliepner (IKU) oil matches very well with Laminaria's). On this basis, SINTEF's Sliepner (IKU) was selected as the modelling oil analogue to simulate oil distributions in the marine environment from a loss of well control scenario.

The stochastic simulation output of the 120 realisations provides a probabilistic temporal and spatial representation of potential impacts from a loss of well control incident. To further inform the development of the FSRP, two (2) of the 120 stochastic realisations were selected to run in OSCAR's deterministic mode to characterise shoreline loading (i.e. arrival times, loads) and the mass balance of the released oil in the marine environment (e.g. proportion of released oil lost to decay or volatilisation, remaining as droplets). The selection of the two deterministic realisations was on the basis of the shortest arrival time to an Australian shoreline and the largest predicted oil mass stranded on an Australian shoreline.

A summary of LOWC scenario parameters and modelling outcomes is shown in **Table 10-2**.

Table 10-2: LOWC Scenario Parameters and Modelling Outcomes

Parameter	Details
Hydrocarbon type	Light oil (Group I)
Total spill volume	Modelling was undertaken for a loss of well control from the blow out preventer (BOP) at the rig floor (sea surface) for one-week with an oil release rate of 96,861 bbl/day and 10 weeks from the seafloor with a decreasing weekly rate from 85,168 bbl/day in week 2 to 47,004 bbl/day in week 11 (total release of 5,007,618 bbl or 796,124 m^3). The gas release rate decreased from 11,526 MScf/day in week 1 to 5,593 MScf/day in week 11 (total 595,907 MScf).
Modelled release location	Buffalo Field (10° 40' 23.15"S 126° 07' 18.19" E)
Release depth	Modelling was undertaken for a loss of well control from the BOP at the rig floor (sea surface) for 1 week and 10 weeks from the seafloor with a decreasing weekly rate.
Release depth justification	The BOP is situated on the jack-up Mobile Offshore Drilling Units (MODU). Carnarvon identified the duration of the credible spill scenarios for a well blowout to be an uncontrolled surface release for one-week, when the MODU would provide a conduit

Parameter	Details
	to the surface for the uncontrolled flow, followed by a 10-week uncontrolled seabed release as the MODU would no longer be present to provide a conduit. In an explosion scenario, the MODU may collapse due to an anticipated compromise in structural integrity and stability after a period of time.
Release duration	77 days
Release duration justification	When calculating the worst-case spill duration, Carnarvon uses a 77-day base case as this was the time taken to kill the Montara loss of well control incident in 2009. The 77-day release duration assumes that the maximum depth of the hydrocarbon reservoir would be open and takes into account the estimated time to drill a relief. In this situation the response time was broken down as: • Mobilisation of relief MODU: 21 days. • Relief well drill time: 42 days. • Kill the well: 14 days.
Simulation duration	120 days (allowed an additional ~6 weeks after blowout cessation for subsequent oil transport and weathering).
Model type	SINTEF's Oil Spill Contingency and Response (OSCAR) system. For the well blowout, Sleipner (IKU) was selected as the simulated crude oil analogue from an extensive OSCAR oil library based on a comparison of the bulk properties and distillation cuts from a representative crude assay of the Buffalo drilling program's target reservoir (i.e. Laminaria). Three-dimensional (3D) modelling was undertaken in stochastic mode (total of 121 individual realisations) with start dates spaced approximately fortnightly over a five-year period between the months of April and September. Inputs into the model were sourced from HYCOM (regional ocean currents, temperature and salinity profiles), TPXO7.2 (tidal currents) and NCEP/NCAR (regional winds).
Stochastic modelling	On the basis of the environmental impact thresholds, the stochastic simulations of a loss of well control incident over the nominated drilling period (April-September) predict that: • The three Australian geographic receptors most susceptible to shoreline oiling are islands, namely Cartier Island (maximum loading of ~25 tonnes, 80% probability of shoreline oiling >100g/m^2), Browse Island (~5 tonnes, 19%) and Christmas Island (~15 tonnes, 17%). The three geographic receptors most susceptible to high shoreline loading are West Timor (~2,300 tonnes, 59%), Timor-Leste (~1,200 tonnes, 23%) and the Minor Indonesian Islands (~800 tonnes, 85%). • The instantaneous 10 g/m^2 surface oil threshold at >30% probability of contact is limited to within ~150 km of the well location. Maximum cumulative exposure times of >4 days were limited to within 25-50 km of the well location. No geographical receptors or Australian marine parks had a >5% probability of contact of the instantaneous surface oil threshold. • The instantaneous 500 pbb threshold at a >30% probability of contact at any depth in the water column is limited to within ~200 km of the well location. Maximum cumulative exposure times of >2 days were limited to within 10-20 km of the well location. Receptors with >5% probability contact of the instantaneous 500 ppb total submerged oil threshold included the geographic receptors of Indonesian West Timor (probability of contact within 5 km of 15%) and Australian Ashmore Reef (10%); the Australian marine parks of Oceanic Shoals (5%), Ashmore Reef (5%) and Argo-Rowley Terrace (8%); and the key ecological features (KEFs) of Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters (19%),

Parameter	Details
	Carbonate Bank and Terrace System of the Sahul Shelf (21%) and Continental Slope Demersal Fish Communities (26%). • The instantaneous 100pbb threshold for dissolved submerged hydrocarbons is limited to a very small areal extent within ~150 km of the release site at a probability of contact of >30%. Maximum cumulative exposure times of >2 days were limited to within 10-20 km of the well location over the 120 days. No geographical receptors, Australian marine parks or KEFs had >5% probability of contact.
Deterministic modelling	On the basis of deterministic modelling of five (5) selected stochastic realisations, the following is noted to inform the development of an appropriate oil pollution response strategy for potentially impacted Australian shorelines from a loss of well control incident: • The minimum arrival time to Cartier Island (probability of contact of 80%) is ~15 days, and ~17 days for the maximum predicted loading of ~25 tonnes. • The maximum predicted shoreline load to Browse Island (probability of contact 19%) is less (~5 tonnes) with a much longer minimum arrival time of ~6-7 weeks. • Christmas Island (probability of contact 17%) with a minimum arrival time of ~2 months.

Evaluation		
Consequence	Likelihood	Ranking
5	2	10

Summary of control measures	
CM-44	Planned Maintenance System
CM-45	Well casing, completion and wellhead components are manufactured to relevant API specifications.
CM-47	Third party BOPs are designed and tested at regular intervals in accordance with API standard 53.
CM-48	Wells are designed in compliance with the Company Well Construction Standards Manual
CM-49	Drilling Supervisors, Completions Supervisors and Drilling Superintendents are required to hold current Well Control certification
CM-50	CVN requires kick tolerances to be calculated for all pressure containing casing strings in accordance with Well Operations Management Plan (WOMP).
CM-51	CVN requires the Drilling Contractor and the mud logging service provider to independently monitor mud flows for variances with expectation.
CM-30	First Strike Response Plan (FSRP)) and Incident Management Plan (IMP)
CM-82	OSMP
CM-83	OSMP Response
CM-79	WA OWR Plan

CM-80	Specialist OWR personnel and equipment
CM-81	Permits
CM-67	Vessels
CM-78	Waste Management Plan
CM-77	Response vessels
CM-74	Shoreline clean-up trained oil spill responders
CM-75	Shoreline clean-up operations
CM-71	Trained SCAT oil spill responders
CM-72	SCAT procedure
CM-73	Shoreline clean-up equipment
CM-70	Shoreline Response Plan
CM-88	Manning supply
CM-67	Vessels (accommodation)
CM-69 and CM-66	Trained oil spill responders
CM-68	Protection and deflection operations
CM-39	FSRP provides for task description for response activities to manage oily water during response activities
CM-65	Containment and recovery operations
CM-54	FSRP provides for task description for response activities to manage chemical dispersants including No-Go Zone.
CM-62	Aerial dispersant spraying
CM-64	Dispersant
CM-63	Vessel dispersant spraying
CM-60	Well intervention
CM-61	Safety Case
CM-58	Source Control Plan
CM-59	Well Control Contractors
CM-57	Aerial Surveillance Capability
CM-55	Satellite Tracking Buoys
CM-56	OSTM

Summary of Potential Impacts to Environmental Values(s) **(with control measures in place)**	
Big Bank Shoals	There are numerous submerged banks and shoals within the Big Bank Shoals, which have a diversity of benthic habitats and associated fish and invertebrate assemblages which could be affected by entrained and dissolved hydrocarbons in the water column. Impacts

	to both the Big Bank and other adjacent shoals within the 'Big Bank group' are expected to result in major losses and functions of the benthic coral reefs and habitats, with recovery spanning over decades given toxicity impacts associated with hydrocarbon exposure. As a result of impacts to water quality from the entrained and dissolved hydrocarbons it is possible that impacts to Threatened / Migratory / Local Fauna transiting the area the area may result in localised long term effects on some species. The Blue Pygmy whale BIA (distribution) overlaps the operational area, as a result individuals may pass through the area during the activity, and be impacted by a LOWC scenario. The Operational area does not intersect any Habitat Critical for the Survival of marine turtles (BIAs with the closest nesting area being 350 km away (green turtle nesting area at Cartier Island). However, with an important foraging ground south west of the permit area it is likely there may be groups of animals feeding who would be impacted by a LOWC scenario on Big Bank. There are no known key fish feeding/ breeding areas occur within the Big Bank, however fish will likely transit the area. The worst case consequence of LOWC on the Big Bank shoals was assessed as **Critical**- due to the significant environmental or heritage damage. Large scale >10 km long term (decades) impact and potential widespread degradation to the quality or availability of habitats and/or fauna requiring significant long-term restoration effort
Browse Island	Browse island is an important nesting site for green turtles as well as seabirds. Shoreline loading may impact these important nesting beaches, as well as damage possible cultural and heritage sites at this priority receptor. Oil ashore may have the potential to modify, destroy, remove, isolate or decrease the availability of quality habitat (shorelines/subsurface). However, the maximum predicted loading onto Browse Island (~6 tonnes) is expected to only result in a **Moderate** (impact): • Moderate effects on environment. Limited scale (1-10 km); • Short term impact recovery in months to years; • No lasting effects or persistent effects are highly localised; and • Minor change in habitats or species. The surrounding coral reefs and waters are not expected to be significantly impacted as there is no predicted entrained or dissolved contact above known thresholds. Although the application of dispersant may reduce shoreline loading, it could also increase concentration of entrained and dissolved hydrocarbons at this location.

Cartier Island	Impacts to Cartier Islands are expected to vary dependant on the hydrocarbon phase and receptor exposed. Cartier Island is an important area for seabirds, interesting turtles. Shoreline loading may impact important nesting beaches (for protected birds and turtles), as well as damage possible cultural and heritage sites at this priority receptor. Oil ashore may have the potential to modify, destroy, remove, isolate or decrease the availability of quality habitat (shorelines/subsurface) to the extent that a long-term decline in local population is possible of seabirds and/or turtles. Surface and entrained hydrocarbons will or may impact coral and seagrass habitats, as well as other marine park values fauna including dugongs, sea snakes (protected), fish and other marine mammals. As the predicted concentration at this location are low it is unlikely for potential for major losses and functions of the benthic coral reefs and seagrass habitats, associated with hydrocarbon exposure. Although the application of dispersant may reduce shoreline loading (refer WA-523-P FSRP), it could also increase concentration of entrained and dissolved hydrocarbons. The maximum predicted loading onto Maximum predicted loading onto Cartier Island ~27 tonnes is expected to result in: • Major environmental damage. Large scale: greater than 10 km; • Long term (years to decades) impact; • Decrease in the medium-term (<5 years) availability or quality of a resource affecting usage; and • Local or regional stakeholders' concerns leading to complaints. The worst case consequence was assessed as a **Major.** The objectives of the North-west Marine Parks Management Plan (DoNP 2018) are to provide for: a) The protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks in the North-west Network; and b) Ecologically sustainable use and enjoyment of the natural resources within marine parks in the Northwest Network, where this is consistent with objective (a). A '**Major**' impact on the values of the AMP may also have an impact on the Socio-economic values (i.e. the benefit of marine parks for people, businesses and the economy). This may result in a 'Major' socio-economic impact- Major damage done with stakeholders/users of the park, and national reputational impact.
Christmas Island	Largest predicted shoreline load to Christmas Island is 15 tonnes shoreline loading only. The following Christmas Island values might be impacted by a LOWC scenario this: The waters surrounding the island are critical for the survival of the island's land crabs, including tens of millions of red crabs, as they release their eggs into the sea as part of their breeding life cycle; Two marine turtles listed as vulnerable under the *EPBC Act*, the green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*), are found in the park's waters and green turtles occasionally nest on Dolly Beach; Christmas Island is one of the world's significant seabird islands. More than 100 migrant and vagrant species have been recorded, including nine resident breeding seabird species (with three of these being endemic or endemic subspecies) and 23 vagrant/non-

	breeding seabirds. The Abbott's booby and the Christmas Island frigatebird have their only extant nesting habitat in the world on Christmas Island; and The Dales and Hosnies Spring wetlands, which are listed as Wetlands of International Importance under the Ramsar Convention. Shoreline loading may impact important nesting beaches (for protected birds and turtles and land crabs), as well as damage possible cultural and heritage sites at this priority receptor. Oil ashore may have the potential to modify, destroy, remove, isolate or decrease the availability of quality habitat (shorelines/subsurface), especially to RAMSAR wetland to the extent that a long-term decline in local populations is possible. Entrained hydrocarbons will or may impact coral and seagrass habitats, as well as other values fauna including fish, sharks and rays and other marine mammals. Although the application of dispersant may reduce shoreline loading, it could also increase concentration of entrained and dissolved hydrocarbons. The worst case consequence to Christmas Island was assessed as **Major**: • Major environmental damage. Large scale: greater than 10 km; • Long term (years to decades) impact; • Decrease in the medium-term (<5 years) availability or quality of a resource affecting usage; and • Local or regional stakeholders' concerns leading to complaints.
International waters receptors including West Timor Timor Leste Indonesian Islands	Impacts to International waters are expected to be vary but the worst case may be '**Critical** *-Significant environmental or heritage damage. Large scale <10 km long term (decades) impact.* Widespread degradation to the quality or availability of habitats and/or fauna requiring significant long-term restoration effort. There is potential for major losses and functions of the benthic coral reefs and habitats, with recovery spanning over decades given toxicity impacts associated with hydrocarbon exposure. It may have the potential to modify, destroy, remove, isolate or decrease the availability of quality habitat (shorelines/subsurface) to the extent that a long-term decline in local population is likely of seabirds and/or turtles; and a long term decrease in local population size of some marine fishes or sharks. Some part of the predicted volume ashore may contact the national and marine parks and affect turtle nesting beaches within Meru Betiri, Komodo and Nino Konis National Parks. If the oil ashore occurs at nesting beaches, significant disruption to the turtle activity could result. Of the shoreline habitat types present mangroves are likely to be one the most susceptible and slowest recovering habitat types with recovery potentially on a decadal scale. For traditional fishers, hydrocarbons impacts may affect local fishing grounds used for subsistence and commercial fishing. Impacts to fish and habitats found in these locations are described in above. These impacts could result in a loss of value to local communities and fishing industry.
KEFs	A number of KEFs fall within the EMBA, those closest to the Operational area are likely to experience the highest concentrations of entrained and dissolved hydrocarbons, including; • Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters; • Carbonate Bank and Terrace System of the Sahul Shelf; and • Continental Slope Demersal Fish Communities.

	While many of the features of the impacted KEFs are subtidal and will not be directly contacted by hydrocarbons, they all may support increased productivity or abundance of marine fauna that use surface waters above the features (including plankton, pelagic invertebrates and fish, marine mammals, marine reptiles and seabirds) which may be impacted. In the case of Continental Slope Demersal Fish Communities, the planktonic eggs and larvae of these demersal fish communities may be impacted (see below). Surface exposures do also have the potential to impact those KEFs associated with Islands such as Ashmore Reef and Cartier Island. Impacts to shorelines from hydrocarbons exposures are provided above. At the predicted concentration levels of contact impacts to these KEFs are expected to be **Moderate** (impact): • - Moderate effects on environment. Limited scale (1-10 km); • - Short term impact recovery in months to years; and • - No lasting effects or persistent effects are highly localised.
Australian Marine Parks	The following AMPs are located within either the EMBA and SEMBA: • Oceanic Shoals; • Cartier Island; • Ashmore Reef; • Argo-Rowley Terrace; and • Kimberley. These parks support unique/protected habitats/marine fauna or ecological features. The objectives of the North-west Marine Parks Management Plan (DoNP 2018) are to provide for: a) The protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks in the North-west Network; and b) Ecologically sustainable use and enjoyment of the natural resources within marine parks in the Northwest Network, where this is consistent with objective (a). Impacts to the habitat/fauna receptors have an impact on the values of these reserves which could have flow-on effects to tourism revenue of coastal communities that provide access to these marine reserves. The reserves listed above may also support nursery/feeding/aggregation areas for fisheries species and therefore may assist in maintaining healthy fish stocks and commercial/recreational fisheries. The maximum entrained concentration of hydrocarbons at the AMPs was very low and only just above threshold values and unlikely to have a significant impact on the ecological values. As a result, the risk ranking on environmental impacts was Minor: Minor environmental damage. Limited scale less than 1 km. Recovery in weeks to months. Potential mortality to fauna. However, as the AMPs' species occur in the SEMBA there may be an effect on the aesthetic values of the AMP, which may also have an impact on the Socio-economic objective of the Management Plan (i.e. the benefit of marine parks for people, businesses and the economy). Although, due to their remote location, low lying profile, lack of facilities and the need for a permit to land, these islands are seldom visited (even by passing yachts) and it is expected there would be little impact on tourism values at these sites. This may result in a '**Moderate**' socio-economic impact- Short-medium term decrease in the availability or quality of a resource, noticed by users.
Fish and Fisheries	The socio-economic and heritage features in the region are of high value. In particular, the commercial fisheries that operate in the EMBA. Although larvae, gametes and juveniles are considered sensitive to hydrocarbons, there is no definite evidence reported in literature to suggest hydrocarbon spills have significant effects on fish populations in the open sea. Phased scientific monitoring

	studies to evaluate the impacts of the Montara loss of well control incident showed evidence of exposure to petroleum hydrocarbons at sites close to the Montara well, including increased liver size and occasionally, increased oxidative DNA damage in the earliest phase of the study. However, later phases of the study (2010 and 2011) indicated biomarkers of exposure to petroleum hydrocarbons returning to reference levels, suggesting a return to normal biochemistry/physiology following exposure (Gagnon *et al*. 2012). Hydrocarbon induced deaths of young fish are often of little significance compared to losses each year through natural predation and fishing which sometimes reaches 99.99% (Dicks 1999). Modelling shows that dissolved aromatics may extend over open waters. However, it is expected that only transient fish would be affected in the event of a spill and resulting impacts on fish populations are considered to be **Moderate**. Temporary and localised impacts to commercial and traditional fisheries may occur, due to the direct loss of fishing grounds from the implementation of an exclusion zone in the event of a well blowout, as well as indirect effects such as temporary and localised decrease in water quality resulting in a decrease in fish numbers and associated loss of catch.
Social (Amenity) Values	The surface EMBA (SEMBA where a visible sheen may be seen (1 g/m^2) and shoreline loading were possible) potentially extend ~2,600 km to west of the spill location. However, the only nearshore waters (within 5 km) of any mainland or large island coasts with the potential for surface oil exceeding the 1 g/m^2 surface threshold were the geographic receptors of West Timor, Timor-Leste and the Minor Indonesian Islands. Additionally, the nearshore waters of Ashmore Reef Cartier Island, Seringapatam Reef and Mermaid Reef (1%) (See AMP above) were within the SEMBA. Although 1 g/m^2 surface does not result in environmental harm, a visual sheen may result in socio-economic impact. Only limited tourism activity occurs within the international waters within the SEMBA, however due to the remoteness many tourism operators here market themselves as a pristine, natural experience. A visual sheen impacts on the ability of operators to charge a premium for this type of experience or may encourage tourists to visit other destinations – resulting in loss of income. For those operators who continue to operate to affected destinations, the visual sheen may potentially reduce the visual amenity and enjoyment of clients at these sites. Scott Reef is a high value charter fishing destination. Should a visual sheen extend to this site it may reduce the amenity of the fishing experience and perceived safety of catches from this site – making it a less attractive destination resulting in loss of income for some operators. For traditional fishers, minimal impact would be expected from a visual sheen, shoreline loading effects to local fishing grounds used for subsistence and commercial fishing are described above. The overall risk ranking for impacts to social values was **Critical** - Major' oil spill over a wide area leading to campaigns and major stakeholders concerns' predominately due to the high level of shoreline loading to Timor Leste and Indonesia.

Socio-economic Receptors	*Shipping* Vessels may have to alter routes to avoid fouling of vessels. This may result in increased time and cost from additional fuel/wages. Increased cleaning cost may also be required. *Defence* Due to exclusion zones and risk of fouling, areas may not be available for defence exercises to be undertaken. *Oil and Gas* Operators located within the EMBA may have to alter vessel movements and temporarily implement variations to safety procedures as the result of any surface oil. *Cultural Heritage* Vessel fouling and health risks from direct contact would reduce the ability of indigenous people to access country. Traditional food sources and strong spiritual values associated with animals could also be impacted due to impacts on fauna. Amenity would be reduced due to visual impacts of sheen. Shipwrecks may be impacted by entrained oil but impacts are likely to be temporary and minimal. Any impact on Socio economic receptors shipwrecks is likely to be temporary and minimal. **Slight**
Overall Consequence	On the basis of the assessments above, a loss of well containment has the potential to impact a wide array of receptors. Given the potential for a widespread extent, the overall worst case consequence is considered to be **Critical** with: • Significant environmental or heritage damage; and • Large scale <10 km long term (decades) impact and widespread degradation to the quality or availability of habitats and/or fauna requiring significant long-term restoration effort.
Likelihood Assessment	The likelihood of a loss of well control in the operational area was considered **unlikely** (2).

ALARP Statement

CVN ensures control of its wells through a number of control measures incorporated into contractor selection process, the well design, drilling procedures, mud selection, personnel training and equipment maintenance and testing. Well control requirements are detailed within the NOPSEMA approved Well Operations Management Plan (WOMP) and Safety Case and are not restated in this EP pursuant to Regulation 31 of the OPGGS(E) Regulations. CVN's response strategies will allow responders to meet defined response objectives without causing more environmental damage than the oil spill itself in terms of net environmental benefit. The selected response strategies evaluated through the ALARP process are implemented through the FSRP. These response strategies are consistent with those outlined in the National Plan and have been determined through Carnarvon's spill preparedness planning process, Additional controls were adopted to reduce potential impacts but those considered either not technically feasible, or grossly disproportionate for this type of activity were rejected. In the instance of rejected controls, the additional effort would not result in significant reductions in risk levels. With implementation of the existing management measures, it is considered the risk associated with a loss of well control are reduced to ALARP.

Demonstration of Acceptability

Acceptability Statement: All of the criteria of Acceptability have been met, and as such Carnarvon find potential risks, and mitigation measures associated with a hydrocarbon spill ACCEPTABLE.