Pluto Facility Operations Environment Plan Summary

Production Division

June 2019

Revision 1

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1. INTRODUCTION

Woodside Burrup Pty Ltd (Woodside), as Titleholder, under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (referred to as the Environment Regulations), prepared an Environment Plan (EP) for the Pluto offshore facility and export pipeline on behalf of the Pluto Liquefied Natural Gas (LNG) Joint Venture Participants. The Pluto offshore facility (the facility), including the riser platform and subsea hydrocarbon gathering system, has been in production since 2012 and is operated by Woodside under the Petroleum Titles WA-1-IL, WA-16-PL, WA-17-PL and WA-34-L (**Table 2-1**). The updated Pluto Facility Operations EP was accepted by National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) on the 30 May 2019.

This EP Summary has been prepared to meet the requirements of Regulations 11(3) and 11(4) under the Environment Regulations, as administered by NOPSEMA. This document summarises the Pluto Facility Operations EP, accepted by NOPSEMA under Regulation 10A of the Environment Regulations.

1.1 Defining the Activity

The Petroleum Activities Program constitutes a petroleum activity, as defined in Regulation 4 of the Environment Regulations. As such, an EP is required.

2. LOCATION OF THE ACTIVITY

The riser platform is located in Commonwealth waters off Western Australia (WA), in Production Licence Area WA-1-IL. It is located approximately 160 km north west of Dampier and 75 km north of Barrow Island (**Figure 2-1**). Gas and condensate produced from the facility are exported via the 180 km long pipeline and associated 6-inch chemical supply line, to onshore for processing. Gas produced from a single well in the Xena field is tied in to the Pluto flowlines, 16 km from the riser platform. Additional wells are planned for Pyxis, Pluto and Xena as part of field development. Production from the Pyxis field will be tied in via the Xena subsea tie-in location. All activities associated with drilling, installation of subsea infrastructure and pre-commissioning will be subject to a separate EP.

The riser platform is marked on nautical charts and surrounded by a 500 m petroleum safety zone (PSZ). The riser platform is marked on general aviation maps and categorised as a Danger Area for civil aircraft. The danger-type is listed in the General Pilots Manual as “avoid flight over facility between surface and 1500 feet”. The export pipeline is also marked on nautical charts.

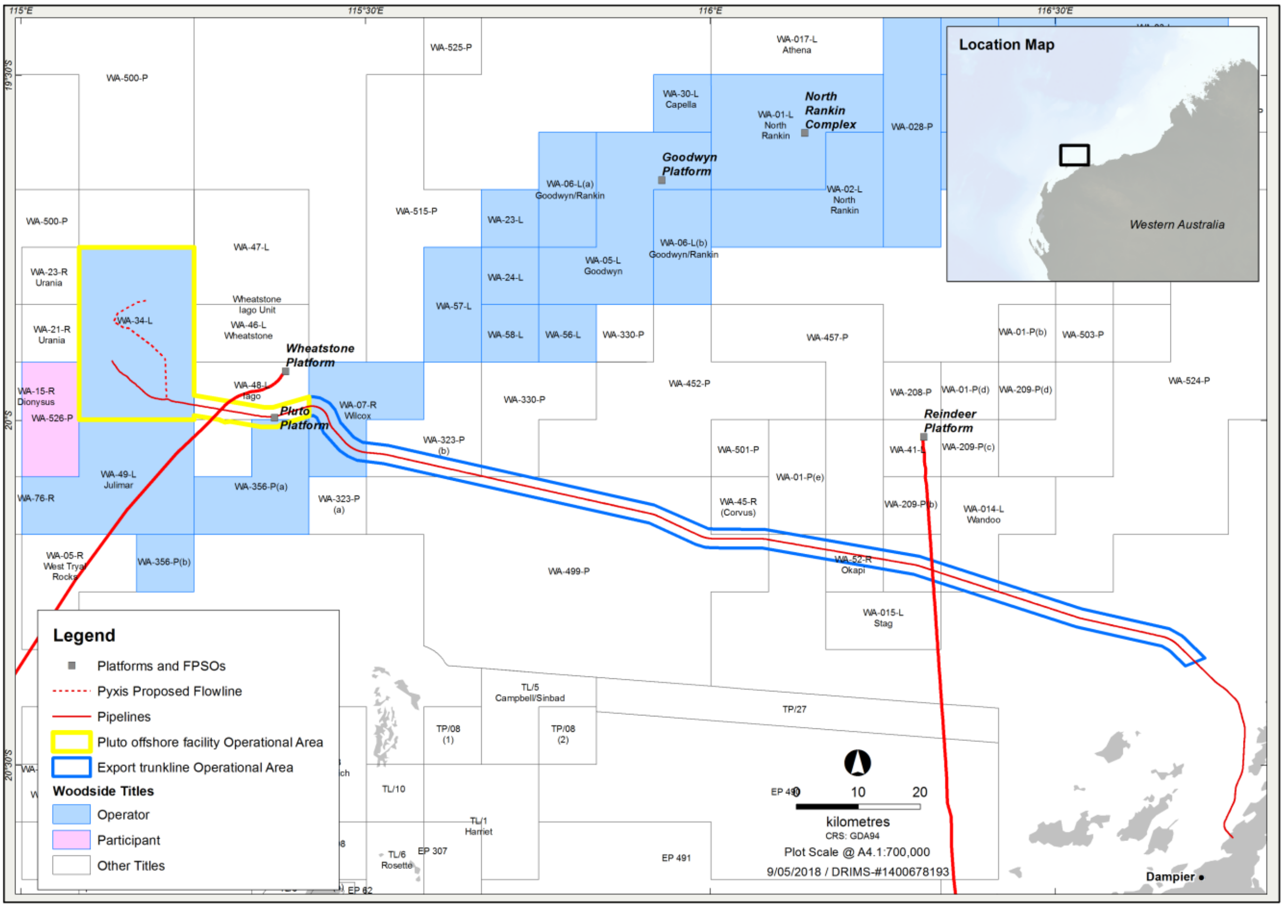

Figure 2-1: Pluto offshore facility and Operational Area

The coordinates and permit areas of the facility and associated infrastructure are presented in **Table 2-1.**

Table 2-1: Locations of the Pluto offshore facility, associated infrastructure and petroleum permits

Structure	Latitude	Longitude	Title
Riser platform	-19 ° 54 ' 49.23614 "	115 ° 7 ' 54.46587 "	WA-1-IL
Pluto A and B flowlines	-	-	WA-16-PL
Export pipeline (Commonwealth)	-	-	WA-17-PL
PLA01ST1 Well	-19 ° 54 ' 48.23107 "	115 ° 7 ' 54.75273 "	WA-34-L
PLA02 Well	-19 ° 54 ' 48.56705 "	115 ° 7 ' 55.78025 "	WA-34-L
PLA03ST1 Well	-19 ° 54 ' 48.70289 "	115 ° 7 ' 56.32877 "	WA-34-L
PLA04 Well	-19 ° 54 ' 48.69494 "	115 ° 7 ' 55.57246 "	WA-34-L
PLA05 Well	-19 ° 54 ' 49.23614 "	115 ° 7 ' 54.46587 "	WA-34-L
PLA06 Well	-19 ° 54 ' 48.25708 "	115 ° 7 ' 54.13355 "	WA-34-L
XNA01 Well	-19 ° 58 ' 13.56660 "	115 ° 12 ' 46.17465 "	WA-34-L
Proposed XNA02 Well *	-19°57'54.089"	115 ° 13'08.957"	WA-34-L
Proposed XNA03 Well*	-19°56'28.914	-115°13'44.302	WA-34-L
Xena tie-in	-19 ° 58 ' 15.25052 "	115 ° 12 ' 45.46775 "	WA-34-L
Proposed PLA07 Well	*-19° 54' 48.96"*	*115° 07' 55.2"*	WA-34-L
Proposed Pluto Well (PL-PYA02)*	*-19 ° 52 ' 11.83574 "*	*115 ° 8 ' 18.55154 "*	WA-34-L
Proposed XNA02 Well	*-19 ° 58 ' 13.56660 "*	*115 ° 12 ' 46.17465 "*	WA-34-L
Proposed PYA01 Well*	*-19 ° 49 ' 34.18078 "*	*115 ° 10 ' 52.96514 "*	WA-34-L
Proposed Pyxis flowlines	-	-	*Licence TBC*

** Proposed well locations may vary up to 3 km in radius subject to further engineering design.*

3. DESCRIPTION OF THE ACTIVITY

3.1 Overview

Woodside is the operator of the facility and associated infrastructure on behalf of itself and its Pluto LNG joint venture partners, Tokyo Gas Pluto Pty Ltd and Kansai Electric Power Australia Pty Ltd. The nominated Titleholder for this activity is Woodside.

The facility produces wet gas and condensate from a series of reservoirs and associated subsea infrastructure. The facility operates as a not normally manned (NNM) platform, with remote operation from the onshore Central Control Room (CCR) located at the onshore LNG Plant. Gas and condensate are transported onshore for processing via a 180 km long export pipeline.

A water handling module is to be installed on the riser platform to enable the processing and discharge of produced water at the platform. Wet gas will be processed through the water handling module, with the processed gas and condensate transported to the onshore LNG Plant for processing.

The infrastructure covered by this EP includes the:

- riser platform
- current and planned future Pluto, Xena and Pyxis wells
- flowlines and riser systems between wells and the riser platform
- export pipeline and 6 inch chemical supply line
- other subsea infrastructure including subsea trees, umbilicals, spools, jumpers, and manifolds.

Emergency shutdown (ESD) valves exist at various locations in the offshore facilities, including at the top of each flowline and pipeline riser to the riser platform.

Due to the potential for ingress of water in the Pluto reservoir towards the production wells, produced water (PW) treatment and disposal may be required if the treatment capacity of the onshore facility is exceeded. Woodside proposes to install a water handling module on the existing riser platform to treat PW. Installation of the module is proposed during 2020, with operation expected to be required from 2021. Operation of the module is dependant of volumes of PW and timing may vary.

3.2 Operational Area

The Operational Area defines the spatial boundary of the Petroleum Activities Program. The area includes (**Figure 2-1**):

- the riser platform and the area within a 500 m PSZ around the riser platform
- the export pipeline (P1TL) and associated 6-inch chemical supply line covered by Pipeline Licence WA-17-PL and an area encompassing 1500 m around the subsea infrastructure
- Pluto, Xena and proposed Pyxis subsea facilities (including wells, production and pigging manifolds, production jumpers, spools, flowlines and flexible jumpers) and an area within 1500 m around the subsea infrastructure.

Vessel related activities within the Operational Area will comply with the EP. Vessels supporting the Petroleum Activities Program when outside the Operational Area will adhere to all applicable maritime regulations and other requirements.

3.3 Timing of the Activities

The facility commenced production in 2012. The facility is designed to operate unmanned 24 hours per day, 365 days per year. Maintenance activities are undertaken to support the day to day operations of the facility as required.

End of life of the Pluto, Xena and Pyxis fields is not expected during the life of this EP. Tie-back opportunities are continuously being reviewed for Woodside's offshore facilities, which have the potential to extend the life of the fields. Any future decommissioning or drilling will be subject to a separate EP.

The installation of water handling facilities and the operation of the Pyxis field tie-in (drilling and installation of additional infill wells and the Pyxis and Pluto tie-back, and associated risks/impacts of these activities will be subject to separate EPs) to the facility is expected to commence during 2020.

The water handling module is proposed to be available for start-up in 2021 after which discharge of produced water may commence, when required.

3.4 Facility Layout and Description

3.4.1 Topsides

The riser platform topsides comprise five decks separated by two major vertical trusses. A pedestal crane is located on the north-east end of the facility. The flare boom is inclined and located at the northern end of the facility. A water handling module will be installed on the western side of the riser platform. The helideck is located above the southern corner.

Other facilities include pig launchers and receivers for the flowlines and export pipeline, vessels for handling pigging fluids, metering for inflow streams, chemical injection facilities (monethylene glycol [MEG] and corrosion inhibitors), diesel power generators, emergency flare, pedestal crane, temporary waste storage, helideck, bunkering facility, telecommunications, monitoring, control and safety systems and marine navigational aids.

An upgrade to the power generation is proposed as part of the water handling module installation, including a gas engine utilising fuel gas as the primary fuel source, supported by two diesel generators. Chemical storage and injection facilities (corrosion inhibitors and water clarifier) are also proposed as part of the water handling module.

Although the riser platform is NNM, permanently installed accommodation facilities are provided on the southern end of the topsides to accommodate personnel required for campaign maintenance, significant modifications and pigging activities.

3.4.2 Wells and Reservoirs

Pluto Wells

Gas and condensate from the Pluto reservoir is currently produced through six big bore gas production wells which are configured in a cluster arrangement around a central manifold at the drill centre. The primary down-hole safety system is a surface control sub-surface safety valve (SCSSSV) fitted to each well. The wells are completed with a subsea tree system.

Additional infill wells from the Pluto reservoir are proposed to be operated during the life of this EP (PLA07 and PL-PYA02). Drilling, completions, pipeline installation and pre-commissioning activities associated with new wells for all reservoirs are covered under separate EPs.

Xena Wells

Condensate and gas from the Xena reservoir is currently produced through one gas production well. The well is independently isolated and controlled via a spur tie-in to the existing Pluto electro-hydraulic umbilical, located close to the existing tee locations. MEG and other chemicals as required are distributed to the well via a dedicated jumper between an existing MEG Pipeline End Termination (PLET) on the chemical supply line. The existing well was completed with a subsea tree system, similar to those installed on the Pluto wells.

An additional infill well from the Xena reservoir (XNA02) is proposed to be operated during the life of this EP.

Pyxis Well

Condensate and gas from the Pyxis reservoir will be produced through one gas production well, approximately 25 km north north-east of the existing Pluto A flow line in-line tee, in approximately 1000 m of water.

The well will be independently isolated and controlled via a spur tie-in to the existing Pluto electro-hydraulic umbilical, located close to the existing tee locations. MEG and other chemicals as required will be distributed to the well via a new integrated service umbilical supplied from an existing MEG PLET on the chemical supply line. The well (PYA01) will be completed with subsea tree system, similar to those installed on the Pluto wells.

3.4.3 Flowline and Riser System

Production from the Pluto wells is routed approximately 27 km through dual 20-inch flowlines with an adjacent chemical supply line, up the continental slope to the riser platform.
During water production through the water handling module, Flowline B operates in wet mode, with Flowline A remaining unchanged as a dry flowline. The Xena well (and proposed future Xena well) is connected to the production flowline via the following subsea infrastructure:

- a flexible production jumper
- mid-line connector system (MLCS) to the existing flowline tees.

The proposed Pyxis and PL-PYA02 wells will be connected to the production flowlines via the following subsea infrastructure:

- an approximately 25 km flexible flowline up to 12-inch
- an 8” flexible production jumper from the flowline end terminal to existing MLCS-A and Pluto flowline A in-line tee.

The flowlines and subsea system are sized to match the peak offtake rate required by the onshore LNG plant.

3.4.4 Pipeline and 6-inch Chemical Supply Line

Gas, condensate and other fluids (process chemicals and produced water) are currently transported from the riser platform to the LNG Plant via a 36-inch pipeline. Flow assurance is aided by the supply of MEG and other process chemicals in small concentrations (including corrosion inhibitor, biocide, oxygen scavenger, scale inhibitor, etc.) as required to protect the integrity of the pipeline. These chemicals are supplied from onshore storage and reclamation infrastructure and pumped via the 6-inch chemical supply line piggy-backed to the pipeline from onshore to the riser platform. Chemicals are then supplied from the riser platform to the wells via a 4-inch chemical supply line.

The offshore gas pipeline and 6-inch chemical supply line route between the shore and the facility is approximately 180 km in length with a shore crossing at Holden Point, just north of the Pluto export jetty.

3.4.5 Subsea Infrastructure

The main components of subsea infrastructure include wells, subsea trees, umbilicals, spools, jumpers, manifolds, flowlines, riser, chemical supply lines and the export pipeline.

The subsea system is typically controlled from the Pluto onshore CCR via satellite links:

- rigid spools transporting hydrocarbons from the wells to the manifold/MLCS where the fluids flow through the 20-inch flowlines to the riser platform for onwards processing at the onshore facility
- jumpers and umbilicals which provide hydraulic and electric power, communications and chemical supplies
- valves which control subsea operations and processes
- chokes which control pressure and flow rates of hydrocarbon
- subsea control module (SCM) which contain sealed and pressure compensated electro hydraulic units (typically found on manifold and/or wellheads) and links the surface and subsea controls.

A number of subsea valves may also be overridden manually from a Remote Operated Vehicle (ROV) or by divers.

3.5 Pluto Water Handling Project

3.5.1 Overview of water handling project

Due to the potential for ingress of water in the Pluto reservoir towards the production wells, PW treatment and disposal may be required if the treatment capacity of the onshore facility is exceeded. Woodside proposes to install a water handling module on the existing riser platform to treat PW.

3.5.2 Project Description

The Pluto Water Handling project comprises the installation of a water treatment module on the existing riser platform to separate and treat up to 3500 m^3 per day of PW prior to discharge overboard. The modification of the riser platform to enable water processing proposes to maintain the NNM philosophy, as per the existing operations. Minor modifications to the existing riser platform are proposed with tie-ins to the existing pipework and the addition of a water disposal line. The installation of a new power generation system on the module is proposed to support the additional power generation requirements associated with water handling. This includes a gas driven engine that will change the current primary fuel source from diesel to fuel gas for the facility.

3.5.3 Installation and Commissioning

Installation of the water handling module on the riser platform is proposed using a single heavy lift Dynamically Positioned (DP2 or higher) vessel. Transportation of the water handling module to the field is proposed via heavy lift vessel (HLV). When a suitable weather window arrives, the platform will be depressurised and the module raised and set down onto the riser platform. The HLV will remain outside the PSZ until a suitable weather window arrives.

Pre-commissioning of the water handling module is proposed prior to the load out for transportation to the field. Further commissioning of the module will be required after module landing, including pipework and valves to be tied in to the existing facility and integration of power generation and other module equipment. Commissioning is expected to take approximately 12 months from installation.

As part of commissioning activities of the water handling module there may be minor discharges to the environment associated with flushing, pressure and leak testing activities; however, these are expected to be limited and of short duration. Fluids may include inhibitors, biocides and scavengers, as required.

3.6 Operational Details

This section provides a description of the main operations associated with the facility. It includes key elements in relation to interaction between the activity and the environment.

3.6.1 Manning and Modes of Operation

The facility is designed to operate without operator intervention. Normal operations are controlled remotely satellite links the from Pluto onshore CCR. Activities which require manning are:

- engineering projects
- campaign maintenance
- unplanned corrective (breakdown) maintenance
- inspections/audits
- planned facility shutdowns.

Operations fall under any one of the following modes of operation:

- production remote operations
- major projects
- maintenance, including subsea IMR activities
- well maintenance.

These modes of operation are described below. Production, maintenance and project activities may occur concurrently.

Production Remote Operations

The facility operates as a NNM facility and may be operated, monitored, controlled, restarted and diagnosed remotely from the riser platform or Pluto onshore CCR.

The Process Control System for the facility provides the following monitoring and control functions:

- basic monitoring of key performance indicators
- adjustment of devices on the facility such as control valves, pumps, and variable speed drives
- alarm signals
- automatic management of duty/standby and lead/lag equipment.

Major Projects

Major projects involve refurbishment, modification or major maintenance on the facility. The Projects function is responsible for undertaking these projects.

Maintenance

Inspection, maintenance and repairs, including those undertaken subsea, are undertaken to maintain production within the platform and subsea infrastructure design constraints.

Maintenance teams routinely visit the facility for:

- planned maintenance undertaken as campaigns during routine interventions, typically conducted five to six times per year, each lasting nominally fourteen days, unplanned corrective (breakdown) maintenance as required
- shutdown maintenance

- pigging of the pipeline/flowlines for sand and debris removal, liquid management, inline inspection, well clean up and hydrate remediation. The frequency of pigging operations is defined in Pluto Pipeline System Inspection, Monitoring and Maintenance (IMM) Plan
- contingent manning on the riser platform involving continuous manning for indefinite periods to address low probability equipment failures, operational issues or major projects such as the installation of the water handling module.

When the facility is manned, primary control is retained by the onshore CCR, with personnel on Pluto communicating with the onshore CCR. Operational control of equipment is handed to 'local control' on the facility on an as-required basis.

3.6.2 Process Description

Production Process

The riser platform receives well fluids (gas, condensate, associated produced water and other fluids such as process chemicals) from the Pluto, Xena and future Pyxis production wells. The facility then exports gas and condensate from the riser platform via the pipeline to the onshore gas plant for processing. With the installation of a water handling module, the facility will have the ability to separate and discharge PW. The riser platform also receives chemicals from the 6-inch chemical supply line, and transports these to the wells via the 4-inch chemical supply flowlines.

Utility and Gas Flare System

The riser platform currently has a combined high pressure flare and utility gas system. As the facility does not currently use gas as combustion fuel for power generation, processing requirements normally required for conditioning fuel gas (such as filtering and superheating) are not included.

Once the water handling module is installed and commissioned, fuel gas will become the primary fuel source for the gas engine. The fuel gas conditioning facilities (filtering and super heating) will be installed as part of the module.

Utility gas is required:

- for continuous purging of the flare header to prevent air ingress
- to supply pilot gas for the flare tip pilots
- to supply to the induced gas floatation unit for gas injection to maximise oil in water separation.

Produced Water System

The riser platform receives minimal wet gas from the Pluto reservoirs and transports it via the pipeline to shore for processing. To date, no PW has been separated or disposed from the offshore facility.
Future PW volumes have the potential to exceed the capacity of the onshore processing facility, as such, produced water treatment facilities are required offshore. The maximum design case for water treatment is 3500 m^3/day. The rate of PW is forecast to range from as low as 30 m^3/day up to a maximum of 3500 m^3/day, dependent on the number of wells producing water and their associated flowrate.

PW Discharge Oil in Water Monitoring

The measurement of oil in water in the PW stream is undertaken prior to discharge to the ocean. Oil in water (OIW) concentrations will be measured using online OIW analysers. The analysers are designed specifically for offshore operations and reports total petroleum hydrocarbons (TPH). Two OIW analysers will be installed on the module, with at least one analyser on-line at any one time in case one breaks down or is suspected of fault.

PW Discharge Monitoring

PW discharge on the facility is managed in accordance with the Offshore Marine Discharges Adaptive Management Plan. This plan has been developed to detail the disposal of routine marine discharges from Woodside's offshore production facilities in accordance with Woodside's Environmental Performance Procedure. Implementation of the plan also verifies the discharges are managed in a way that reduces the potential environmental risks and impacts to ALARP.

Drainage Systems

The open and closed drains system consists of both hazardous and non-hazardous open drains. The open drains system is required for disposal of water and hydrocarbons, which are at atmospheric pressure (e.g. deck water). Drains from hazardous areas are totally segregated from drains from non-hazardous areas, to prevent ingress of gases into a non-hazardous area via the drains system.

The closed drain system is designed to safely collect, contain and recycle depressurized hydrocarbons, chemicals and other liquids from normally pressurized and hazardous equipment and is fully contained. The drained liquids are routed to the flare knock-out drum during normal operations and then pumped into the export pipeline for transfer to shore.

Hazardous Open Drains

The hazardous open drains system collects non-pressurised spillage, overflows, contaminated deck wash-down and some rainwater from the open drain boxes, tundishes and equipment drip trays in areas designated as hazardous. The hazardous open drains flow to the hazardous open drains collection tank (working volume 11.6 m^3) when the facility is manned and work is being undertaken in the area. Areas of the facility have secondary spill protection (bunding) depending on the location, protection and spill risk of each component of the facility to contain and direct flows to the hazardous open drains system.

Non-hazardous Open Drains

The non-hazardous area open drains system collects liquids from open drain boxes, tundishes and equipment drip trays in areas designated as non-hazardous. It is segregated from all other drainage systems to eliminate the risk of hydrocarbon vapour transmission from hazardous to non-hazardous areas. Drains from the diesel generator bunds/tanks are part of the non-hazardous area open drains system. Water and any contamination are routed to the non-hazardous area open drains collection tank. This tank is sized for containing in excess of the full volume from a diesel generator day tank, and has a working volume of 2 m^3 (with max capacity of 2.6 m3).

3.6.3 Utility Systems

Platform Lighting

The riser platform has appropriate lighting to ensure a safe working environment during 24 hour operations. Lighting is split between emergency and normal lighting. The emergency light fittings have been located to illuminate the designated escape routes on the facility. Navigational lights are located on the riser platform flare tower and on the booms and towers of the pedestal crane. Helideck lighting is also provided to assist helicopter landing.

Unless required to support over the side activities (such as bunkering and lifting operations), lighting on the facility is directed to the work area when manned, which limits light spill to the marine environment.

Heating Ventilation and Air Conditioning System

The heating, ventilation and air conditioning (HVAC) system comprises HVAC equipment, ductwork and associated pipework. It provides independent and interdependent sub-systems with pressurised, conditioned, purge and exhaust air services to all living to various areas including accommodation and various modules which can be operated on an as required basis or continuous basis.

Potable Water

Commercially supplied water from onshore is provided for drinking and domestic use on the riser platform, which is bunkered by support vessels and transferred into a storage tank. The service water passes through a UV disinfection unit to ensure water quality for users.

MEG System

Lean MEG is filtered onshore, then transferred to the riser platform via the 6-inch subsea chemical supply line. Once on the riser platform, the MEG is again filtered and distributed to the Pluto/Xena/Pyxis wells via the 4-inch chemical supply line. The MEG flow is controlled by manual adjustments in subsea injection chokes, which are controlled via the CCR. MEG ensures the water in the flowlines is inhibited against hydrates. Other chemicals, such as corrosion inhibitors, biocides, oxygen scavengers, and scale inhibitors, may be mixed with the MEG to aid in integrity and asset protection. These chemicals are injected into the wells in dilute concentrations as required for technical requirements.

If required for intervention purposes, MEG or methanol may also be transferred onto the facility via iso-tanks to a 10 m^3 storage vessel.

Wet Flowline Conversion

To segregate wet wells for processing through the water handling module, the Pluto flowline B will be converted to a wet mode flowline. Pigging of the wet flowline will be required approximately four yearly. Prior to pigging operations, the flowline will be required to be converted from wet to dry mode to treat the flowline with MEG and prevent hydrate blockage. Upon restart post pigging, the flowline is required to be converted from dry mode back to wet mode. As part of this, up to 52 tonnes of diluted MEG will be displaced from the flowlines and wells, which will enter the water treatment process on the facility and be discharged overboard.

If the wet flowline is shut down, residual MEG in each wet well (1.6 tonnes) and uninsulated sections of the flowlines subsea (14 tonnes) will be displaced to the water treatment process to be processed on the facility and discharged overboard.

Power Generation

As the riser platform is NNM and includes no processing, the power demand of the facility is characterised by long periods of very low power demand and short duration peaks in demand. Continuous power during normal operations is required by the utility gas pre-heater, to maintain charge in the uninterruptible power supply (UPS) batteries, and for lighting and navigational aids. Peaks in demand occur during flowline pigging (which requires running of the flare knock-out drum pumps) and recovery from an extended blackout (which requires the UPS batteries to be heavily recharged).

Power for the facility is currently provided by three small diesel generators located on the platform, with capacity of 240 kW per generator. One out of the three diesel generators remains online during normal operating mode, with the other two on standby. For operations requiring additional power, one of the standby generators is brought online. The generator tanks are located in a bunded area which drains into the non-hazardous open drains system.

Sewage and Putrescibles Wastes

No sewage or putrescible wastes are produced from the riser platform for the majority of the time (i.e. during unmanned periods). When the facility is manned, the sanitary drainage system is a combined black and grey water system, with black and grey water discharged to the marine environment as untreated, un-macerated waste. Sewage is disposed via a dedicated overboard caisson. The caisson is a 300 mm carbon steel pipe that discharges at approximately 7.5 m below LAT. A rodding point is also provided at the top of the disposal caisson.

When the facility is manned, putrescible waste (principally food scraps) are bagged and transported to shore for disposal as domestic waste, in accordance with the requirements of Woodside's Waste Management Plan for Offshore Facilities.

Sand Management

Subsea wells are equipped with sand screens and acoustic sand detection meters and erosion probe located on the subsea trees. The facility basis of design assumes there is a low probability of sand production. Hence, any sand produced in normal operation should not cause any significant erosion or corrosion impact in the flowlines. In the event of sand production, the sand is expected to accumulate in the onshore facilities, where there is provision for sand removal, if required.

Sand and other material (sludge, scale, etc.) with the potential to be contaminated with NORMs is tested and disposed of in accordance with Woodside's Waste Management Plan for Offshore Facilities.

Diesel Fuel System

Low sulphur diesel is transferred to the riser platform in bulk from supply vessels via a hose reel located at the dedicated bunker station on the platform. Diesel is bunkered directly into the crane pedestal diesel bulk storage tank which has a maximum storage capacity of 80 m^3. Filters provided on the diesel inlet assist in preventing blockage of the tank level devices. Diesel is metered and distributed to users via a continuously pressurised ring main. Unused diesel is recycled back to the crane pedestal. The tank is equipped with level fall alarms and remote shut-off systems to allow shutdown of the system locally or from the Pluto onshore CCR.

Diesel is required for:

- crane tank
- lifeboat tank
- diesel generators.

With the installation of the water handling module and the change to fuel gas being the primary source for power generation, diesel consumption is forecast to reduce which is expected to reduce the bunkering frequencies.

Hydraulic Fluid System

The riser platform is provided with a hydraulic power unit (HPU) hydraulic fluid storage tank of 4 m^3 capacity. A glycol based hydraulic fluid is supplied to actuate valves on the topsides and subsea facilities including shutdown valves, blowdown valves, high integrity pressure protection system (HIPPS) valves, control valves and subsea tree, surface controlled sub surface safety valve and choke valves.

Hydraulic fluid supplied to the subsea facilities is in an open-loop configuration, and each actuation of a valve will release a small quantity of the fluid at the SCM vent port.

3.7 Hydrocarbon and Chemical Inventories and Selection

3.7.1 Hydrocarbons

The main hydrocarbon inventories associated with major topside process and non-process equipment is summarised in **Table 3-1.** In addition to the chemicals listed, the riser platform may also maintain small volumes of various facility maintenance chemicals as previously described.

Table 3-1: Hydrocarbon Inventories of process and non-process equipment

Material	Storage Means	Capacity/Storage Volume
Hydrocarbons		
Condensate	Knock-out drum	Usual volume 5 to 10 m^3, with capacity 90 m^3
Diesel	Crane pedestal diesel storage tank	80 m^3
	Generator set day tanks	3 x 1.8 m^3
Oily water and chemical waste	Hazardous Drain Collection Tank Non Hazardous Drain Collection Tank Waste Oil Storage Tank (transportable ISO container)	14 m^3 (working volume 11.6 m^3) 2.3 m^3 4 m^3
Water Handling Module – indicative hydrocarbon inventories		
Production separator	Vertical gas/liquid separator	30 m^3
Liquid-liquid separator	Produced water/condensate separator	40 m^3
Degasser	Produced water vessel	40 m^3
Induced gas floatation vessel	Produced water vessel	30 m^3
Oily water separation tank	Oily water storage tank	4 m^3

3.7.2 Chemical Usage

Chemicals are used on the facility for a variety of purposes and can be divided into two broad categories (operational and facility maintenance).

Operational Chemicals

Operational Process Chemicals

An operational process chemical is the active chemical added to a process or static system, which provides functionality when injected in produced fluid, utility system streams or for pipeline treatment. These chemicals may be present in routine or non-routine discharge streams from the facility.

Currently no operational process chemicals are discharged from the facility, however water handling will introduce additional operational process chemicals such as corrosion inhibitors (up to 75 ppm dependent on water flow rate) and water clarifiers (up to 50 ppm), some of which will be present in the routine discharge of produced water.

Operational Non-Process Chemicals

Operational non-process chemicals include chemicals which do not fall into the category described above but which may be required for operational reasons and, by virtue of their use, may be intermittently discharged or have the potential to be discharged (e.g. required as a result of maintenance or intervention activities). Examples include subsea control fluids, dyes and well intervention/workover chemicals.

Water handling will introduce additional operational non-process chemicals such as hydraulic fluids (e.g. required for operation of the water handling module HPU).

Maintenance Chemicals

Maintenance chemicals include chemicals which are required for general maintenance or ‘housekeeping’ activities and are critical for overall maintenance of the riser platform and its equipment. These may include paints, degreasers, greases, lubricants and domestic cleaning products. They may also include chemicals required for specialty tasks, such as laboratory testing and analysis. Maintenance chemicals generally present negligible risk to the environment, as they are not discharged as a result of their use (e.g. paint) or are used intermittently and discharged in low volumes (e.g. domestic cleaning products).

3.7.3 Indicative Chemical Inventories

An indicative list of bulk chemicals commonly used (or planned to be used on the facility) and estimated storage quantities, is summarised in **Table 3-2**. Other chemicals may be used in the future if chemical requirements change, for example, during start-up of new wells, there may be also be temporary well clean-up skid which may include water clarifiers. In addition to the chemicals listed, the riser platform may also maintain other small volumes of various operational chemicals and facility maintenance chemicals as previously described.

Table 3-2: Indicative bulk inventories of chemicals

Material	Storage Means	Storage Capacity
MEG	Hydrate inhibitor storage vessel[1] Transportable ISO container	12 m^3 (working volume 10 m^3)
Methanol (if required)	Hydrate inhibitor storage vessel [1] Transportable ISO container	Typically 4-6 m^3 ISO containers
Subsea control fluid	Hydraulic power unit storage tank	4 m^3
Water Handling Module – indicative inventories		
Water clarifier (if required)	Water clarifier storage tank	4 m^3
Demulsifier	Demulsifier storage tank	4 m^3
Corrosion inhibitor	Corrosion inhibitor storage tank (stainless steel) Transferred by hose from supply vessel	28 m^3 N/A
Subsea control fluid	Hydraulic power unit storage tank for water handling module	3 m^3

[1] Only a single hydrate inhibitor storage vessel is provided on the platform; however, the utility fluid may vary between methanol and MEG depending on operations requirements.

Environmental Selection Criteria

As part of Woodside's chemical approval process, operational chemicals required by the Petroleum Activities Program are selected and approved in accordance with the Woodside Chemical Selection and Assessment Environment Guideline.

The chemical assessment process follows the principles outlined in the Offshore Chemical Notification Scheme (OCNS) which manages chemical use and discharge in the United Kingdom (UK) and the Netherlands (background on the OCNS scheme provided is below), specifically:

- Where operational chemicals with an OCNS rating of Gold/Silver/E/D and no OCNS substitution or product warning are selected, or a substance is considered to pose little or no risk to the environment (PLONOR), no further control is required. (Such chemicals do not represent a significant impact on the environment under standard use scenarios and therefore, are considered ALARP and acceptable).
- If other OCNS rated or non-OCNS rated operational chemicals are selected, the chemical will be assessed further.

If no environmental data is available for a chemical or if the environmental data does not meet the acceptability criteria outlined above, potential alternatives for the chemical will be investigated, with preference for options with an HQ band of Gold or Silver or which are OCNS Group E or D with no substitution or product warnings.

If no more environmentally suitable alternatives are available, further risk reduction measures (e.g. controls related to use and discharge) will be considered for the specific context and implemented where relevant to ensure the risk is ALARP and acceptable.

Once the further assessment/ALARP justification has been completed, concurrence from the relevant manager that the environmental risk as results of chemical use is ALARP and acceptable is obtained.

Background Overview of the OCNS Scheme

The OCNS Scheme applies the requirements of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention). The OSPAR Convention is widely accepted as best practice for chemical management.

All chemical substances listed on the OCNS ranked list of registered products have an assigned ranking based on toxicity and other relevant parameters such as biodegradation, and bioaccumulation, in accordance one of two schemes:

- Hazard Quotient Colour Band: Gold, Silver, White, Blue, Orange and Purple (listed in order of increasing environmental hazard), or
- OCNS Grouping: E, D, C, B or A (listed in order of increasing environmental hazard). Applied to inorganic substances, hydraulic fluids and pipeline chemicals only.

3.7.4 Facility Operations

Operational Flaring

Flaring is expected to occur during a range of operational circumstances; key operational flaring events are explained in further detail in the following sections. Annual internal facility flare targets are set based on operational activities planned for the year. This target is used to assess facility flare performance.

Normal Operations

A relatively small quantity of gas is required to be continuously flared associated with purge and pilot of the flare system and disposal of waste streams which are not recovered to the process.
Prior to installation and operation of the water handling module, typical annual flaring is 530 tonnes per annum (tpa). Following installation of the water handling module, continuous flows to the flare will increase to approximately 3500 tpa. Sources include:

- flare pilot
- HP flare header purges
- leakage past flare header values such as pressure safety valves (PSVs) and blowdown valves (BDVs)

- PW degasser
- PW induced gas floatation
- oily water separator tank.

Intermittent Process Upsets and Activities

During process upsets, the process control valves on the main process equipment open to relieve excess pressure to the HP flare. The following sources make up intermittent flaring.

Operational Pigging

Flaring to facilitate round-trip pigging of the flowlines is an integral part of operation of the facility and occurs as required (approximately once every four years). Produced gas is flared during flowline pigging operations, with liquids exiting the flowlines stored in the flare knock-out drum. Pipeline gas is used to propel the pig in the first half of the flowline loop. Well fluid is used to propel the pig in the second half of the flowline loop, with produced gas and liquids from flowline pigging directed to the pipeline.

Emergency Blowdown

The topsides equipment and piping are divided into isolatable sections, each with a dedicated BDV. During an ESD, each section is separately depressurised to the HP flare. Each section contains a fail-open actuated BDV which allows blowdown of the entire riser platform inventory. The total volume depressurised is 7 tonnes. With the water handling module on the platform, this will increase to approximately 8 tonnes as a result of additional process vessels and pipework.

Manual Depressurisation

Manual depressurisations will result in intermittent flaring of hydrocarbons, triggered by routine equipment maintenance, planned ESD testing and/or depressurisation of equipment and piping to remove the equipment from service. Furthermore, equipment must be depressurised prior to draining as the closed drains system is not intended for high pressure service.

Subsea Flowline Depressurisation

The well fluid in the subsea flowlines (which carry hydrocarbons from the subsea wells to the Riser platform) may on rare occasions need to be routed to the flare to allow the pressure in the flowlines to be reduced. The flowlines may require depressurisation for the following reasons:

- over-pressurisation of flowlines above integrity limit
- leak-off testing
- production flowline maintenance (if required)
- to facilitate remediation in the event of an unplanned hydrate blockage in the subsea flowlines
- for flowline hydrate management.

Estimated Flare Volumes

The amount of gas that may be flared on an annual basis is a dependent of continuous and intermittent process sources, planned activities requiring flaring, and unplanned process upsets. The estimated annual amount of gas flared prior to water handling ranges between 530 tpa and 5530 tpa, and following installation of the water handling module ranges between approximately 3500 and 13,000 tpa.

Lifting Operations

A pedestal crane is located on the east side of the riser platform at the weather deck, providing the necessary coverage for all on-deck material handling requirements and lifting between the riser platform and supply vessels. The pedestal crane is powered by diesel.

Routine lifting operations primarily include transferring stores and equipment from a support vessel to the facility. Support vessels are equipped with dynamic positioning (DP) control for holding station during lifting operations. The types of 'lifted equipment' may vary but generally include containers or skips of various sizes. The stores and equipment required by the facility are secured inside the skip or container. Containers for supply of chemicals are routinely lifted. Equipment is to be appropriately rated for offshore lifting.

Once lifted to the lay down area, there may be a need to re-position equipment at various locations throughout the facility for operational purposes. This includes lifting stores or equipment to various landing areas throughout the facility for unloading or use, and moving waste bins to required areas.

There is also a requirement to undertake operational lifting utilising rigging, chain blocks or electric hoists. This lifting is primarily undertaken for maintenance or repairs and involves lifting and removing equipment such as valves, spools and motors.

3.7.5 Safety Features and Emergency Systems

A range of safety features and emergency systems have been integrated into the design and operation of the Offshore Facility to manage safety risk. Based on Woodside's Health and Safety Design Premises for Hydrocarbon Facilities, risk management measures have been grouped into the categories of:

- prevention
- detection
- control
- mitigation.

The safety features and emergency measures in place on the facility are listed in **Table 3-3**. Specific details of these and other safety systems can be found in the Pluto A Safety Case.

Table 3-3: The Pluto facility safety features and emergency systems

Category	Description
Prevention	Inherently safe design (leak minimisation, layout) Dropped object/impact protection (including vessel collision avoidance) Structural design Material selection and corrosion control
Detection	Fire, gas and smoke detection (including manual alarm callpoints)
Control	Process control system Ignition control Depressurisation systems Passive fire protection Heating, ventilation and air conditioning
Mitigation	Escape and evacuation routes Temporary refuge Emergency power and UPS

Category	Description
	Emergency and escape lighting Critical communications systems Evacuation and rescue facilities and equipment

3.7.6 Support Vessel Operations

Platform Support Vessels

Platform support vessels are used to transport material and equipment to and from the riser platform when manned. The specifications of the *Mermaid Strait* are presented in **Table 3-4** as an example, and represent the typical specifications of a platform support vessel. Vessels supporting the facility may vary depending on vessel schedules and availability.

While in the field, the vessel also backloads materials and segregated waste for transportation back to the King Bay Supply Facility in Karratha, as well as carrying out standby duties including during helicopter operations and working over the side activities while in the field.

Table 3-4: Indicative platform support vessel specifications (Mermaid Strait)

Particulars	
Type	Diesel Electric, Azimuth, AHT, OSV, DP1
Length overall (LOA)	52.35 metres
Breadth	14.6 metres
Draft	4.9 metres
Dead weight tonnage (DWT)	930 tonnes
Accommodation	Berthing for 24 personnel
Dynamic positioning (DP) system	Kongsberg Simrad DP1 with Poscon joystick control
Performance	
Max speed	12.5 knots
Service speed	11 knots
Economical speed	10 knots at 7.5 t/day
Machinery	
Main engines	Three Caterpillar 3516C @1825 kW
Bow thrusters	One Schottel STT02 550 kW
Stern thrusters	N/A
Capacities	
Fuel	592 m^3
Potable water	283 m^3
Glycol	Nil
Deck area	620 m^3
Pollution Control	

Spray booms	Nil
Dispersant pump	Nil
Dispersant storage	Woodside issued dispersant kit: tank volume 350 gallons.

3.7.7 Subsea Support Vessels

Subsea support vessels are also used for field work such as subsea inspection, maintenance and repair activities. Vessels supporting offshore activities may vary depending on operational requirements, vessel schedules, capability and availability.

Subsea activities are typically undertaken from a diving or installation support vessel via one or more ROV and/or divers. Typical support vessels use a DP system to allow manoeuvrability and avoid anchoring when undertaking works, due to the close proximity of subsea infrastructure. However, vessels are equipped with anchors which may be deployed in an emergency.

The DP system requires the temporary deployment of up to six transponders on the seabed. Transponders are also used for monitoring the location of infrastructure/equipment during a repair. The transponders are attached to small recoverable moorings (metal clump weight or tripod) that are lowered to the seabed and placed in position by ROV. The transponders have a small footprint; less than 0.5 m^2. The transponders and moorings are recovered using ROVs at the end of the activity.

3.7.8 Accommodation Support Vessel

An Accommodation Support Vessel (ASV) may be required for short periods (typically < 1 month) to support planned maintenance campaigns, shutdown maintenance or major projects. ASV vessel specifications may vary depending on operational requirements, vessel schedules, capability and availability. Typical ASV's use a DP system so as to allow manoeuvrability and avoid anchoring when in close proximity of the platform. However, vessels are equipped with anchors which may be deployed in an emergency. Indicative ASV specifications are provided in **Table 3-5.**

Table 3-5: Indicative accommodation supply vessel specifications

Particulars	
Type	Accommodation Support Vessel
Length overall (LOA)	78.25 m
Breadth	21 m
Dead weight tonnage (DWT)	4150 t
Accommodation	55 persons approx.
Dynamic Positioning System	DP 2
Capacities	
Fuel	Largest tank < 1000 m3

3.7.9 Heavy Lift Vessel (HLV)

A HLV will be used for the installation of the water handling module. The HLV uses a DP system to allow manoeuvrability and avoid anchoring when undertaking works, due to the close proximity of subsea infrastructure. Indicative HLV specifications are provided in **Table 3-6**.

Table 3-6: Indicative heavy lift vessel specifications

Particulars	
Type	Heavy lift vessel
Length overall (LOA)	Up to 210 m
Breadth	Up to 47 m
Draft	Approximately 11 m
Dead weight tonnage (DWT)	Up to 51,000 t
Accommodation	Up to 330 persons
Dynamic positioning system	Minimum DP2
Capacities	
Fuel	Up to 5000 m^3 in total (individual tanks in the order 1000 m^3)

3.8 Subsea Inspection, Maintenance and Repair Activities

3.8.1 Inspection, monitoring, maintenance and repair activities (IMR) Activities

A range of subsea inspection, monitoring, maintenance and repair activities (referred to as IMR) may be undertaken during the operations of the facility. Subsea IMR activities are typically undertaken from a diving or support vessel via one or more ROVs and/or divers. Typical support vessels use DP systems to allow manoeuvrability and avoid anchoring when undertaking works due to the proximity of subsea infrastructure. IMR activities may include:

- inspections
- chemical usage
- intervention isolation
- pipeline pigging operations
- pressure and leak testing
- flushing
- marine growth removal
- sediment relocation
- hotstab interventions
- repair / replacement of corrosion protection
- span rectification of grout bags, mattresses and rock dump
- cycling of valves
- choke module change out
- subsea control module (scm) change out
- jumper and umbilical replacement
- tree cap change out
- logic plate/cap change out

- spool repair, replacement and recovery
- suspension and preservation of redundant equipment.

3.8.2 Well Management and Maintenance Activities

The facility subsea well interventions, workovers and well kills require a suitable vessel or MODU to accommodate and support intervention packages. Therefore, these activities do not form part of the scope of this EP. Unloading and clean-up from subsea wells via the facility may be required infrequently. Unloading and clean-up discharges are routed via the process facilities to be cleaned of any remaining chemicals and fluids in the wellbore or reservoir.

Well Unloading and Clean-up

Following subsea interventions, workovers and well kills, the well may be unloaded and flowed via the process facilities to be cleaned of any remaining chemicals and fluids in the wellbore or reservoir. During this phase, the products may be processed, as follows:

- **Gas**: will be routed into the production process where possible, or flared if unsuitable
- **Fluids**: will be routed to the HP flare knock-out drum which discharges liquids to the closed drain system
- **Wastes (may include fluids and sand/solids):** will be managed as appropriate based on composition. Solids will be separated for onshore disposal as required following Woodside’s Waste Management Plan for Offshore Facilities. An additional strainer may be placed in the flowlines prior to the main separators to remove any large debris that may be in the wellbore.

4. DESCRIPTION OF THE RECEIVING ENVIRONMENT

The existing environment characteristics are described in terms of the Operational Area and Zone of Consequence (ZoC). The Operational Area is located within offshore waters approximately 160 km north-west of Dampier, and the wider ZoC has been identified by hydrocarbon spill modelling of the credible worst case scenario (loss of well containment, subsea equipment loss of containment and loss of marine vessel separation described in **Appendix A**).

Table 4-1: Summary of key existing environment characteristics

	Sensitive Receptor	Description
Physical Environment	***Climate and Meteorology***	***Operational Area and Wider ZoC*** • Dry tropical climate with hot summers and mild winters. • Most rainfall occurs during October to April. • Seasonal wind patterns with south-westerly winds characterising summer months and south easterly winds characterising winter. Winds during transition period between seasons typically more variable. • Tropical cyclones have occurred in region during summer period.
	Oceanography	***Operational Area*** • Locally generated wind surface currents are superimposed on geostrophic and tidal currents. • Geostrophic flow characterised by the southward flowing Leeuwin Current, which strengthens in winter and weakens in summer. • Water quality is expected to reflect the offshore oceanic conditions of the North West Shelf Province (NWSP) and wider North West Marine Region (NWMR). • Surface water temperatures are relatively warm, ranging seasonally from approximately 24.3 to 28.5 °C. • Offshore waters are expected to be of high quality given the distance from shore and lack of terrigenous inputs. Wider ZoC • Water quality is regulated by the Indonesian Throughflow (ITF), which plays a key role in initiating the Leeuwin Current and brings warm, low-nutrient, low-salinity water to the NWMR. It is the primary driver of the oceanographic and ecological processes in the NWMR. • Variation in surface salinity throughout the year is minimal (35.2 and 35.7 practical salinity units (PSU)). • During summer, the Leeuwin Current typically weakens and the Ningaloo Current develops, facilitating upwelling of cold, nutrient-rich waters up onto the continental shelf. • Other areas of localised upwelling in the NWMR include the Exmouth Plateau, where these seabed topographical features force the surrounding deeper, cooler, nutrient rich waters up into the photic zone. • Turbidity is primarily influenced by sediment transport by oceanic swells and primary productivity.
	Bathymetry	***Operational Area*** • The facility located in deep waters of approximately 85–962 m, with the riser platform located near the edge of the continental shelf (85 m water depth) and the hydrocarbon gathering system reaching from the platform to deep waters of the continental shelf (wells located between 180 and 962 m water depth).

		• Export pipeline located in continental shelf waters in depths between 40 and 85 m • Seabed across the export pipeline and around the riser platform is generally flat with gentle gradient (0.05°); within the hydrocarbon gathering system the seabed has a steep decline at water depths between 200 and 300 m on the continental slope. ***Wider ZoC*** • Relatively complex bathymetric features in close proximity to Operational Area include plateaus, deeps/holes/valleys, terraces, trenches/troughs and canyons within the continental slope. • A number of bathymetric features occur within in the wider ZoC.
	Marine Sediment	***Operational Area*** • Seabed around the riser platform comprised soft sediments, with surface layer of sand between 1–4 m thick overlying cemented sands, typical of the region. • Sediments along the export pipeline route are predominantly fine sand with variable proportions of coarser sand fractions, silt, shells and shell fragments, coral cemented materials. ***Wider ZoC*** • Sediment character changes with depth and distance from shore, with sediments becoming progressively finer with increasing depth and distance, particularly beyond continental shelf break.
	Air Quality	There is limited air quality data for the NWMR. However, ambient air quality in the Operational Area and wider ZoC is expected to be of high quality.
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. Refer to the relevant section for each protected species for a description of the critical habitats that may occur within the wider ZoC.
	Marine Primary Producers	***Operational Area*** • Given the water depth, benthic primary producers will not occur within the Operational Area. ***Wider ZoC*** <u>Coral Reefs</u> • Nearest coral habitat to the Operational Area is Rankin Bank. • Coral reef habitats include the Montebello/Barrow Islands and the Ningaloo Coast. <u>Seagrass Beds/Macroalgae</u> • Nearest seagrass/macroalgae habitat is widely distributed in coastal waters that receive sufficient light to support seagrass and macroalgae. <u>Mangroves</u> • Broadly distributed in protected coastlines throughout the wider ZoC.

<table>
<tr><td rowspan="2"></td><td>Lifecycle Stages ‘Critical’ Habitats</td><td>Refer to Biologically Important Areas (BIAs) and species descriptions.</td></tr>
<tr><td>Other Communities/ Habitats</td><td>Operational Area
<u>Plankton</u>
• Plankton communities in the Operational Area are likely to reflect the broader NWMR.
<u>Pelagic and Demersal Fish Populations</u>
• Fish communities in the Operational Area are likely to comprise small and large species pelagic fish, as well as demersal species associated with subsea infrastructure.
• The Continental Slope Demersal Fish Communities Key Ecological Feature (KEF) and Ancient Coastline at 125 m Depth Contour KEF overlap the facility section of the Operational Area and may support demersal fish assemblages.
<u>Filter Feeders and Other Benthic Communities</u>
• The continental slope region of the Operational Area comprises a sparse abundance, high variability and high diversity of infauna dominated by polychaetes with other fauna including nemerteans and sipunculids and crustaceans.
• Over the continental shelf region of the Operational Area discrete areas of hard substrate hosting sessile filter feeding communities may be associated with the Ancient Coastline at the 125 m Depth Contour KEF.
Wider ZoC
<u>Plankton</u>
• Offshore phytoplankton communities in the NWMR are characterised by smaller taxa (e.g. bacteria), while shelf waters are dominated by larger taxa (e.g. diatoms).
• Peak primary productivity along the shelf edge of the Ningaloo Reef occurs in late summer/early autumn.
<u>Pelagic and Demersal Fish Populations</u>
• Key demersal fish biodiversity areas are likely to occur in other complex habitats (e.g. coral reefs).
• Relatively complex habitats (e.g. reefs, Rankin Bank) support high demersal fish richness and abundance.
<u>Filter Feeders and Other Benthic Communities</u>
• The NWMR has been identified as a sponge diversity hotspot with a high variety of biodiverse areas, particularly in the Ningaloo Marine Park.</td></tr>
<tr><td>Protected Species</td><td>Biologically Important Areas</td><td>Operational Area
• Flatback turtle internesting buffer BIA during their summer nesting period.
• Foraging area for the wedge-tailed shearwater during its breeding season (August–April).
• Whale shark foraging area with seasonally high use (April–June).</td></tr>
</table>

		• Pygmy blue whale migration corridor (northern migration April to August; southern migration October to January). • Humpback whale migration corridor (north and south) from the Kimberley to near Esperance in southern West Australia. • Green turtle year round internesting buffer over the Dampier Archipelago. • Hawksbill turtle internesting BIA (peak season in spring and early summer). • Loggerhead internesting buffer and nesting BIAs. • Australian Fairy tern breeding BIA from July to late September. • Roseate tern breeding BIAs from mid-March to July. ***Wider ZoC*** • Large number of BIAs within wider ZoC.
	Marine Mammals	***Operational Area and Wider ZoC*** • Sei, fin and sperm whales – likely to infrequently occur within proximity to the continental slope section of the Operational Area during winter months. • Blue whale – migration corridor BIA overlaps the facility section of the Operational Area; occurrence is expected between approximately April and January. • Humpback whale – migration corridor BIA overlaps the export pipeline section of the Operational Area; occurrence is expected between May and November. • Bryde's whale – presence in the Operational Area is likely to be a remote occurrence and limited to a few individuals; may be seasonally present between December and June. • Antarctic minke whale – unlikely to occur within Operational Area, but may occur in wider ZoC. • Southern right whale – unlikely to occur in Operational Area, but may occur in southern extent of ZoC. • Killer whale, orca – no recognised key localities, expected to rarely occur within Operational Area. • Spotted bottlenose dolphin – likely to occur within the export pipeline section of the Operational Area with potential infrequent occurrence near the riser platform of the facility. • Indo-pacific humpback dolphin – likely to transit only the inner section of the export pipeline within the Operational Area. • Dugongs – likely to rarely transit the export pipeline within the Operational Area.
	Marine Turtles	***Operational Area*** • The Operational Area contains a number of internesting BIAs for flatback, green, hawksbill and loggerhead turtles. • Presence of the five species of Threatened marine turtles (loggerhead, green, leatherback, hawksbill and flatback) within the Operational Area is likely to be infrequent within the facility area; however, they are expected to commonly transit sections the export pipeline section, particularly near significant nesting beaches adjacent to the Operational Area during their breeding seasons (e.g. Montebello Islands, and the Dampier Archipelago).

		Wider ZoC • Green, loggerhead, flatback and hawksbill turtles have significant nesting rookeries on beaches along the Montebello/Barrow/Lowendal Islands Group, Ningaloo Coast and the Muiron Islands. Leatherback turtles may occur within the wider ZoC but there are no known nesting beaches in Western Australia. • Marine turtles may forage in shallow waters on the continental shelf, including Rankin Bank.
	Seasnakes	***Operational Area*** • Given the offshore location and deeper water depths of the Operational Area, seasnake sightings will likely be infrequent and comprise a few individuals, but may be more prevalent within the export pipeline section of the Operational Area. ***Wider ZoC*** • Seasnakes frequent the waters of the continental shelf and around offshore islands.
	Fishes and Elasmobranchs	***Operational Area and Wider ZoC*** • Great white sharks – unlikely to occur within the Operational Area given absence of preferred prey; known to occur within the wider ZoC. • Shortfin and longfin mako sharks – potential for infrequent transit of the Operational Area, known to occur within the wider ZoC. • Whale sharks – foraging BIA overlaps the Operational Area (although this may constitute migration corridor for animals moving to and from annual aggregation off Ningaloo Coast); occurrence is expected between March and July. • Grey nurse sharks – may infrequently transit continental shelf waters overlapping the Operational Area; are likely to be found in shallow waters of the wider ZoC. • Giant and Reef Manta Rays – occurrence within the Operational Area is expected to be infrequent; Ningaloo Reef is an important area for giant and reef manta rays in autumn and winter, and they are known to occur in tropical waters throughout the wider ZoC. • Narrow, Dwarf and Green sawfish – may infrequently transit continental shelf waters of the Operational Area; will occur in shallow coastal habitats in the wider ZoC. • Porbeagle shark – not expected to occur within the Operational Area; may occur in temperate waters in southern portion of wider ZoC.
	Birds	***Operational Area*** • Thirteen species of Threatened and/or Migratory bird species (red knot, curlew sandpiper, southern giant-petrel, eastern curlew, common sandpiper, common noddy, sharp-tailed sandpiper, pectoral sandpiper, lesser frigatebird, streaked shearwater, osprey, Australian fairy tern, and roseate tern) were identified as potentially occurring within the Operational Area; two of these were identified as only occurring within the export pipeline. No EPBC listed critical habitat associated with these species has been identified within the Operational Area. • A foraging BIA for wedge-tailed shearwater, during their breeding season (August–April), overlaps the Operational Area. • Breeding BIAs for Australian fairy terns and roseate terns overlaps the export pipeline section of the Operational Area; they are expected to occur within the Operational Area between July–September and March–July, respectively.

		Wider ZoC • There are several additional breeding BIAs (key breeding/nesting, roosting, foraging and resting areas) for fairy terns, roseate terns and lesser crested terns in the wider ZoC, including areas on the islands of the Montebello/Barrow/Lowendal Islands group, Pilbara Islands, Ningaloo Coast and Muiron Islands. • No Ramsar wetlands in the wider ZoC.
Socio-economic	***Cultural Heritage***	***Operational Area*** • There are no known sites of Aboriginal or European cultural or heritage significance within or in the vicinity of the Operational Area. ***Wider ZoC*** • Barrow Island, Montebello Islands, Ningaloo Reef and the adjacent foreshore contain numerous registered Indigenous heritage sites. • The closest recorded shipwreck to the Operational Area with a confirmed location is *McDermott Derrick Barge No. 20*, less than 1 km south of the Operational Area. • World Heritage Areas include the Ningaloo Coast World Heritage Area and Shark Bay World Heritage Area. • National Heritage listed and proposed places include Barrow Island, Montebello Islands, Dampier Archipelago and the Ningaloo Coast. • Commonwealth Heritage listed places include the Ningaloo Marine Area – Commonwealth Waters and the Learmonth Air Weapons Range Facility Heritage Place.
	Ramsar Wetlands	No Ramsar wetlands in Operational Area or wider ZoC.
	Fisheries – Commercial	***Operational Area*** • There are a number of Commonwealth and State fisheries designated management areas that overlap the Operational Area; however, only the State Pilbara Demersal Scalefish Fishery (mainly trap fishing), Specimen Shell Managed Fishery (diving and ROV methods), Onslow Prawn Managed Fishery (trawl fishing), Mackerel Managed Fishery (near-surface trawling and jig methods) are expected to be active within the Operational Area. The latter three fisheries are expected to only operate within the export pipeline section of the Operational Area: Commonwealth Fisheries • Southern Bluefin Tuna Fishery • Western Skipjack Fishery • Western Tuna and Billfish Fishery • North-West Slope Trawl Fishery (overlapping only the export pipeline section of the Operational Area). State Fisheries • Pilbara Demersal Scalefish Fishery • West Coast Deep Sea Crustacean Managed Fishery

		• Specimen Shell Managed Fishery • Onslow Prawn Managed Fishery • Pearl Oyster Managed Fishery • Marine Aquarium Managed Fishery • West Australian Abalone Fishery • Mackerel Managed Fishery • South West Coast Salmon Managed Fishery • There are no aquaculture activities within or adjacent to the Operational Area. ***Wider ZoC*** • Five State and one Commonwealth fisheries overlap the ZoC.
	Fisheries – Traditional	There are no traditional, or customary fisheries within or adjacent to the offshore Operational Area. Traditional fisheries are typically restricted to shallow coastal waters and/or areas with structure such as reef. Ningaloo Coast, Barrow Island and Montebello Islands and the adjacent foreshores have a known history of fishing, when areas were occupied (as identified from historical records).
	Tourism and Recreation	***Operational Area*** • Given the distance to the nearest access node from the facility section of the Operational Area (> 160 km to the Dampier boat ramp on the Burrup Peninsula), recreational fishing effort is not expected. • Within the export pipeline section of the Operational Area (36 km to the Dampier boat ramp at its closest point) recreational fishing is likely to occur; however, it is likely to be restricted to few relatively large vessels transiting mainly between offshore islands and shoals. ***Wider ZoC*** • Recreational fishing is expected to occur throughout wider ZoC, primarily in continental shelf waters including Rankin Bank. • The Ningaloo Marine Park and Montebello Islands are popular for marine nature-based tourist activities.
	Shipping	***Operational Area*** • Two shipping fairways overlap the export pipeline section of the Operational Area. ***Wider ZoC*** • The coastal and offshore waters of the region support significant commercial shipping activity, the majority of which is associated with the mining and oil and gas industries. • Major shipping routes are associated with entry to the ports of Barrow Island, Dampier, Port Walcott, Onslow and Port Hedland.
	Oil and Gas Infrastructure	***Operational Area*** • The Wheatstone Platform lies within 5 km of Operational Area.

		Wider ZoC • Numerous Petroleum Titles surrounding the Operational Area. • Two platforms are currently within 20 km of the Operational Area, including Jadestone's Stag and Quadrant's Reindeer facilities.
	Defence	There are designated Defence practice areas in the offshore marine waters off Ningaloo and the North West Cape, beyond the Operational Area.
Values and Sensitivities	***Montebello/Barrow/ Lowendal Islands***	Relevant protected areas in this locality include: • Montebello Australian Marine Park • Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area • Montebello Islands Conservation Park/Barrow Island Nature Reserve.
	Dampier Coast	Relevant protected areas in this locality include: • Class A Nature Reserve comprising the whole of Rosemary Island.
	Ningaloo Coast and Gascoyne	Relevant protected areas in this locality include: • Ningaloo Coast World Heritage Area • Ningaloo Australian Marine Park • Ningaloo Marine Park and Muiron Islands Marine Management Area • Gascoyne Commonwealth Marine Park.
	Pilbara Coast and Islands	Relevant sensitive areas in this locality include: • Pilbara Islands (north group) • Pilbara Islands (middle group) • Pilbara Islands (south group).
	Key Ecological Features	***Operational Area*** • Ancient Coastline at 125 m Depth Contour. • Continental Slope Demersal Fish Communities. ***Wider ZoC*** • Three additional KEFs occur within the wider ZoC.
	Other Sensitive Areas	Rankin Bank lies approximately 24 km west of the Operational Area, within the wider ZoC.

4.1 Species

A total of 78 EPBC Act listed marine species were identified as potentially occurring within the Operational Area and wider ZoC. Of the species identified by the Protected Matters Search Tool (PMST) report, 25 are listed as threatened and 51 are migratory under the EPBC Act, of which a subset of 38 and 34 species were identified as potentially occurring within the export pipeline and the facility sections of the Operational Area, respectively. (**Table 4-2**).

Table 4-2 Threatened and Migratory Marine Species under the EPBC Act Potentially Occurring within the Operational Area

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC		
				Export Pipeline	Pluto Offshore Facility	ZoC
Mammals						
Balaenoptera borealis	Sei Whale	Vulnerable	Migratory	Y	Y	Y
Balaenoptera musculus	Blue Whale	Endangered	Migratory	Y	Y	Y
Balaenoptera physalus	Fin Whale	Vulnerable	Migratory	Y	Y	Y
Megaptera novaeangliae	Humpback Whale	Vulnerable	Migratory	Y	Y	Y
Balaenoptera edeni	Bryde's Whale	N/A	Migratory	Y	Y	Y
Physeter macrocephalus	Sperm Whale	N/A	Migratory	N/A	Y	Y
Balaenoptera bonaerensis	Antarctic Minke Whale, Dark-shoulder Minke Whale	N/A	Migratory	N/A	N/A	Y
Balaena glacialis australis	Southern Right Whale	Endangered	Migratory	N/A	N/A	Y
Orcinus orca	Killer Whale, Orca	N/A	Migratory	Y	Y	Y
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	N/A	Migratory	Y	Y	Y
Sousa chinensis	Indo-Pacific Humpback Dolphin	N/A	Migratory	Y	N/A	Y
Dugong dugon	Dugong	N/A	Migratory	Y	N/A	Y
Reptiles						
Caretta caretta	Loggerhead Turtle	Endangered	Migratory	Y	Y	Y
Chelonia mydas	Green Turtle	Vulnerable	Migratory	Y	Y	Y

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC		
				Export Pipeline	Pluto Offshore Facility	ZoC
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	Endangered	Migratory	Y	Y	Y
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable	Migratory	Y	Y	Y
Natator depressus	Flatback Turtle	Vulnerable	Migratory	Y	Y	Y
Aipysurus apraefrontalis	Short-nosed Seasnake	Critically endangered	N/A	Y	N/A	Y
Sharks and Rays						
Carcharodon carcharias	White Shark, Great White Shark	Vulnerable	Migratory	Y	Y	Y
Isurus oxyrinchus	Shortfin Mako, Mako Shark	N/A	Migratory	Y	Y	Y
Isurus paucus	Longfin Mako	N/A	Migratory	Y	Y	Y
Rhincodon typus	Whale Shark	Vulnerable	Migratory	Y	Y	Y
Carcharias taurus	Grey Nurse Shark (west coast population)	Vulnerable	N/A	Y	Y	Y
Lamna nasus	Porbeagle, Mackerel Shark	N/A	Migratory	N/A	N/A	Y
Manta birostris (recently revised taxonomy Mobula birostris (White et al., 2017)	Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	N/A	Migratory	Y	Y	Y
Manta alfredi (recently revised taxonomy Mobula alfredi (White et al., 2017)	Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	N/A	Migratory	Y	Y	Y
Anoxypristis cuspidata	Narrow Sawfish, Knifetooth Sawfish	N/A	Migratory	Y	Y	Y
Pristis clavata	Dwarf Sawfish, Queensland Sawfish	Vulnerable	Migratory	Y	Y	Y
Pristis zijsron	Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable	Migratory	Y	Y	Y
Fish						

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC		
				Export Pipeline	Pluto Offshore Facility	ZoC
Sphyrna lewini	Scalloped Hammerhead	Conservation Dependent	N/A	Y	Y	Y
Thunnus maccoyii	Southern Bluefin Tuna	Conservation Dependent	N/A	Y	Y	Y
Birds						
Calidris canutus	Red Knot, Knot	Endangered	Migratory	Y	Y	Y
Calidris ferruginea	Curlew Sandpiper	Critically endangered	Migratory	Y	Y	Y
Macronectes giganteus	Southern Giant-Petrel, Southern Giant Petrel	Endangered	Migratory	Y	Y	Y
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Critically endangered	Migratory	Y	Y	Y
Actitis hypoleucos	Common Sandpiper	N/A	Migratory	Y	Y	Y
Anous stolidus	Common Noddy	N/A	Migratory	Y	Y	Y
Calidris acuminata	Sharp-tailed Sandpiper	N/A	Migratory	Y	Y	Y
Calidris melanotos	Pectoral Sandpiper	N/A	Migratory	Y	Y	
Fregata ariel	Lesser Frigatebird, Least Frigatebird	N/A	Migratory	Y	Y	
Calonectris leucomelas	Streaked Shearwater	N/A	Migratory	Y	Y	
Pandion haliaetus	Osprey	N/A	Migratory	Y	Y	
Sternula nereis	Australian Fairy Tern	Vulnerable	Migratory	Y	N/A	
Sterna dougallii	Roseate Tern	N/A	Migratory	Y	N/A	
Limosa lapponica baueri	Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit	Vulnerable	Migratory	N/A	N/A	
Limosa lapponica menzbieri	Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri)	Critically endangered	Migratory	N/A	N/A	
Pterodroma mollis	Soft-plumaged Petrel	Vulnerable	N/A	N/A	N/A	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC		
				Export Pipeline	Pluto Offshore Facility	ZoC
Thalassarche impavida	Campbell Albatross, Campbell Black-browed Albatross	Vulnerable	Migratory	N/A	N/A	
Fregata minor	Great Frigatebird, Greater Frigatebird	N/A	Migratory	N/A	N/A	
Ardenna carneipes	Flesh-footed Shearwater, Fleshy-footed Shearwater	N/A	Migratory	N/A	N/A	
Ardenna pacifica	Wedge-tailed Shearwater	N/A	Migratory	N/A	N/A	
Hydroprogne caspia	Caspian Tern	N/A	Migratory	N/A	N/A	
Onychoprion anaethetus	Bridled Tern	N/A	Migratory	N/A	N/A	
Charadrius veredus	Oriental Plover, Oriental Dotterel	N/A	Migratory	N/A	N/A	
Glareola maldivarum	Oriental Pratincole	N/A	Migratory	N/A	N/A	
Thalasseus bergii	Crested Tern	N/A	Migratory	N/A	N/A	
Tringa nebularia	Common Greenshank, Greenshank	N/A	Migratory	N/A	N/A	

Seabirds

The Operational Area may be occasionally visited by migratory and oceanic birds, but does not contain any emergent land that could be used as roosting or nesting habitat (and contains no known critical habitats (including feeding) for any species. Thirteen species of birds considered to be MNES were identified as potentially occurring within the Operational Area (13 within the export pipeline and 11 within the facility) including the common sandpiper, common noddy, sharp-tailed sandpiper, red knot, pectoral sandpiper, lesser frigatebird, great frigatebird, eastern curlew, and osprey.

A BIA for the migratory wedge-tailed shearwater overlaps the Operational Area. The NWMR lies within the East Asian-Australasian flyway for migratory birds; species undertaking migrations between East Asia and Australia may be present between late spring and early autumn.

Based on the results of two survey cruises and other unpublished records, Dunlop et al. (1988) recorded the occurrence of 18 species of seabirds over the NWSP. These included a number of species of petrel, shearwater, tropicbird, frigatebird, booby and tern, as well as the silver gull. Of these, eight species occur year round, and the remaining ten are seasonal visitors. From these surveys, it was noted that seabird distributions in tropical waters were generally patchy, except near islands.

Migratory shorebirds may be present in or fly through the region between July and December and again between March and April as they complete migrations between Australia and offshore locations (Bamford et al. 2008, Commonwealth of Australia 2015c). Note that no Ramsar wetlands were identified within the Operational Area or wider ZoC. The nearest Ramsar wetland is Eighty Mile Beach, over 400 km east of the Operational Area and beyond the wider ZoC.

Marine Mammals

Blue whales were identified as potentially occurring within the Operational Area and wider ZoC. There are no known pygmy blue whale migration BIAs that overlap the Operational Area at the closest point or the wider ZoC. Based on pygmy blue whale migration timing, occurrence of the species within the Operational Area, and the wider ZoC is likely to be mostly restricted to one or few individuals occasionally transiting the area, with a higher likelihood of occurrence during April–August and October–January, during their seasonal migrations. A foraging BIA lies off the Ningaloo Reef/North West Cape region (approximately 232 km south-west of the Permit Area), within which pygmy blue whales may feed (Double et al. 2014).

Humpback whales were identified as occurring within the Operational Area and wider ZoC. The species regularly migrates seasonally between feeding grounds in the Southern Ocean and breeding and calving grounds off northern WA, particularly Camden Sound (Jenner et al. 2001). Calving typically occurs at the northern extent of the migration corridor (beyond the wider ZoC). The humpback whale migration BIA and a resting BIA situated in Exmouth Gulf lie approximately 21 km from the Operational Area at its closest point. The Exmouth Gulf and Shark Bay humpback whale BIAs are located outside the ZoC. Noise loggers deployed near Woodside’s GWA facility 53 km from the Operational Area) detected humpback whales present at the end of September, likely migrating south, and from June to mid-August in deeper water, nearer to the continental shelf, likely migrating north (RPS Environment and Planning 2012). The southward migration of cow/calf pairs is slightly later during October (extending into November and December). During the southbound migration, it is likely that most individuals, particularly cow/calf pairs, stay closer to the coast than the northern migratory path. Humpback whales may occur within the Operational Area and wider ZoC during these migration periods.

There is the potential for seven species of cetaceans, including, Sei whale, Bryde’s whale, Fin whale, Sperm whale, Antarctic Minke whale, Southern Right Whale, Killer whale, Spotted Bottlenose dolphin and Indo-pacific humpback dolphin to infrequently transit the Operational Area.

The dugong may be present in the wider ZoC, although was not identified as occurring within the Operational Area. Dugong distribution is correlated with seagrass habitats in which dugong feed, although water temperature has also been correlated with dugong movements and distribution (Preen et al. 1997, Preen 2004). Dugongs are known to migrate between seagrass habitats (hundreds of kilometres) (Sheppard et al. 2006). However, given the Operational Area is located offshore in deep water which does not support seagrass habitat and does not contain any critical dugong habitat, the occurrence of dugongs in the area is considered very unlikely. A dugong BIA for breeding, calving, foraging and nursing lies within the wider ZoC, approximately 212 km south-east of the Operational Area. Dugongs may occur along the Ningaloo Coast and around islands of the Pilbara Coast, within the wider ZoC, and may rarely transit the export pipeline section of the Operational Area.

Marine Reptiles

Five of the six marine turtle species recorded for the NWMR have the potential to occur within the Operational Area; the loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle and the flatback turtle. Four of the turtle species (green, loggerhead, flatback and hawksbill) have significant nesting rookeries on beaches along the mainland coast and islands in the wider ZoC.

There is no emergent habitat within the Operational Area; therefore, nesting aggregations are unlikely to occur in the vicinity of the Operational Area (both the export pipeline and the facility). Given the water depth and lack of suitable benthic prey, foraging adult turtles are not expected to occur within the facility section of the Operational Area, with the exception of the leatherback turtle which feed predominantly on gelatinous pelagic fauna such as jellyfish. Turtles may forage at Rankin Bank, which lies approximately 24 km west of the Operational Area, as well as transit through and potentially forage within shallow areas of the export pipeline.

The BIA areas that overlap the Operational Area include:

Overlapping both sections of the Operational Area:

- flatback turtle internesting buffer around the Montebello Islands and Dampier Archipelago during their summer nesting period (a nesting habitat critical to the survival of flatback turtles with a 40 km internesting buffer also overlaps this BIA).

Overlapping the export pipeline:

- green turtle year round internesting buffer over the Dampier Archipelago (a nesting habitat critical to the survival of green turtles with a 20 km internesting buffer also overlaps and slightly expands this BIA)
- hawksbill turtle internesting BIA over the Dampier Archipelago (peak season in spring and early summer) (a nesting habitat critical to the survival of hawksbill turtles with a 20 km internesting buffer also overlaps and very slightly expands this BIA)
- loggerhead internesting buffer and nesting BIAs around Cohen and Rosemary Islands.

Seventeen species of sea snakes were identified as potentially occurring within the wider ZoC. One of these species, the short-nosed sea snake, is listed as Critically Endangered and identified as potentially occurring within the Operational Area. This species has primarily been recorded on the Sahul Shelf at Ashmore Reef and Hibernia Reef. Given the water depth of the Operational Area, sea snake sightings will be infrequent and likely comprise few individuals within the Operational Area.

Sharks, Rays and Fishes

The whale shark was identified as potentially occurring within the Operational Area. Whale sharks aggregate annually to feed in the waters of the Ningaloo Coast (this feeding BIA lies approximately 228 km south-west of the Operational Area, within the wider ZoC) from March to July, with the largest numbers recorded in April and May (Sleeman et al. 2010). However, seasonal aggregation can be variable, with individual whale sharks recorded at other times of the year. The population (comprised of individuals that visit the reef at some point during their lifetime) has been estimated to range between 300 and 500 individuals; the number visiting Ningaloo Reef in any given year is expected to be somewhat smaller (Meekan et al. 2006). Timing of the whale shark migration to and from Ningaloo coincides with the coral mass spawning period, when there is an abundance of food (krill, planktonic larvae and schools of small fish) in the waters adjacent to Ningaloo Reef. At Ningaloo Reef, whale sharks stay within a few kilometres of the shore and in waters approximately 30–50 m deep (Wilson et al. 2006).

Several shark/ray species including the great white shark, shortfin mako, longfin mako, giant manta ray, grey nurse shark, green sawfish, porbeagle shark, dwarf sawfish, reef manta ray and narrow sawfish may be present within the Operational Area, for short durations when individuals transit the area.

Of the fish species identified as potentially occurring within the Operational Area, 36 are species of pipefish and seahorse. However, bycatch data indicates they are uncommon in deeper continental shelf waters (50–200 m) and therefore, are unlikely to occur within the Operational Area. This family (Syngnathidae) are commonly found in seagrass and sandy habitats around coastal islands and shallow reef areas along the NWSP, and is more likely to be found in coastal areas including the Ningaloo Coast.

4.2 Socio-Economic and Cultural

There are no known sites of Indigenous or European cultural heritage significance within the vicinity of the Operational Area.

Within the wider ZoC area, Barrow Island, Montebello Islands, southern Pilbara coast, Exmouth, Shark Bay, Ningaloo Reef and the adjacent foreshores have a long history of occupancy by Aboriginal communities. Indigenous heritage places are protected under the *Aboriginal Heritage Act 1972* (WA) or EPBC Act.

A search of the National Shipwreck Database indicated that there are no known shipwrecks recorded within the Operational Area. There are eleven shipwrecks within less than 50 km from either section of the Operational Area and their approximate distances are as follows:

- McDermott Derrick Barge No 20, Curlew. Marietta, Vianen and Wild Wave (China) all within 1 km of the Operational Area;
- Tanami (28 km from the Operational Areas);
- Trial (30 km from the Operational Areas);
- Dampier (33 km from the Operational Areas);
- Plym HMS (36 km from the Operational Areas);
- Tropic Queen (40 km from the Operational Areas); and
- Parks Lugger (45 km from the Operational Areas).

There are no heritage listed sites within the Operational Area; however, there are a number of gazetted and proposed National and Commonwealth heritage places in the wider ZoC, including the Ningaloo Coast World Heritage Area, Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves Nominated Heritage Place, Dampier Archipelago (including Burrup Peninsula) Indigenous Heritage Place, the Ningaloo Coast Natural Heritage Place, Learmonth Air Weapons Range Facility Heritage Place and Ningaloo Marine Area (Commonwealth Waters) Commonwealth Heritage Place.

No Ramsar wetlands overlap the Operational Area or wider ZoC.

A number of Commonwealth and State fisheries are located within the Operational Area and/or wider ZoC including the following:

- Mackerel Managed Fishery;
- Marine Aquarium Fish managed Fishery;
- Onslow Prawn managed Fishery;
- Pearl Oyster Managed Fishery
- Pilbara Demersal Scalefish Fishery;
- North West Slope trawl Fishery;
- Western Deepwater Trawl Fishery
- Southern Bluefin Tuna Fishery;
- South West Coast Salmon Managed Fishery
- Specimen Shell Fishery;
- West Coast Deep Sea Crustacean Managed Fishery;
- Western Abalone Fishery;

- Western Skipjack Tuna Fishery; and
- Western Tuna and Billfish Fishery.

State fisheries designated management areas within the Operational Area or ZoC include the following:

- Gascoyne Demersal Scalefish Managed Fishery;
- Nickol Bay Prawn Managed Fishery;
- Shark Bay Scallop Managed Fishery;
- Shark Bay Prawn Managed Fishery; and
- West Coast Rock Lobster Fishery.

There are no aquaculture operations within or adjacent to the Operational Area as these operations are typically restricted to shallow coastal waters.

There are no traditional or customary fisheries within the Operational Area, as these are typically restricted to shallow coastal waters and/or areas with structure such as reef. However, it is recognised that Barrow Island, Montebello Islands and Ningaloo Reef, all within the wider ZoC, have a known history of fishing when areas were occupied (as from historical records) (Department of Conservation and Land Management, 2005c; Department of Environment and Conservation, 2007).

Tourism and Recreation

No tourist activities take place specifically within the Operational Area; however, it is acknowledged that there are growing tourism and recreational sectors in WA which have expanded over the last couple of decades. Growth and the potential for further expansion in tourism and recreational activities is recognised for the Pilbara and Gascoyne regions, with the development of regional centres and a workforce associated with the resources sector (SGS Economics & Planning 2012).

Tourism is one of the major industries of the Gascoyne region and contributes significantly to the local economy in terms of both income and employment. The main marine nature-based tourist activities are concentrated around and within the Ningaloo World Heritage Area (approximately 204 km south-west of the Operational Area) including recreational fishing, snorkelling and scuba diving, whale shark (April to August) and manta ray (year round) encounters, whale watching (July to October), whale encounters (August and November) and turtle watching (all year round) (Schianetz et al. 2009). The Montebello Islands State Marine Park (25 km from the Operational Area), is the closest location for tourism with some charter boat operators taking visitors to these islands (Department of Environment and Conservation, 2007).

Given the distance to the nearest access node from the facility section of the Operational Area (> 160 km to the Dampier boat ramp on the Burrup Peninsula), recreational fishing effort is not expected. Within the export pipeline section of the Operational Area (36 km to the Dampier boat ramp at its closest point) recreational fishing is likely to occur; however, will be restricted to few relatively large vessels transiting mainly between offshore islands and shoals.

Shipping

The NWMR supports significant commercial shipping activity, the majority of which is associated with the mining and oil and gas industries. The Australian Maritime Safety Authority (AMSA) has introduced a network of marine fairways across the NWMR of WA to reduce the risk of vessel collisions with offshore infrastructure. The fairways are not mandatory but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region. Two fairways overlap the export pipeline section of the Operational Area; however, none overlap the facility section of the Operational Area (**Figure 4-1).**

Ports in the region are nodes of increased vessel activities; active ports in the vicinity of the Operational Area include:

- Dampier (approximately 36 km south)
- Barrow Island (approximately 84 km south)
- Port Walcott (approximately 160 km south)
- Onslow (approximately 187 km south)
- Port Hedland (approximately 207 km south-east).

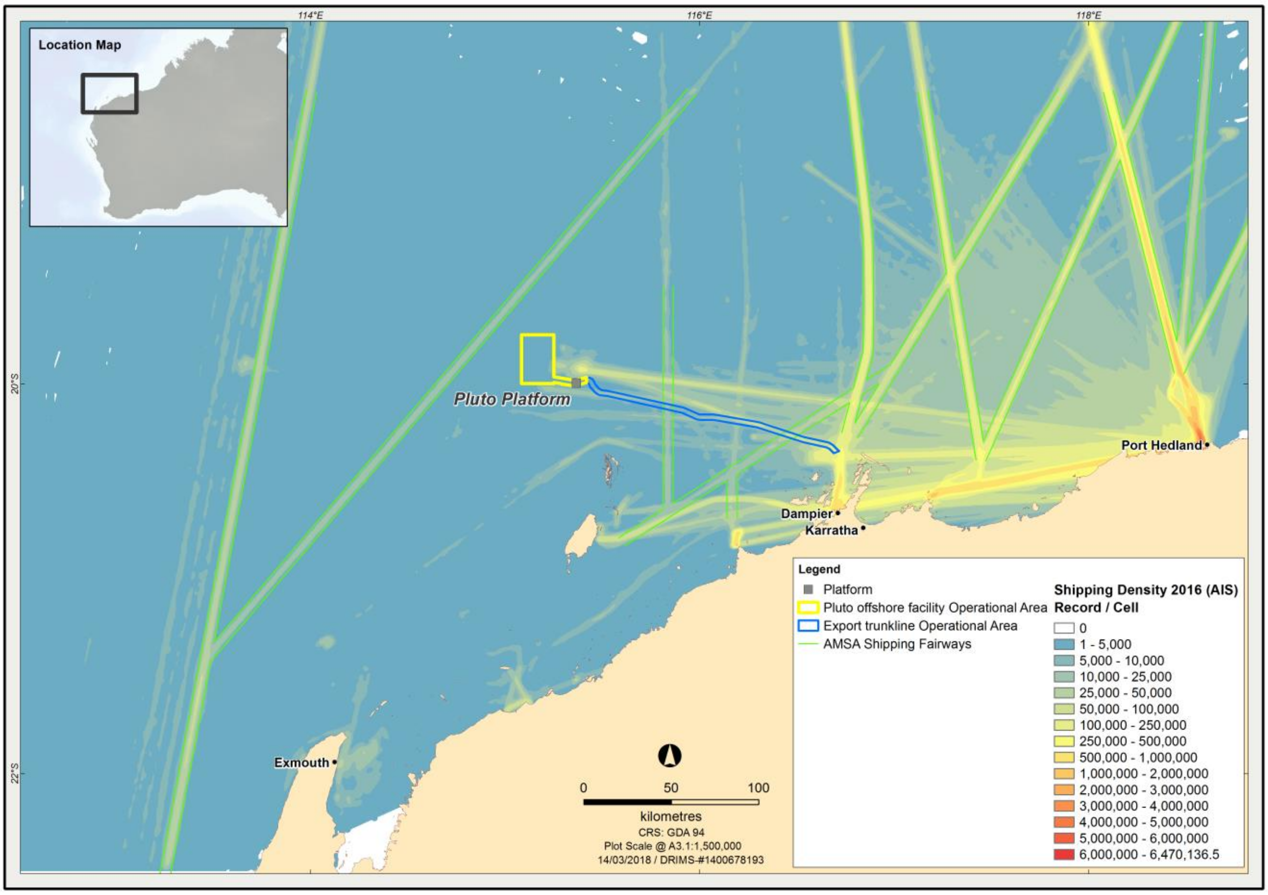

Figure 4-1: Vessel density map in the vicinity of Operational Area from 2016, derived from AMSA satellite tracking system data (vessels include cargo, LNG tanker, ore carriers passenger vessels, support vessels and other vessels)

Oil and Gas Infrastructure

The Operational Area is located within an area of established oil and gas operations in the broader NWMR. Several facilities are located in proximity to the Operational Area. Several FPSOs and platforms are currently in operation in the vicinity of the Operational Area.

Defence

There are designated Department of Defence practice areas in the offshore marine waters off Ningaloo and the North West Cape, of which a military flying training area overlaps the Pluto offshore facility section of the Operational Area. A Royal Australian Air Force base located at Learmonth, on North West Cape, lies approximately 298 km south-west of the Operational Area.

4.3 Values and Sensitivities

The offshore environment of the NWMR contains environmental assets (such as habitat and species) of high value or sensitivity including Commonwealth offshore waters, as well as the wider regional context including coastal waters and habitats such as the Montebello/Barrow/Lowendal Island Group and the Ningaloo World Heritage Area, and the associated resident, temporary or migratory marine life including species such as marine mammals, turtles and birds.

Many sensitive receptor locations are protected as part of Commonwealth and State managed areas, and have been allocated conservation objectives (International Union for Conservation of Nature (IUCN) Protected Area Category) based on the Australian IUCN reserve management principles in Schedule 8 of the EPBC Regulations 2000. These principles determine what activities are acceptable within a protected area under the EPBC Act. All planned petroleum activities will take place within the Operational Area, which overlaps with the Montebello Australian Marine Park two Key Ecological Features **(**described below**)**, The planned activities associated with the Petroleum Activities Program will be conducted in a manner consistent with the Australian IUCN reserve management principles for the IUCN categories which have been identified in **Table 4-3** and shown in **Figure 4-2**.

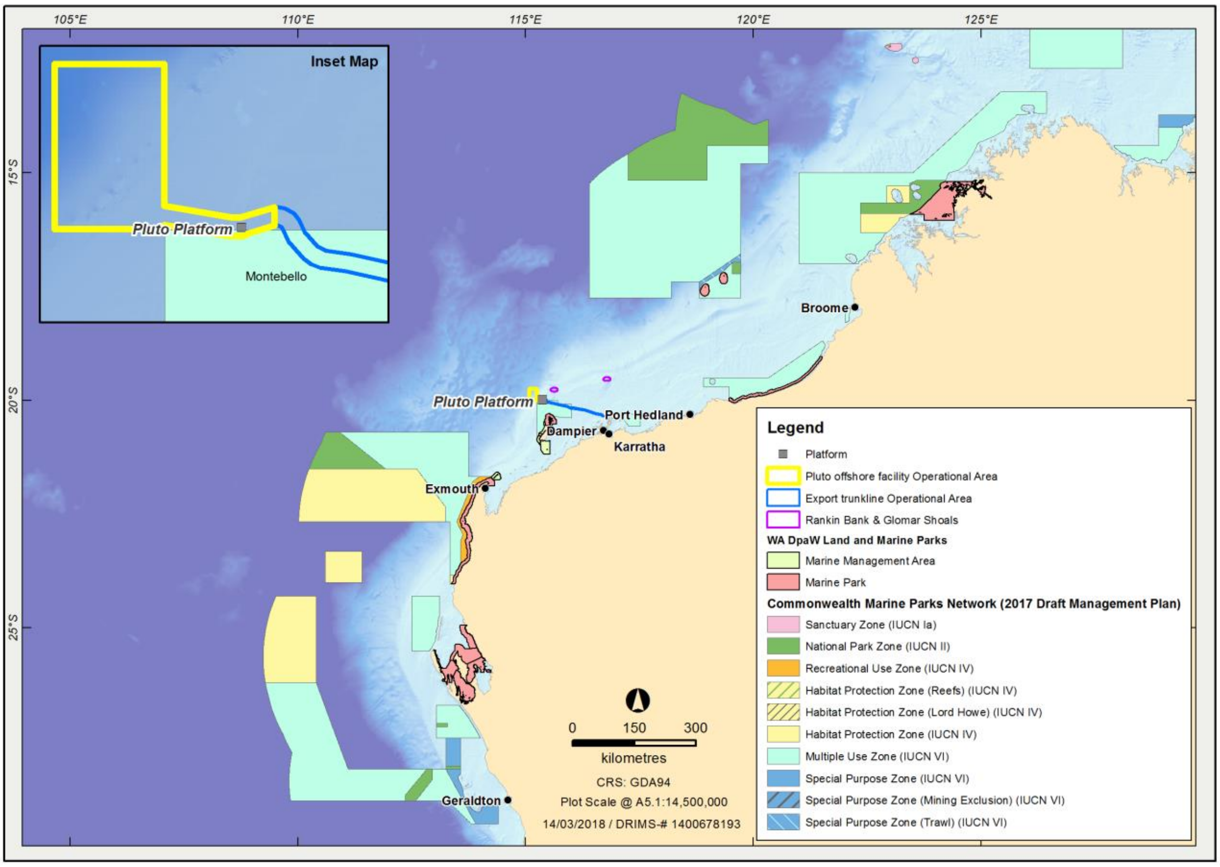

Figure 4-2: Established and proposed Commonwealth and State Marine Protected Areas in Relation to the Operational Area

Table 4-3: Summary of Established and Proposed Marine Protected Areas (MPAs) and Other Sensitive Locations in the Region Relating to the Operational Area

	Distance from Operational Area to Values/Sensitivity boundaries (km)	UCN Protected Area Category*
Australian Marine Parks (AMP) (formerly Commonwealth Marine Reserves)		
Montebello†	Overlapping both sections of the Operational Area	VI
Gascoyne†	177	II, IV and VI
Ningaloo†	206	II
State Marine Parks and Nature Reserves		
Marine Parks		
Montebello Islands	25	IA, II, IV and VI
Barrow Island	76	IA, IV and VI
Ningaloo	207	IA, II and IV
Marine Management Areas		
Barrow Island	42	IV and VI
Muiron Islands	190	IA and VI
Fish Habitat Protection Areas		
None overlapping the Operational Area or ZoC		
Nature Reserves		
Dampier Archipelago Island Reserves (Rosemary Island)	13	IA
Montebello Islands Conservation Park	32	II
Barrow Island Nature Reserve	79	IA
Lowendal Islands Nature Reserve	57	IA
Boodie, Double Middle Islands Nature Reserve	94	IA
Thevenard Island Nature Reserve	160	IA
Bessieres Island Nature Reserve	172	IA
Heritage		
World Heritage Areas		
The Ningaloo Coast	17	Not applicable
National Heritage Areas		

	Distance from Operational Area to Values/Sensitivity boundaries (km)	UCN Protected Area Category*
Dampier Archipelago (including Burrup Peninsula)	10	Not applicable
Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves	25	Not applicable
The Ningaloo Coast	190	Not applicable
Commonwealth Heritage Areas		
Ningaloo Marine Area - Commonwealth Waters	206	Not applicable
Key Ecological Features		
Ancient coastline at 125 m depth contour	Overlapping both sections of the Operational Area	Not applicable
Continental Slope Demersal Fish Communities	Overlapping both sections of the Operational Area	Not applicable
Exmouth Plateau	74	Not applicable
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	164	Not applicable
Commonwealth waters adjacent to Ningaloo Reef	206	Not applicable

Montebello Australian Marine Park

The Montebello Australian Marine Park is adjacent to the Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area, providing a contiguous marine park covering both state and Commonwealth waters.

Major conservation values within the Montebello Australian Marine Park include (Department of the Environment and Energy, n.d.; Director of National Parks, 2018b):

- habitats, species and ecological communities associated with the North West Shelf Province
- BIAs for a range of MNES
- two historic shipwrecks; the *Trial* and the *Tanami*
- diverse social values including tourism, fishing mining and recreation
- foraging areas adjacent to important nesting sites for marine turtles
- includes part of the migratory pathway of the protected humpback whale
- the park includes shallow shelf environments with depths ranging from 15 to 150 m and provides protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features
- examples of the seafloor habitats and communities of the NWMR as well as the Pilbara (offshore) mesoscale bioregion (Heap et al., 2005)
- one key ecological feature for the region, the Ancient Coastline at 125 m Depth Contour

- the entire Montebello Australian Marine Park, an area of 341,300 ha, is designated a Multiple Use Zone (IUCN Category IV), allowing for long-term protection and maintenance of the Australian Marine Park in conjunction with sustainable use, including oil and gas exploration activities.

Ancient Coastline at 125 m Depth Contour

Several steps and terraces as a result of Holocene sea level changes occur in the region with the most prominent of these features occurring as an escarpment along the NWMR and Sahul Shelf at a water depth of 125 m, which forms the Ancient Coastline at 125 m depth contour KEF (the Ancient Coastline). The Ancient Coastline KEF overlaps the Operational Area, extending along a line approximated by the 125 m isobath. The Ancient Coastline is not continuous throughout the NWMR, and coincides with a well-documented eustatic still stand at approximately 130 m worldwide (Falkner *et al.*, 2009b).

Where the Ancient Coastline provides areas of hard substrate, it may contribute to higher diversity and enhanced species richness relative to soft sediment habitat (Falkner *et al.*, 2009b). Parts of the Ancient Coastline, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly made up of soft sediment.

The escarpment type features may also potentially facilitate mixing within the water column due to upwelling, providing a nutrient rich environment. Although the Ancient Coastline adds additional habitat types to a representative system, the habitat types are not unique to the coastline as they are widespread on the upper shelf (Falkner *et al.*, 2009b).

Continental Slope Demersal Fish Communities

The continental slope demersal fish communities in the region have been identified as a KEF of the NWMR (DSEWPaC, 2012d), and lies approximately 25 km west of the Operational Area. The continental slope between North West Cape and the Montebello Trough has been identified as one of the most diverse slope assemblages in Australian waters, with over 508 fish species and the highest number of endemic species (76) of any Australian slope habitat (DEWHA, 2008). Additional features relating to the fish populations of this area are as follows:

Continental slope demersal fish communities have been identified as a key ecological feature of the NWMR due to the notable diversity of the demersal fish assemblages and high levels of endemism (DSEWPaC, 2012d).

The North West Cape region is a transition area for demersal shelf and slope fish communities between the tropical dominated communities to the north and temperate communities to the south (Last *et al.*, 2005). The benthic shelf and slope communities offshore of the North West Cape comprise both tropical and temperate fish species with a north-south gradient (DEWHA, 2008).

The fish fauna of the North West Cape region, like the ichthyofauna of many regions, exhibits decreasing species richness with depth (Last *et al.*, 2005). Fish species diversity has been shown to be positively correlated with habitat complexity, with more complex habitats (e.g. coral reefs) typically hosting higher species richness than simpler habitats such as bare, unconsolidated muddy sediments (Gratwicke and Speight, 2005). A total of 500 finfish species from 234 genera and 86 families have been recorded within the Ningaloo Marine Park, and 393 species were identified at study sites of the Muiron Islands (Department of Conservation and Land Management, 2005c). The offshore sediment habitats of the Operational Area are expected to support lower fish species richness than other shallower, more complex habitats in the coastal areas of the region.

5. ENVIRONMENTAL IMPACTS AND RISKS

5.1 Risk and Impact Identification and Evaluation

Woodside undertook an environmental risk assessment (with outputs applicable to the EP provided in **Appendix A**) to identify the potential environmental impacts and risks associated with the operation of the facility and the control measures to manage the identified environmental impacts and risks to as low as reasonably practicable (ALARP) and an acceptable level. This risk assessment and evaluation was undertaken using Woodside's Risk Management Framework.

Environmental impacts and risks include those directly and indirectly associated with the Petroleum Activities Program, and includes potential emergency and accidental events. Planned activities have the potential for inherent environmental impacts. An environmental risk is an unplanned event with the potential for impact (termed risk 'consequence').

Herein, potential impact from planned activities are termed 'impacts', and 'risks' are associated with unplanned events with the potential for impact (should the risk be realised), with such impact termed potential 'consequence'.

The key steps of Woodside's Risk Management Processes are shown in **Figure 5-1**. A summary of each step and how it is applied to the proposed Program is provided below.

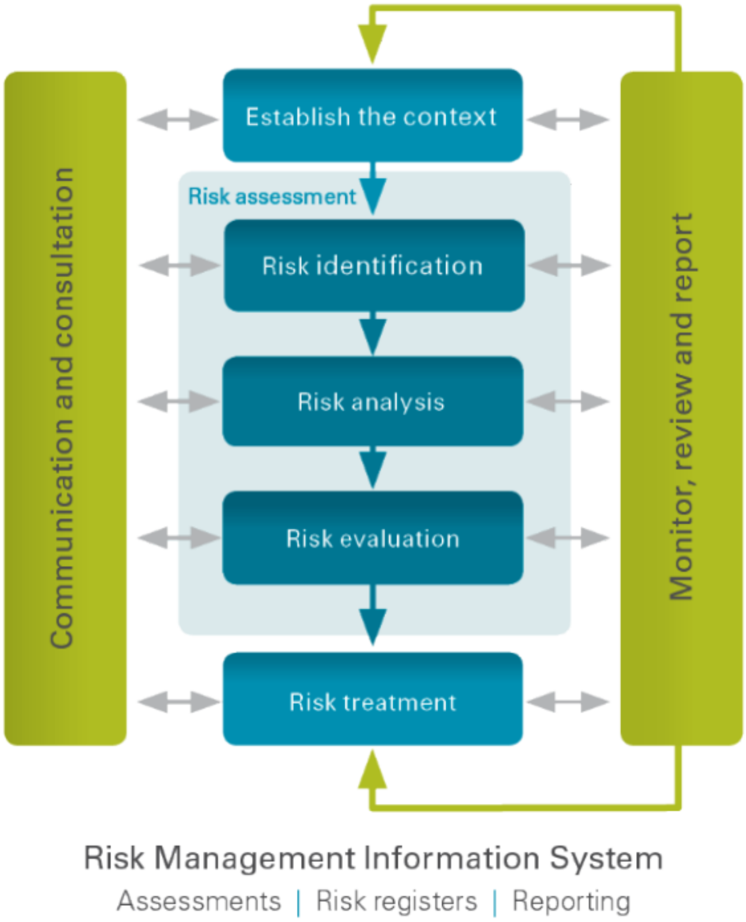

Figure 5-1: Key steps in Woodside's Risk Management Process

5.1.1 Establish the Context

The objective of a risk assessment is to assess identified risks and apply appropriate control measures to eliminate, control or mitigate the risk to ALARP and to determine if the risk is acceptable.

Hazard identification workshops aligned with NOPSEMA's Hazard Identification Guidance Note were undertaken by multidisciplinary teams made up of relevant personnel with sufficient breadth of knowledge, training and experience to reasonably assure that risks and associated impacts were identified and assessed.

5.1.2 Impact and Risk Identification

An Environmental Hazard Identification (ENVID) was undertaken by multidisciplinary teams consisting of relevant engineering and environmental personnel with sufficient breadth of knowledge, training and experience to reasonably assure that risks were identified and their potential environmental impacts assessed.

Impacts and risks were identified during the ENVID for both planned (routine and non-routine) activities and unplanned (accidents/incidents/emergency conditions) events.

5.1.3 Risk Analysis

Risk analysis further develops the understanding of a risk by defining the impacts and assessing appropriate controls. Risk analysis considered previous risk assessments for similar activities, review of relevant studies, review of past performance, external stakeholder consultation feedback and review of the existing environment.

The following key steps were undertaken for each identified risk during the risk assessment:

- Identification of decision type in accordance with the decision support framework;
- Identification of appropriate control measures (preventative and mitigation) aligned with the decision type; and
- Assessment of the risk rating.

5.1.4 Decision Support Framework

To support the risk assessment process and Woodside's determination of acceptability, Woodside's HSE risk management procedures include the use of decision support framework based on principles set out in the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This concept has been applied during the ENVID or equivalent preceding processes during historical design decisions to determine the level of supporting evidence that may be required to draw sound conclusions regarding risk level and whether the risk or impacts is acceptable and ALARP. This is to confirm:

- activities do not pose an unacceptable environmental risk
- appropriate focus is placed on activities where the impact or risk is anticipated to be acceptable and demonstrated to be ALARP
- appropriate effort is applied to the management of risks and impacts based on the uncertainty of the risk, the complexity and risk rating (i.e. potential higher order environmental impacts are subject to further evaluation assessment).

The framework provides appropriate tools, commensurate to the level of uncertainty or novelty (referred to as the decision type A, B or C). The decision type is selected based on an informed discussion around the uncertainty and documented in ENVID worksheets.

This framework enables Woodside to appropriately understand a risk, determine if the risk or impact is acceptable and can be demonstrated to be ALARP.

Decision Type A

Decision Type A are well understood and established practice, they generally consider recognised good industry practice which is often embodied in legislation, codes and standards and use professional judgment.

Decision Type B

Decision Type B typically involves greater uncertainty and complexity (and can include potential higher order impacts/risks). These risks may deviate from established practice or have some lifecycle implications and therefore require further engineering risk assessment in order to support the decision and ensure that the risk is ALARP. Engineering risk assessment tools may include:

- risk-based tools such as cost based analysis or modelling
- consequence modelling
- reliability analysis
- company values.

Decision Type C

Decision Type C typically has significant risks related to environmental performance. Such risks typically involve greater complexity and uncertainty, therefore requiring adoption of the precautionary approach. The risks may result in significant environmental impact; significant project risk/exposure or may elicit negative stakeholder concerns. For these risks or impacts, in addition to Decision Type A and B tools, company and societal values need to be considered by undertaking broader internal and external stakeholder consultation as part of the risk assessment process.

5.1.5 Identification of Control Measures

Woodside applies a hierarchy of control measures when considering Good Practice and Professional Judgement. The hierarchy of control is applied in order of importance as follows; elimination, substitution, engineering control measures, administrative control measures and mitigation of consequences/impacts.

5.1.6 Risk Rating Process

The current risk rating process is undertaken to assign a level of risk to each impact measured in terms of consequence and likelihood. The assigned risk level is the current risk (i.e. risk with controls in place) and is therefore determined following the identification of the decision type and appropriate control measures.

The risk rating process considers the environmental impacts and where applicable, the social and cultural impacts of the risk. The risk ratings are assigned using the Woodside Risk Matrix (refer to **Figure 5-2**).

The risk rating process is performed using the following steps:

Select the Consequence Level

Determine the most credible impacts associated with the selected event assuming all controls (prevention and mitigation) are absent or have failed (refer to **Table 5-1**). Where more than one potential consequence applies, the highest severity consequence is selected.

Table 5-1: Woodside Risk Matrix (Environment and Social and Cultural) Consequence Descriptions

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

Select the Likelihood Level

Select the likelihood level from the description that best fits the chance of the selected consequence actually occurring, assuming reasonable effectiveness of the prevention and mitigation controls (refer to **Table 5-2**).

Table 5-2: Woodside Risk Matrix Likelihood Levels

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

Calculate the Risk Rating

A likelihood and risk rating is only applied to environmental risks using the Woodside Risk Matrix. This risk level is used as an input into the risk evaluation process and ultimately for the prioritisation of further risk reduction measures. Once each risk is treated to ALARP, the risk rating articulates the ALARP baseline risk as an output of the ENVID studies.

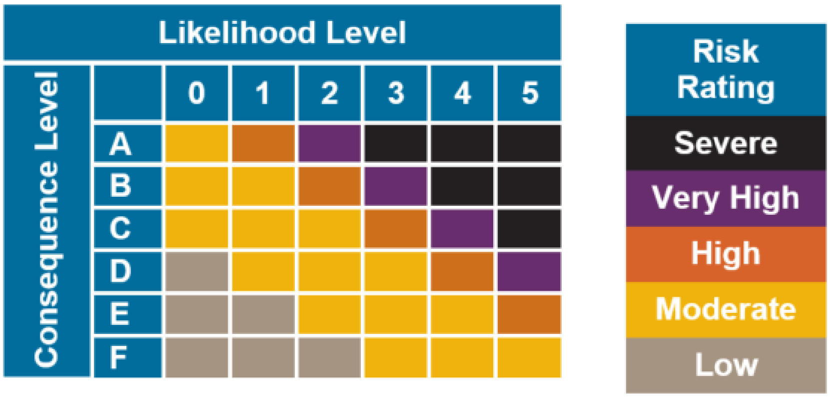

Table 5-3: Woodside Risk Matrix: Risk Level

The risk analysis and evaluation for the Petroleum Activities Program indicate that all of the current environmental risks and impacts associated with the activity are reduced to ALARP and are of an acceptable level (refer to **Table 5-3**: Woodside Risk Matrix: Risk Level

5.2 Classification and Analysis of Major Environment Events

For Woodside's offshore production facilities, a further level of analysis is undertaken to identify, classify and analyse Major Environment Events (MEEs). This extra level of rigour is applied to ensure sufficient controls are in place for risks with potential Major and above consequences. In the health and safety area Major Accident Events (MAE) are identified using a similar process which supports consistency in management of key risks within Woodside in accordance with Process Safety Risk Management Procedures.

MEEs are defined by Woodside as:

- an event with potential environment, reputation (pertaining to environment events), social or cultural consequences of category B or higher as per Woodside Risk Matrix (**Table 5-3**: Woodside Risk Matrix: Risk Level
-), which are evaluated against credible worst case scenarios which may occur when all controls are absent or have failed.

5.2.1 MEE Identification

The ENVID and risk rating process results in the generation of numerous sources of risk with differing consequence levels. Not all of these risks meet the MEE definition and are therefore screened out at this stage of the MEE process.

Although these risks are screened out, all risks identified in this EP (including MEEs), are evaluated for ALARP and acceptability using the methodology described in **Section 5.3**.

5.2.2 MEE Classification

A standard naming convention has been established for MEEs; this is based around ensuring the MEE titles reflect the cause of the event e.g. 'subsea system loss of containment', rather than the event itself e.g. significant hydrocarbon spill to the marine environment. The MEEs are assigned a unique identification code e.g. MEE-01, MEE-02 etc.

5.2.3 Safety and Environment Critical Elements (SCE) and Performance Standards

Woodside identifies and manages Safety Critical Elements (SCE) technical performance standards and management system performance standards (MSPS) in accordance with Process Safety Management Procedures, Risk Management Procedure, and Change Management Procedures. SCEs are identified for MAE and MEEs. An SCE is a hardware control, the failure of which could cause or contribute substantially to, or the purpose of which is to prevent or limit the effect of a MAE, MEE or Process Safety Event. In addition, Woodside defines Safety and Environment Critical Equipment (SCE) as an item of equipment or structure forming part of a hardware SCE that supports the SCE in achieving the safety function[1].

Once each SCE is selected, technical performance requirements are developed in accordance with Safety and Environment Critical Element (SCE) Management Procedure which form the SCE technical Performance Standards. These standards are a statement of the performance required of a SCE (e.g. functionality, availability, reliability, survivability), which is used as the basis for establishing agreed assurance tasks for each SCE and therefore support the management of operations within acceptable safety and/or environment risks levels, and ensure continuous management of risk to ALARP. An assurance task is an activity carried out by the operator to confirm that the SCE meets, or will meet its SCE Performance Standard. Examples of assurance tasks include inspection routines, test routines, instrumentation calibration and reliability monitoring.

SCE technical Performance Standards are not inherently aligned directly to Environment Performance Standards (EPS), and are used in conjunction with Woodside's management system to identify and treat potential step-outs from expected controls performance or integrity envelopes, and ensure SCE performance can be optimised. Woodside's HSE Event Reporting Guideline describes the identification of 'Damage to SCEs' which is an SCE failure presenting a risk level which requires that Immediate Control Actions must be put in place to manage increased current risk. For applicable SCEs, 'Damage to SCE' failures represent scenarios which may fail to achieve an EPS presented in this EP.

Safety Critical Management System Barriers

For each MEE, Safety Critical Management System specific measures are also identified. These are management system components (generally Woodside Management System (WMS) processes) that are key barriers in the management of MEEs.

5.3 Impact and Risk Evaluation

Environmental impacts and risks, as opposed to safety risks, cover a wider range of issues, differing species, persistence, reversibility, resilience, cumulative effects and variability in severity. Determining the degree of environmental risk and the corresponding threshold for whether a risk/impact has been reduced to ALARP and is acceptable is evaluated to a level appropriate to the nature and scale of each impact or risk. Evaluation includes consideration of the following evaluation criteria:

- The Decision Type
- Principles of Ecologically Sustainable Development as defined under the EPBC Act;
- Internal context - the proposed controls and risk level are consistent with Woodside policies, procedures and standards
- External context – consideration of the environment consequence and stakeholder acceptability
- Other requirements – the proposed controls and risk level are consistent with national and international industry standards, laws and policies.

[1] *Note: not all individual equipment items which make up SCE are safety critical.*

In accordance with Regulation 10A(a), 10A(b) and 10A(c), and 13(5)(b) of the Environmental Regulations, Woodside applies the following process to demonstrate ALARP and acceptability for environmental impacts and risks appropriate to the nature and scale of each impact or risk.

5.3.1 Demonstration of ALARP

Descriptions have been provided below (**Table 5-4**) to articulate how Woodside demonstrates different risks, impacts and Decision Types identified within the EP are ALARP.

Table 5-4: Summary of Woodside's Criteria for ALARP Demonstration

Risk	Impact	Decision Type
Low and Moderate	***Negligible, Slight or Minor (D, E or F)***	***A***
Woodside demonstrates these Risks, Impacts and Decision Types are reduced to ALARP: • If controls identified meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines. • Further effort towards impact/risk reduction (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.		
High, Very High or Severe	***Moderate and above (A, B, or C)***	***B and C***
Woodside demonstrates these higher order Risks, Impacts and Decision Types are reduced to ALARP (where it can be demonstrated using good industry practice and risk based analysis) that; • Legislative requirements, applicable company requirements and industry codes and standards are met; • Societal concerns are accounted for; and • The alternative control measures are grossly disproportionate to the benefit gained.		

5.3.2 Demonstration of Acceptability

Descriptions have been provided below (**Table 5-5**) to articulate how Woodside demonstrates how different risks, impacts and Decision Types identified within the EP are Acceptable.

Table 5-5: Summary of Woodside's Criteria for Acceptability

Risk	Impact	Decision Type
Low and Moderate (below C level consequence)	***Negligible, Slight or Minor***	***A***
Woodside demonstrates these Risks, Impacts and Decision Types are 'Broadly Acceptable', if they meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines. Further effort towards risk reduction (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.		
High, Very High or Severe (C+ consequence risks)	***Moderate and above***	***B and C***
Woodside demonstrates these higher order Risks, Impacts and Decision are 'Acceptable if ALARP' can be demonstrated using good industry practice and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained. In undertaking this process for moderate and high current risks, Woodside evaluates the following criteria:		

- Principles of Ecological Sustainable Development (ESD) as defined under the EPBC Act;
- Internal context - the proposed controls and consequence/ risk level are consistent with Woodside policies, procedures and standards;
- External context – consideration of the environment consequence and stakeholder acceptability; and
- Other requirements – the proposed controls and consequence/ risk level are consistent with national and international industry standards, laws and policies.

Additionally, Very High and Severe risks require 'Escalated Investigation' and mitigation to reduce the risk to a lower and more acceptable level. If after further investigation the risk remains in the Very High or Severe category, the risk requires appropriate business engagement in accordance with Woodside's Risk Management Procedure to accept the risk. This includes due consideration of regulatory requirements.

5.4 Hydrocarbon Spill Risk Assessment Methodology

Quantitative hydrocarbon spill modelling was undertaken using a three-dimensional hydrocarbon spill trajectory and weathering model which is designed to simulate the transport, spreading and weathering of specific hydrocarbon types under the influence of changing meteorological and oceanographic forces.

5.4.1 ZoC and Hydrocarbon Contact Thresholds

The outputs of the quantitative hydrocarbon spill modelling are used to assess the environmental risk, if a credible hydrocarbon spill scenario occurred, solely in terms of delineating which areas of the marine environment could be exposed to hydrocarbon levels exceeding hydrocarbon threshold concentrations.

The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as the ZoC. A stochastic modelling approach was applied to the quantitative hydrocarbon spill modelling. Stochastic modelling is the combination of a number of individual spill trajectory simulations, modelled under a range of historical metocean data considered seasonally and geographically representative for the scenario modelled. The stochastic results indicate the probability of where hydrocarbon might travel, and the time taken by the hydrocarbon to reach a given sensitive receptor for all modelled simulations. When considering the ZoC, it is important to understand that the ZoC does not represent the extent of any single spill event, which would be significantly smaller in spatial extent than a ZoC presenting stochastic modelling probabilities.

As the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, a different ZoC is presented for each fate.

The spill modelling outputs are presented as threshold concentrations for surface, entrained and dissolved hydrocarbons for the modelled scenarios. Surface spill concentrations are expressed as grams per square metre (g/m^2), with entrained and dissolved aromatic hydrocarbon concentrations expressed as parts per billion (ppb). A conservative approach, adopting accepted contact thresholds that are documented to impact the marine environment, is used to define the ZoC. Hydrocarbon thresholds are presented in the table below (**Table 5-5**) and described in the following subsections.

Table 5-6: Summary of Thresholds Applied to the Quantitative Hydrocarbon Spill Modelling Results

Surface Hydrocarbon (g/m^2)	Entrained hydrocarbon (ppb)	Dissolved aromatic hydrocarbon (ppb)	Accumulated hydrocarbon (g/m^2)
10	500	500	100

5.4.2 Surface Hydrocarbon Threshold Concentrations

The spill modelling outputs defined the ZoC for surface hydrocarbon spills (contact on surface waters) using the ≥10 g/m^2 based on the relationship between film thickness and appearance (Bonn Agreement, 2015) (**Table 5-7**). This threshold concentration expressed in terms of g/m^2 is geared towards informing potential oiling impacts for wildlife groups and habitats that may break through the surface slick from the water or the air (for example: emergent reefs, vegetation in the littoral zone and air-breathing marine reptiles, cetaceans, seabirds and migratory shorebirds).

Thresholds for registering biological impacts resulting from contact of surface slicks have been estimated by different researchers at approximately 10–25 g/m^2 (French et al., 1999; Koops et al., 2004; NOAA, 1996). Potential impacts of surface slick concentrations in this range for floating hydrocarbons may include harm to seabirds through ingestion from preening of contaminated feathers or the loss of the thermal protection of their feathers. The 10 g/m^2 threshold is the reported level of oiling to instigate impacts to seabirds and is also applied to other wildlife though it is recognised that 'unfurred' animals where hydrocarbon adherence is less, may be less vulnerable. 'Oiling' at this threshold is taken to be of a magnitude that can cause a response to the most vulnerable wildlife such as seabirds. Due to weathering processes, surface hydrocarbons will have a lower toxicity due to change in their composition over time. Potential impacts to shoreline sensitive receptors may be markedly reduced in instances where there is extended duration until contact.

Table 5-7: The Bonn Agreement Oil Appearance Code

Appearance (following Bonn visibility descriptors)	Mass per area (g/m^2)	Thickness (µm)	Volume per area (L/Km^2)
Discontinuous true oil colours	50 to 200	50 to 200	50,000 to 200,000
Dull metallic colours	5 to 50	5 to 50	5,000 to 50,000
Rainbow sheen	0.30 to 5.00	0.30 to 5.00	300 to 5,000
Silver sheen	0.04 to 0.30	0.04 to 0.30	40 to 300

5.4.3 Entrained Hydrocarbon Threshold Concentrations

The spill modelling outputs are used to define the ZoC by defining the spatial variability of entrained hydrocarbons above a set concentration threshold contacting sensitive receptors (expressed in ppb).

Entrained hydrocarbons present a number of possible mechanisms for harmful exposure to marine organisms. The entrained hydrocarbon droplets may contain soluble compounds, hence have the potential for generating elevated concentrations of dissolved aromatic hydrocarbons (e.g. if mixed by breaking waves against a shoreline). Physical and chemical effects of the entrained hydrocarbon droplets have also been demonstrated through direct contact with organisms, for example through physical coating of gills and body surfaces, and accidental ingestion (National Research Council 2005).

The threshold concentration of entrained hydrocarbons that could result in a biological impact cannot be determined directly using available ecotoxicity data for water accommodated fraction (WAF) of oil hydrocarbons. However, it is likely this data specific to dissolved oil hydrocarbon represents a worst-case scenario. This is owing to the fact that entrained oil hydrocarbons are less biologically available to organisms through absorption into their tissues than dissolved oil hydrocarbons. It is therefore expected that the entrained threshold concentration of 500 ppb will represent a potential impact substantially lower than the 'no observed effect' concentrations (NOEC) presented in

Table 5-9.

5.4.4 Dissolved Aromatic Hydrocarbon Threshold Concentrations

To confirm the appropriate threshold for dissolved hydrocarbon impacts associated with the Petroleum Activities Program Woodside examined various ecotoxicology data available. Woodside has undertaken ecotoxicological testing of Pluto condensate and was used to determine the threshold concentration value for dissolved hydrocarbons. The Pluto condensate is considered representative of the target reservoir fluids within the Xena and Pyxis fields.

The ecotoxicity testing focusses on the total petroleum hydrocarbons (TPH) concentration of the WAF of the hydrocarbon and includes the carbon chains C6 to C36. Typically, C4 to C10 compounds are volatile (BP < 180 °C), C11 to C15 compounds are semi-volatile (BP 180–265 °C), C16 to C20 compounds have low volatility (265–380 °C) and C21 compounds and above are residual (BP > 380 °C). A summary of the characteristics of the hydrocarbons used as a basis for the modelling studies used to inform the assessment of MEEs is provided in **Table 5-8.**

Table 5-8: Characteristics of the hydrocarbon types used in the modelling of scenarios

Hydrocarbon Type	Initial Density (g/cm³ at 15 °C)	Wax Content (% by Weight)	Asphaltene Content (% by weight)	Pour Point (°C)	Viscosity (cP @ 20 °C)	Component boiling point percentage of total (°C)				Aromatic of whole product < 380 °C BP
						Volatiles < 180 °C	Semi-volatiles 180-265 °C	Low volatility 265-380 °C	Residual > 380 °C	
						Non-persistent			Persistent	
Pluto condensate	0.738	< 5%	<0.1%	<-36	0.617	73	16	10	1	3.5
Marine diesel	0.829	-	-	-	4.0	6	34.6	54.4	5	-

Table 5-9 presents the ecotoxicological test results of no observable effect concentration (NOEC) for fresh NWS condensate .

Table 5-9: Summary of Total Recoverable Hydrocarbons NOECs for Key Life-histories of Different Biota Based on Toxicity Tests for WAF of fresh NWS Condensate

Biota and Life Stage	Exposure Duration	NOEC – Aromatic Concentration of unweathered condensate showing no direct biological affect (ppb)	EC/LC/IC50 – TPH Concentrations of unweathered condensate (ppb)
Sea urchin fertilisation	1 hours	442.1	2981 (EC50)
Sea urchin larval development	72 hours	2027.5	10,790 (EC50)
Milky oyster larval development	48 hours	3654	10,060 (EC50)
Micro-algal growth test	72 hours	140[2]	3006 (IC50)
Macro-algal germination test	72 hours	24481953.4	4801 (EC50)
Amphipod juvenile survival	96 hours	230.6	690* (LC50)
Copepod juvenile survival	48 hours	555.7	1273 (LC50)
Larval fish imbalance test	96 hours	6327.3	> 6805 (EC50)

** Value estimated due to TPH concentration measurement method limitations.*

Source: ESA 2012

The ecotoxological testing focusses on the total petroleum hydrocarbons (TPH) concentration of the water accommodated fraction (WAF) of the hydrocarbon. It includes the carbon chains C6 to C36. Typically, C4 to C10 compounds are volatile (BP <180°C), C11 to C15 compounds are semi-volatile (BP 180–265°C), C16 to C20 compounds have low volatility (265–380°C), and C21 compounds and above are residual (BP >380°C).

The purpose of the threshold is to inform the assessment of the potential for toxicity impacts on sensitive marine biota. The ecotoxicity tests were undertaken on a broad range of taxa of ecological relevance, for which accepted standard test protocols are well established. These ecotoxicology tests are focussed on the early life stages of test organisms, when organisms are typically at their most sensitive. The ecotoxicology tests were conducted on six mainly tropical–subtropical species representatives from six major taxonomic groups.

The laboratory-based ecotoxicology tests used a range of WAF concentrations to expose the different test organisms. For each ecotoxicity test, samples of the WAF were analysed to determine the TPH concentration of the solution.

[2] Value estimated due to TPH concentration measurement method limitations and 95% confidence limits not reliable.

Table 5-9 presents the results of no observed effect aromatic concentrations (NOEC) and the EC, LC or IC 50 TPH concentrations for each of the condensate WAFs tested. With the exception of the NOEC value for the micro-algal growth test, sea urchin fertilisation and the amphipod acute toxicity test, all other toxicity tests indicated NOECs ranged from 554 to 6805 ppb. EC, LC and IC50 TPH concentrations ranged from 690 to 10,790 ppb (although it should be noted that the lowest value is outside 95% confidence intervals).

5.4.5 Accumulated Hydrocarbon Threshold Concentrations

Owens et al. (1994) define accumulated hydrocarbon < 100 g/m^2 to have an appearance of a stain on shorelines. French-McKay (2009) defines accumulated hydrocarbons ≥ 100 g/m^2 to be the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat; therefore, ≥ 100 g/m^2 has been adopted as the threshold for shoreline accumulation.

5.5 Potential Environment Risks Not Included Within the Scope of the Environment Plan

The ENVID identified a number of sources of environmental risk/impact as a result of the Petroleum Activities Program, that were assessed as not being applicable (not credible) within or outside the Operational Area and therefore, were determined to not form part of this EP. This is described in the following section for information only.

Shallow/Near-shore Activities

The Petroleum Activities Program is located in water depths of approximately between 40 and 962 m and at a distance approximately 46 km from nearest landfall (Montebello Islands), consequently risks/impacts associated with shallow/near-shore activities such as anchoring and vessel grounding were assessed as not credible.

6. ENVIRONMENTAL RISK AND IMPACTS SUMMARY

Table 6-1 presents a summary of the sources of impact/risk, analysis and evaluation for the Petroleum Activities Program.

The risks identified during the ENVID (including decision type, current risk level, acceptability of risk and tools used in the demonstration of acceptability and ALARP) have been divided into two broad categories:

- planned (routine and non-routine) activities; and
- unplanned events (accidents, incidents or emergency situations).

Within these categories, impact assessment groupings are based on stressor type e.g. emissions, physical presence etc. In all cases the worst credible consequence was assumed.

The analysis and evaluation for the Petroleum Activities Program indicate that all of the current environmental risks and impacts associated with the activity are reduced to ALARP and are of an acceptable level (see **Appendix A**: Environmental Impacts and Risks).

Table 6-1: Environmental Risk and Impacts Register Summary

Aspect	Source of Impact	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Controlled Impact Classification	Residual Impact Level (ALARP controls in place)	Acceptability of Impact
Planned Activities (Routine and Non-routine)					
Physical presence: disturbance to marine users	Presence of facility and subsea infrastructure excluding and/or displacing other users from PSZ and Operational Area respectively.	Potential isolated social impact potentially resulting from interference with other sea users (e.g. commercial and recreational fishing, and shipping).	F	Social and Cultural – No lasting effect (< 1 month). Localised impact not significant to areas/items of cultural significance.	Broadly acceptable
Physical presence: Disturbance to seabed	Presence of facility and subsea infrastructure modifying marine habitats.	Localised modification of seabed habitat (formation of artificial reef) within the Operational Area.	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
	Subsea operations, inspection, maintenance and repair activities resulting in disturbance to seabed.	Localised modification of seabed habitat within the Operational Area with potential for impacts to water quality and benthic communities of no lasting effect.	E	Environment – Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
Routine and non-routine acoustic emissions: generation of noise during routine operations	Noise generated within the Operational Area from; • the offshore facility and associated infrastructure, • vessels, • IMR activities, • helicopters.	Potential localised behavioural impacts to marine fauna within the Operational Area.	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Routine and non-routine discharges: discharge of hydrocarbons and chemicals during subsea operations and activities	Discharge of subsea control fluids.	Localised, decrease in water quality around subsea system within the Operational Area.	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
	Discharge of hydrocarbons remaining in subsea infrastructure and equipment as a result of subsea intervention works.	Potential slight short-term, localised decrease in water quality with potential impacts to marine fauna (toxicity).	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
	Discharge of chemicals remaining in subsea infrastructure and equipment or the use of chemicals for subsea IMR activities.	Localised decrease in water quality at release location during IMR activities.	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
	Discharge of minor fugitive hydrocarbons from subsea equipment.	Potential short-term, localised decrease in water quality around subsea system within the Operational Area with no lasting effect.	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Routine and non-routine discharges: discharge of produced water	Discharge of produced water during routine and non-routine operations.	Potential slight short-term, localised decrease in water quality (increased hydrocarbon and chemical concentrations) at discharge location and within mixing zone, with potential impacts to marine fauna (toxicity).	E	Environment – Slight short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable

Aspect	Source of Impact	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Controlled Impact Classification		Residual Impact Level (ALARP controls in place)	Acceptability of Impact
Routine and non-routine discharges of sewage, putrescible waste, grey water, bilge water, drain water, cooling water and brine	Discharge of sewage, grey water and putrescible waste from vessels and riser platform to the marine environment.	Potential localised, short-term decrease in water quality (increased nutrients and biological oxygen demand) at the discharge location.	F	Cumulative E	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
	Discharge of deck, bilge and drain water from vessels and riser platform to the marine environment.	Potential localised, short-term decrease in water quality (increased hydrocarbon and chemical concentrations) at the discharge location.	F		Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
	Discharge of reverse osmosis brine and cooling water from vessels.	Highly localised, short-term increase in salinity at the discharge location.	F		Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Routine and non-routine atmospheric emissions: fuel combustion, flaring and fugitives	The riser platform internal combustion engines, operational flaring and fugitive emissions, and vessel emissions (including incinerators).	Localised, short-term decrease in air quality, limited to the airshed local to the facility.	F		Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Routine light emissions: light emissions from platform lighting, vessels operations and operational flaring	Light emissions from the riser platform and vessels.	Negligible, localised potential for behavioural disturbance of species in close proximity to riser platform and vessels.	F		Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
	Light emissions from the riser platform during flaring.	Negligible, localised potential for behavioural disturbance of species in close proximity to riser platform.	F		Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable

Aspect	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Risk Rating				Acceptability of Risk
			Consequence Classification	Potential Consequence/Level of Impact	Likelihood	Residual Risk Rating	
Unplanned Events (Accidents/Incidents)							
Unplanned hydrocarbon or chemical release: hydrocarbon release during bunkering, refuelling and chemical release during transfer, storage and use, rupture of chemical supply lines	Accidental spill of hydrocarbons to the environment during bunkering/refuelling and loss of topside containment (non-process)	Potential minor short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or temporary impacts to water quality.	D	Environment – Minor short-term impact (1–2 years) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	2	M	Broadly acceptable
	Accidental discharge of chemicals to the marine environment from storage, use or transfer.	Potential minor short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or temporary impacts to water quality.	D	Environment – Minor short-term impact (1–2 years) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	M	Broadly acceptable
	Accidental release of MEG from the chemical supply	Potential slight, short term impacts to marine	E	Environment – Slight, short-term impact	2	M	Broadly

Aspect	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Risk Rating				Acceptability of Risk
			Consequence Classification	Potential Consequence/Level of Impact	Likelihood	Residual Risk Rating	
	line	water quality.		(< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.			acceptable
Unplanned discharges: hazardous and non-hazardous waste management	Incorrect disposal or accidental discharge of non-hazardous and hazardous waste to the marine environment.	Potential slight short term impacts to the marine fauna, and localised temporary impacts to water quality and marine sediments.	E	Environment – Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	2	M	Broadly acceptable
Physical presence: vessel collision with marine fauna	Physical presence of vessels resulting in collision with marine fauna.	Potential injury or death of marine fauna (single animal), including protected species.	E	Environment – Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	L	Broadly acceptable
Physical presence: introduction of invasive marine species	Invasive species in vessel ballast tanks or on vessels/submersible equipment.	Potential introduction of invasive marine species possibly resulting in an alteration of the localised environment.	E	Environment – Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	L	Broadly acceptable
Unplanned hydrocarbon release: topside loss of containment	Release of process and non-process hydrocarbons resulting from topside loss of containment to the marine environment.	Potential minor short-term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or temporary impacts to water quality.	D	Environment – Minor short-term impact (1–2 years) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	M	Broadly acceptable
Unplanned Events (Accidents/Incidents) – MEEs							
Unplanned hydrocarbon release: loss of well containment (MEE-01)	Release of hydrocarbons resulting from loss of platform well containment.	Potential significant impacts to the marine environment: • long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines • disruption to marine fauna, including protected species • potential medium-term interference with or displacement of other sea users.	B	Environment – Major, long-term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
Unplanned hydrocarbon release: subsea equipment loss of containment (MEE-02)	Release of hydrocarbons resulting from loss of containment of export pipeline, riser and infrastructure	Potential significant impacts to the marine environment: • long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines • disruption to marine fauna, including protected species • potential medium-term interference with or displacement of other sea users.	B	Environment – Major, long-term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
	Release of hydrocarbons resulting from loss of containment of flowlines riser and infrastructure	Potential moderate medium term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological	1	M	Acceptable if ALARP

Aspect	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Risk Rating				Acceptability of Risk
			Consequence Classification	Potential Consequence/Level of Impact	Likelihood	Residual Risk Rating	
		impacts to water quality.		attributes.			
Unplanned hydrocarbon release: loss of structural integrity (MEE-03)	Hydrocarbon release from pipeline, flowline(s) and riser(s) to the marine environment and atmosphere.	Potential moderate medium term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
	Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of riser platform.	Potential moderate medium term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
Unplanned hydrocarbon release: loss of marine vessel separation (MEE-04)	Hydrocarbon release from pipeline, flowline(s) and riser(s) to the marine environment and atmosphere.	Potential moderate medium term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
	Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of riser platform.	Potential moderate medium term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
Unplanned hydrocarbon release: loss of control of platform suspended load (MEE-05)	Hydrocarbon release from pipeline, flowline(s) and riser(s) to the marine environment and atmosphere	Potential moderate medium term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes	1	M	Acceptable if ALARP

7. ONGOING MONITORING OF ENVIRONMENTAL PERFORMANCE

The Petroleum Activities Program will be managed in compliance with the Pluto Operations EP accepted by NOPSEMA under the Environment Regulations, other relevant environmental legislation and Woodside's Management System.

The objective of the EP is to identify, mitigate and manage potentially adverse environmental impacts associated with the Petroleum Activities Program, during both planned and unplanned operations, to ALARP and an acceptable level.

For each environmental aspect (risk) and associated environmental impact (identified and assessed in the Environmental Risk Assessment of the EP) a specific environmental performance outcome, environmental performance standards and measurement criteria have been developed. The performance standards and control measures (available in **Appendix A**) that will be implemented (consistent with the performance standards) to achieve the environmental performance outcomes. The specific measurement criteria provide the evidence base to demonstrate that the performance standards (control measures) and outcomes are achieved.

7.1 Training and Competency

The implementation strategy detailed in the Pluto Operations EP identifies the roles/responsibilities and training/competency requirements for personnel (Woodside and its contractors) in relation to implementing controls, managing non-conformance, emergency response and meeting monitoring, auditing, and reporting requirements during the activity.

Environmental training is undertaken to ensure employees and contractors whose work may impact on the environment have the necessary awareness, knowledge and competence appropriate for their role. Different levels of training are undertaken in relation to managing environmental risks and impacts for the production offshore facilities and associated Subsea Support Vessel based IMR activities:

- inductions for offshore facility workers and visitors
- production division competency framework training
- permit to work training (ISSoW)
- production environmental leadership training and environment awareness training
- emergency and hydrocarbon spill response training
- inductions for subsea IMR (vessel based) personnel.

Training records for Woodside production personnel, in relation to the above listed training, are maintained in Woodside's learning management system. Contractor training records are also maintained.

7.2 Monitoring, Auditing, Management of Non-conformance and Review

Regulation 14(6) states that the Implementation Strategy is to provide for the monitoring, audit, management of non-conformance and review of operator's environmental performance and the Implementation Strategy itself. The EP outlines the measures undertaken by Woodside to regularly monitor the management of environmental risks and impacts of the facility against the EPOs, EPSs and MCs with a view to continuous improvement of environmental performance. The effectiveness of the Implementation Strategy is also reviewed periodically as part of the monitoring and assurance process.

Woodside and its Contractors will undertake a program of periodic monitoring during the Petroleum Activities Program using a number of tools and systems. The tools and systems collect, as a minimum, the data (evidence) referred to in the measurement criteria. The collection of this data (and assessment against the measurement criteria) forms part of the permanent record of compliance maintained by Woodside and the basis for demonstrating that the environmental performance outcomes and standards are met.

Monitoring of environmental performance is undertaken as part of the following:

- external annual performance reporting to NOPSEMA verify compliance with the environmental performance outcomes, standards and measurement criteria outlined in the EP
- internal inspection and assurance activities daily reports which include leading indicator compliance
- use of contractor's risk identification program that requires personnel to record and submit safety and environment risk observation cards on a routine basis
- collection of evidence of compliance with the controls detailed in the EP relevant to offshore activities by the Woodside Offshore HSE Adviser (or equivalent) (other compliance evidence is collected onshore)
- environmental discharge reports that record volumes of planned and unplanned discharges to ocean and atmosphere
- monitoring of progress against the Developments function scorecard for key performance indicators
- internal auditing and assurance program.

Woodside employees and Contractors are required to report all environmental incidents and non-conformances with environmental performance outcomes and standards in the EP. Incidents will be reported using an Incident and Hazard Report Form, which includes details of the event, immediate action taken to control the situation, and corrective actions to prevent reoccurrence. An internal computerised database is used for the recording and reporting of these incidents.

7.3 Risk Management

Risk management processes and practices are applied on an ongoing basis to design, production and maintenance activities at the facility to manage risks to personnel, assets and the environment. Potential environmental consequences and impacts from the facility are risk assessed and controlled in accordance with the Woodside risk management processes (Environmental Risk Management Methodology).

The results of the Pluto Offshore Facility ENVID are described in Appendix A and in the facility Environmental Impacts and Risk Register. This register, in conjunction with the EP and ongoing risk management and monitoring and review processes provides a demonstration that environmental risks have been identified and that appropriate controls are in place to manage those risks to a level that is acceptable and ALARP throughout the life of the facility.

A number of other risk management tools and techniques are used by the facility to manage environmental and other risks on a routine basis during operational, maintenance and inspection tasks.

7.4 Environmental Risk Review

Woodside risk management processes include risk review and are applied on a day-to-day basis. The Facility Environmental Impacts and Risk Register must be reviewed and updated every five years. Monitoring and assurance and review are also used to identify potential new information that may arise during the activity and ensure that EPOs and EPSs are being met and EP environmental control measures are effective.

7.5 Management of Change

Management of changes relevant to the Pluto Operations EP, concerning the scope of the activity description, changes in understanding of the environment, including advice on species protected under EPBC Act and potential new advice from external stakeholders, will be managed in accordance with internal procedures for management of change. These provide guidance on the Environment Regulations that may trigger a revision and resubmission of the Pluto Operations EP to NOPSEMA. They also provide guidance on what constitutes a significant new risk or increase in risk. A risk assessment will be conducted in accordance with Woodside's Environmental Risk Management Methodology to determine the significance of any potential new environmental impacts or risks not provided for in the Pluto Operations EP. Risk assessment outcomes are reviewed in compliance with Regulation 17 of the Environment Regulations.

Minor changes where a review of the activity and the environmental risks and impacts of the activity do not trigger a requirement for a revision, under Regulation 17 of the Environment Regulations, will be considered a 'minor revision'. Minor administrative changes to the Pluto Operations EP, where an assessment of the environmental risks and impacts is not required (e.g. document references, phone numbers, etc.), will also be considered a 'minor revision'. Minor revisions and administrative changes as defined above will be made to the Pluto Operations EP using Woodside's document control process. Minor revisions will be tracked and incorporated during scheduled internal reviews.

7.6 Continuous Improvement

Continuous Improvement (CI) projects to improve production or environmental performance that involve refurbishment, modification or major maintenance on the facility are typically required to follow the Appraise and Develop Management Procedure. Currently, procedure requires that all projects be managed in accordance with the Opportunity Management Framework, which supports the progressive maturation of an opportunity through value creation in the Assess and Select Phases, and the maintenance of value in the Develop and Execute phases. Decisions are typically made with two key considerations; whether the business is ready to proceed which has a technical/functional focus and whether there is a business case for progressing to the next phase. The business case may consider the ALARP position for the CI Project, if relevant.

7.7 Auditing

Environmental assurance activities are conducted on a regular basis to help:

- verify environmental risks and potential impacts are being managed in accordance with the environmental performance outcomes and standards detailed in the Pluto Operations EP
- monitor, review and evaluate the effectiveness of the performance outcomes and standards detailed in the EP
- verify effectiveness of the EP Implementation Strategy
- identify potential non-conformances.

The outputs of the assurance process are corrective actions that feed the improvement process. Therefore, assurance is a key driver of continuous improvement.

7.8 Operations Assurance

To provide confidence, based on evidence commensurate with risk, that business objectives are met, business activities are performed, and risks are managed, assurance is performed as described in the Provide Assurance Procedure and the Operations Assurance Guideline. The Guideline aims to explain how the Operations Division Assurance Team implement Woodside Management System (WMS) Assurance requirements, while concurrently satisfying the Operations Division's specific objectives.

Operations Assurance Activities for environment comprise an annual assurance review of environmental performance, which forms the basis for the routine external annual environmental performance reporting.

7.9 Environment Plan Revisions

Revision of the Pluto Operations EP will be undertaken in accordance with the requirements outlined in Regulations 17, Regulation 18 and Regulation 19 of the Environment Regulations. Woodside will submit a proposed revision of the Pluto Operations EP to NOPSEMA including as a result of the following:

- when any significant modification or new stage of the activity that is not provided for in the EP is proposed;
- before, or as soon as practicable after, the occurrence of any significant new or significant increase in environmental risk or impact not provided for in the EP;
- at least 14 days before the end of each period of five years commencing on the day in which the original and subsequent revisions of the EP is accepted under Regulation 11 of the Environment Regulations; and
- as requested by NOPSEMA.

8. OIL POLLUTION EMERGENCY RESPONSE ARRANGEMENTS

The documents listed below, meet the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations) relating to hydrocarbon spill response arrangements.

- Oil Pollution Emergency Arrangements (OPEA) (Australia);
- The Pluto Offshore Facility Oil Pollution First Strike Plan;
- Oil Spill Preparedness and Response Strategy Selection and Evaluation;
- Operational Plans; and
- Tactical Response Plans.

8.1 Oil Pollution Emergency Arrangements (Australia)

This document outlines the emergency and crisis management incident command structure (ICS) and Woodside's response arrangements to competently respond to and escalate a hydrocarbon spill event. The document interfaces externally with Commonwealth, State and industry response plans and internally with Woodside's ICS.

Woodside's Oil Pollution Emergency Arrangements (Australia) details the following support arrangements:

- access to MODU to drill intervention well via Memorandum of Understanding (MoU) with other industry participants;
- master services agreement with Australian Marine Oil Spill Centre (AMOSC) for the supply of experienced personnel and equipment;
- other support services such as 24/7 hydrocarbon spill trajectory modelling and satellite monitoring services as well as aerial, marine, logistics and waste management support; and
- Mutual Aid Agreements with other oil and gas operators in the region for the provision of assistance in a hydrocarbon spill response.

All operations personnel involved in crisis and emergency management are required to commit to ongoing training, process improvement and participation in emergency and crisis response (both real and simulated), including emergency drills specific to potential incidents at the Pluto Facility. Training includes task specific training and role-based training and 'on the job' experience (i.e. participation in crisis or emergency management exercises).

The Corporate Incident Communication Centre (CICC) based in Woodside's head office in Perth, is the onshore coordination point for an offshore emergency. The CICC is staffed by an appropriately skilled team available on call 24 hours a day. The purpose of the team is to coordinate rescues, minimise damage to the environment and facilities and to liaise with external agencies.

There are a number of arrangements which in the event of a spill will underpin Woodside's ability to implement a response across its petroleum activities. To ensure each of these arrangements are adequately tested tests are conducted in alignment with the Hydrocarbon Spill Arrangements Testing Schedule which aligns with international good practice for spill preparedness & response management. The schedule identifies the type of test which will be conducted annually for each arrangement, and how this type will vary over a five-year rolling schedule. Testing methods may include (but are not limited to): audits, drills, field exercises, functional workshops, assurance reporting, assurance monitoring and reviews of key external dependencies.

8.2 Pluto Oil Pollution First Strike Plan

The Pluto Oil Pollution First Strike Plan is an activity-specific document which provides details on the tasks required to mobilise a first strike response for the first 24 hours of a hydrocarbon spill event. These tasks include key response actions and regulatory notifications. The intent of the document is to provide immediate oil spill response guidance to the Incident Management Team until a full Incident Action Plan specific to the oil spill event is developed.

The facility and subsea support vessels will have Ship Oil Pollution Emergency Plans (SOPEPs) in accordance with the requirements of International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 Annex I. These plans outline responsibilities, specify procedures and identify resources available in the event of a hydrocarbon or chemical spill from vessel activities. The Pluto Oil Pollution First Strike Plan is intended to work in conjunction with the SOPEPs.

Woodside’s oil spill arrangements are tested by conducting periodic exercises. These exercises are conducted to test the response arrangements outlined in the Pluto Oil Pollution First Strike Plan and Oil Spill Preparedness and Response Mitigation Assessment to ensure that personnel are familiar with spill response procedures, in particular, individual roles and responsibilities and reporting requirements.

8.3 Oil Spill Preparedness and Response Mitigation Assessment

Woodside has developed an oil spill preparedness and response position in order to demonstrate that risks and impacts associated with loss of hydrocarbons from the Petroleum Activities Program would be mitigated and managed to ALARP and would be of an acceptable level.

The following oil spill response strategies were evaluated and subsequently pre-selected for a significant oil spill event (level 2 or 3 under the National Plan) from the Petroleum Activities Program:

- Monitor and Evaluate (Operational Monitoring) – Operational Monitoring commences immediately following a spill and includes the gathering and evaluation of data to inform the oil spill response planning and operations. It includes fate and trajectory modelling, spill tracking, weather updates and field observations. The following operational monitoring programs are available for implementation:
  - predictive modelling of hydrocarbons to assess resources at risk
  - surveillance and reconnaissance to detect hydrocarbons and resources at risk
  - monitoring of hydrocarbon presence, properties, behaviour and weathering in water
  - pre-emptive assessment of sensitive receptors at risk
  - monitoring of contaminated resources and the effectiveness of response and clean-up operations.

The following response strategies may be applied based on the outcomes of the implemented Operational Monitoring Programs:

- source control - a loss of well control is the identified worst case spill scenario. Woodside’s primary mitigation strategy is to minimise the volume of hydrocarbons released. Woodside pre-operational NEBA evaluation has identified relief well drilling as the primary source control strategy
- containment and recovery- the aim of this response strategy is to reduced damage to sensitive receptors by the physical removal of hydrocarbons from the marine environment
- wildlife response - an oiled wildlife response would be undertaken in accordance with Woodside’s Health, Safety, Environment and Quality Policy and values and recognition of societal expectations. The response would involve reconnaissance from vessels, aircraft and shoreline surveys, the capture, transport, rehabilitation and release of oiled wildlife
- scientific monitoring - a scientific monitoring program (SMP) would be activated following a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental

receptors. This would consider receptors at risk (ecological and socio-economic) for the entire predicted ZoC and in particular, the identified Pre-emptive Baseline Areas (PBAs) in the event of a loss of well control from the PAP drilling activities (refer to response planning assumptions). The SMP would be informed by the operational monitoring programs, but differs from the operational monitoring program in being a long-term program independent of, and not directing, the operational oil spill response. Key objectives of the Woodside oil spill scientific monitoring program are:

  - assess the extent, severity and persistence of the environmental impacts from the spill event
  - monitor subsequent recovery of impacted key species, habitats and ecosystems

- waste management - Waste management is considered a support strategy to the response strategies examined above.

9. CONSULTATION

In support of the Pluto Operations EP, Woodside conducted a stakeholder assessment and engaged with relevant stakeholders to inform decision-making and planning for this petroleum activity in accordance with the requirements of Regulation 11A and 14(9) of the Environment Regulations.

Woodside conducted an assessment to identify relevant stakeholders, based on the location of the Pluto Operations and potential environmental and social impacts. A consultation information sheet was sent to all stakeholders identified through the stakeholder assessment process prior to lodgement of the Pluto Operations EP with NOPSEMA for assessment and acceptance. Woodside provided information about the Petroleum Activities Program to the relevant stakeholders listed in **Table 9-1**. Woodside considers relevant stakeholders for routine operations as those that undertake normal business or lifestyle activities in the vicinity of the existing Petroleum Activities Program (or their nominated representative) or have a State or Commonwealth regulatory role.

Table 9-1: Relevant Stakeholder Identified for the Petroleum Activities Program

Organisation	Relevance
Department of Industry, Innovation and Science	Department of relevant Commonwealth Minister
Department of Mines, Industry Regulation and Safety (formerly Department of Mines and Petroleum)	Department of relevant State Minister
Director of National Parks	Authority responsible Australian Marine Parks
Australian Maritime Safety Authority (maritime safety)	Maritime safety
Australian Hydrographic Service	Maritime safety
Department of Primary Industries and Regional Development (formerly Department of Fisheries (Western Australia))	Fisheries management
Western Australian Fisheries	Commercial fisheries – State • Pilbara Demersal Scale Fishery (Pilbara Trap and Trawl) • Marine Aquarium Managed Fishery • Specimen Shell Managed Fishery • Onslow Prawn Managed Fishery • West Australian Mackerel Fishery.
Department of Defence	Defence estate management
Department of Transport	Hydrocarbon spill preparedness (Western Australian waters)
Australian Fisheries Management Authority (AFMA)	Commonwealth fisheries management
Commonwealth Fisheries Association	Commercial fisheries – Commonwealth
Western Australian Fishing Industry Council (WAFIC)	Commercial fisheries – State
Chevron, Quadrant and Jadestone	Other operators with subsea infrastructure in the vicinity of the Petroleum Activities Program

9.1 Ongoing Consultation

Woodside continue to engage and consult with relevant stakeholders throughout the Petroleum Activities Program by implementing its established approach to stakeholder engagement that includes;

- direct stakeholder and community engagement providing advice to community stakeholders on progress in execution of activities;
- provision of updated activity factsheets prior to the commencement of activities; and
- toll free number provided on activity factsheets.

Identified relevant stakeholders were emailed a Consultation Information Sheet (fact sheet), which is also published on Woodside's website. Communication with specific stakeholders has been tailored to individual requirements. For example, fishing and other marine stakeholders were provided with activity maps that overlay relevant State and Commonwealth fishing zones.

Feedback gathered during the consultation informs Woodside's engagement requirements for ongoing consultation during the activity. Ongoing consultation is used to inform stakeholders on specific activity timing, duration, location and other information relevant to the activity and stakeholder needs.

Woodside uses email notifications to keep relevant stakeholders informed of intermittent activities. Woodside maintains an email database of fishery licence holders contacts to provide details about specific activity timing, duration, location and other relevant information such as vessels and exclusion zones. Woodside also provides the same advice via email to the Australian Hydrographic Services, AMSA and industry bodies, such as WAFIC; who then can cascade advice to other marine users. Consideration of whether stakeholder engagement is required for an intermittent activity, such as maintenance or project activities, will be given prior to the commencement of that activity. If engagement is required, it will be undertaken in a format that is relevant given stakeholder needs.

If a change requiring further engagement occurs, Woodside undertakes an assessment to identify new relevant stakeholders or a potential change to level of relevance for previously identified stakeholders. Previously identified and new relevant stakeholders will be notified of the updated scope.

Woodside will continue to accept feedback from all stakeholders throughout the duration of the accepted Pluto Operations EP. Stakeholder feedback should be made to the nominated liaison person.

Feedback received through community engagement and consultation will be captured in Woodside's stakeholder database and actioned where appropriate through the Petroleum Activities Program Project Manager. Implementation of ongoing engagement and consultation activities for the Petroleum Activities Program will be undertaken by Woodside Corporate Affairs consistent with Woodside's External Stakeholder Engagement Operating Standard.

9.2 Non-Routine Events

Woodside recognises that the relevance of stakeholders identified in the EP to the activity may change in the occurrence of a non-routine event or emergency. Woodside also acknowledges that other stakeholders not identified in the EP may be affected.

Stakeholder groups include:

- government ministers
- government agencies
- local governments, including representation local communities (Exmouth and Coral bay)
- emergency response organisations
- border protection and defence
- fisheries

- charter boat operators
- marine and terrestrial tourism operators
- other petroleum operators
- other industry
- development commissions and industry associations
- aboriginal claimant groups
- community representative organisations
- non-government organisations.

10. TITLEHOLDER NOMINATED LIAISON PERSON

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11. ABBREVIATIONS

Acronym	Description
AFMA	Australian Fisheries Management Authority
AIMS	Australian Institute of Marine Science
ALARP	As low as reasonably practicable
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
APPEA	Australian Petroleum Production and Exploration Association
AUSREP	Australian Ship Reporting System
BDV	Blowdown valve
BIA	Biologically Important Area
BoM	Bureau of Meteorology
BTEX	Benzene, toluene, ethylbenzene and xylenes
CCR	Central Control Room
CICC	Corporate Incident Communication Centre
CP	Cathodic protection
dB	Decibels
DCS	NRC control system
DEHP	di (2-ethylhexyl) phthalate
DoEE	Department of the Environment and Energy
DMIRS	Department of Mining, Industry Regulation and Safety
DP	Dynamic positioning
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EET	Emission Estimation Techniques
EEZ	Exclusive Economic Zone
EP	Environment Plan
EPBC Act	Environment Protection and Biodiversity Conservation Act
EPOs	Environmental performance outcomes
EPS	Environment Performance Standards
ESD	Ecological Sustainable Development
ERP	Emergency Response Plan
FPSO	Floating production storage and offloading

Acronym	Description
GWA	Goodwyn Alpha
HAZID/EVID	Hazard identification studies
HP	High Pressure
HSE	Health, Safety and Environment
HSEQ	Health, Safety, Environment and Quality
HVAC	Heating, ventilation and air conditioning
ICS	Incident command structure
IUCN	International Union for the Conservation of Nature
IMR	Inspection, maintenance and repair
ISO	International Organisation of Standardisation
ITF	Indonesian Throughflow
KBSF	King Bay Supply Facility
KGP	Karratha Gas Plant
KEF	Key Ecological Feature
kHz	kilohertz
km	Kilometre
KO	Knock-out
KPI	Key performance Indicator
L	Litres
LAT	Lowest Astronomical Tide
LCS	Legislation, Codes and Standards
LNG	Liquefied natural gas
LP	Low Pressure
MACs	Manual alarm callpoints
MAEs	Major Accident Events
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	Multibeam Echo Sounder
MEEs	Major Environmental Events
MEG	Monoethylene glycol
MCS	Master Control Station
MMscfd	Million standard cubic feet per day
MNES	Matters of Environmental Significance
MODU	Mobile Offshore Drilling Unit

Acronym	Description
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MSPS	Management System Performance Standards
NEPM	National Environmental Protection Measure
NGERS	National Greenhouse and Energy Reporting
NIMS	Non-indigenous Marine Species
NNM	Not Manually Manned
NOAA	National Oceanic and Atmospheric Administration
NOEC	No observed effect concentrations
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NORM	Naturally occurring radioactive material
NPI	National Pollutant Inventory
NRC	North Rankin Complex
NT	Northern Territory
NWMR	North West Marine Region
NWS	North West Shelf
OCNS	Offshore Chemical Notification Scheme
OIW	Oil in water
OMDAMP	Offshore Marine Discharges Adaptive Management Plan
OPEP	Oil Pollution Emergency Plan
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage*
OVID	Offshore Vessel Inspection Database
PAH	Polycyclic aromatic hydrocarbon
PAR	Photosynthetically active radiation
PCS	Process Control System
PFW	Produced formation water
PHD	Process historian database
PJ	Professional Judgement
PLONOR	Pose little or no risk
PMST	Protected Matters Search Tool
PNEC	Predicted No-effect concentration
POB	Personnel on board
PSU	Practical salinity units

Acronym	Description
PSV	Pressure safety Valves
PTS	Permanent threshold shift
PW	Produced Water
RBA	Risk Based Analysis
RESDV	Riser Emergency Shutdown Valve
ROV	Remotely operated vehicle
SBP	Sub-bottom profiler
SCE	Safety and Environmental Critical Element
SCEW	Standing Council on Environment and Water
SCM	Subsea Control Module
SCQ	Safety and Environmental Critical Equipment
SCSSV	Surface controlled sub-surface safety valves
SEL	Sound exposure level
SOPEP	Ship Oil Pollution Emergency Plan
SPL	Sound pressure level
SSS	Side Scan Sonar
SV	Societal Values
SVOC	Semi-volatile organic chemicals
TEG	Triethylene glycol
TL	Transmission loss
TPH	Total petroleum hydrocarbon
TRH	Total recoverable hydrocarbon
TTS	Temporary threshold shift
UK	United Kingdom
UPS	Battery power system
USEPA	U.S. Environmental Protection Agency
UTA	Umbilical Termination Assemblies
UV	Ultra violet
VOC	Volatile organic compound
WA	Western Australia
WAF	Water accommodated fraction
WAFIC	Western Australian Fishing Industry council
WET	Whole effluent Toxicity

Acronym	Description
WHA	World Heritage Area
WMS	Woodside Management System
WOMP	Well Operations Management Plan
ZoC	Zone of Consequence

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APPENDIX A: ENVIRONMENTAL IMPACTS AND RISKS

Physical Presence: Disturbance to Marine Users

Impacts Evaluation Summary													
Source of Impact	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Presence of facility excluding and/or displacing other users from Petroleum Safety Zone (PSZ) and Operational Area respectively.							X	A	F	-	-	LCS GP PJ	Broadly Acceptable

Description of Source of Impact
The facility commenced operation in 2012, and is marked on nautical charts. The riser platform is surrounded by a 500 m radius PSZ, which vessels are prohibited from entering unless authorised by Woodside. The PSZ is a critical safety control intended to reduce the likelihood of interactions between vessels and the platform, which increases safety for both vessels and the facility. Implementation of the PSZ, around the riser platform, excludes other users from a small area of the sea (approximately 0.079 km^2). The riser platform is highly visible under most conditions and is well lit, and the nature of the riser platform (large steel structure) ensures a clear radar return to alert ships fitted with anti-collision radars. Routine support vessel activities associated with the Petroleum Activities Program are concentrated within the PSZ (e.g. platform support vessels during manned mode). Subsea support vessels may undertake activities (e.g. IMR activities) within the Operational Area at any time, including the Operational Area beyond the PSZ. The duration and location of these activities varies depending on the activity being undertaken. Vessels required for major projects including during the PW handling installation (heavy lift vessel) may undertake activities within the operational area as required.

Impact Assessment

Exclusion and Displacement of Other Users

Commercial Fishing

Thirteen commercial fisheries overlap the Operational Area. The presence of commercial fishing vessels was assessed based on fishing gear type, historical effort and consultation.

Commercial fishing vessels in the vicinity of the Facility Operational Area are most likely to be participants of the Pilbara demersal scalefish fishery and may employ several gear types (including trawling). The presence of subsea infrastructure could present a hazard to bottom trawl fisheries due to risk of equipment entanglement and subsequent equipment damage/ loss. However, the majority of the Facility Operational Area (including the riser platform) lies within the management area, designated for trap fishing only. Some of the export pipeline Operational Area (about 10 km^2) lies in the Zone 2 of the Pilbara demersal scalefish fishery designated for trap and trawl fishing.

Commercial fishing in the export pipeline Operational area may also include the Mackerel Managed Fishery, Specimen Shell Managed Fishery (using ROVs) and the Onslow Prawn Managed Fishery. Both the prawn and mackerel fishery are trawling fisheries and therefore there may be a risk of equipment entanglement and subsequent equipment damage/loss.

Consultation with fishing industry participants did not indicate any claims or objections from commercial fishers to the Petroleum Activities Program.

The impact to commercial fishers as a result of Petroleum Activities Program is the potential for highly localised displacement of effort and of no lasting effect. Little trawling effort is expected to occur in the Operational Area; therefore, potential for trawling gear to be snagged on subsea infrastructure is considered to be remote.

Tourism and Recreation: Tourism and recreation activity in the Operational Area is expected to be infrequent, recreational and charter fishing from vessels are the only tourism and recreation activities identified as potentially occurring in the Operational Area. Any recreational and charter fishing from vessels is largely undertaken using lines. The Montebello Islands State Marine Park (25 km from the Operational Area), is the closest location for tourism with some charter boat operators taking visitors to these islands. Additionally, there may be recreational fishing at Rankin

Bank (approximately 24 km from the Operational Area). The Operational Area of the export pipeline is 36 km to the Dampier boat ramp at its closest point (at the state boundary) and therefore, low numbers of recreational vessels may be encountered within that nearshore portion of the Operational Area, near the State/Commonwealth boundary.

Given the distance from boating facilities, lack of natural attractions and water depth of the Operational Area, very little recreational or charter fishing is expected to occur. As such, impacts to recreational and charter fishing are expected to be localised with no lasting effect.

Shipping: Significant commercial shipping occurs in the region, with commercial shipping traffic comprising vessels such as:

- bulk carriers (e.g. mineral ore, salt, etc.) from Port Hedland, Port Walcott and Dampier
- offtake tankers
- support vessels for offshore oil and gas activities
- LNG carriers from Dampier, Barrow Island and Ashburton North.

To reduce the likelihood of interactions between commercial vessels and offshore facilities, AMSA has introduced a series of shipping fairways, within which commercial vessels are advised to navigate. The fairways are not mandatory but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region. The use of shipping fairways is considered to be good seafaring practice, with AUSREP data from AMSA indicating cargo ships and tankers routinely navigate within the established fairways.

No shipping fairways interact the with riser platform, however two fairways overlap the export pipeline:

- A fairway directs north/south-bound vessel traffic from Barrow Island and the southern Montebello Islands.
- A fairway travels parallel to the coast, from Barrow Island to the Dampier Shipping Fairways.

In addition, most vessel activity in the vicinity of the Operational Area is associated with nodes such as offshore facilities (e.g. Wheatstone) and ports; no such nodes occur within the Operational Area (aside from the Pluto facility). Consultation undertaken in 2013 as part of the previous EP submission did not identify any concerns from potentially affected parties. Further consultation in 2017 also did not identify any concerns raised by shipping stakeholders.

The presence of the riser platform, vessels and subsea infrastructure does not result in impacts to commercial shipping beyond a localised exclusion of shipping traffic from the PSZ and the temporary displacement of commercial shipping from subsea support vessels as a result of vessels undertaking activities in the Operational Area.

Oil and Gas: The nearest oil and gas platform, about 5 km north of the riser platform, is the Chevron-operated Wheatstone Platform. In addition, the Jadestone-operated Stag Platform is about 8 km south of the export pipeline. Operational history of the facility has shown that interactions with other titleholders has not been an issue to date.

Cumulative Impacts Given the presence of the riser platform, subsea infrastructure and export pipeline as well as support vessels there is the potential for cumulative impacts due to the presence of the Wheatstone platform, subsea infrastructure and support vessels. However, cumulative impacts, such as the interference and displacement of third party vessels, are not expected due to the short duration of vessel based activities and the controls (detailed below) to be implemented. Therefore, cumulative impacts in relation to this impact are localised with no lasting effect.

Summary of Control Measures

- Contract vessels complying with Marine orders for safe vessel operations:
  - Marine Order 21 (Safety of navigation and emergency procedures)
  - Marine order 30 (prevention of Collisions)
- Implementation of a 500 m Petroleum Safety Zone around riser platform
- Notifying AHS of locations of new permanent infrastructure to enable AHS to update maritime charts
- Undertaking consultation program to advise relevant persons of the Petroleum Activities Program and provide opportunity to raise objections or claims
- Notify AMSA Joint Rescue Coordination Centre (JRCC) of IMR activities within shipping lanes
- Implementing Pluto’s collision prevention system to alert marine vessels of the facility location which reduces the likelihood of adverse interaction with other marine users

Physical Presence: Disturbance to Seabed

<table>
<tr><th colspan="14">Impacts Evaluation Summary</th></tr>
<tr><th rowspan="2">Source of Impact</th><th colspan="7">Environmental Value Potentially Impacted</th><th colspan="6">Evaluation</th></tr>
<tr><th>Soil and Groundwater</th><th>Marine Sediment</th><th>Water Quality</th><th>Air Quality (incl. Odour)</th><th>Ecosystems/Habitat</th><th>Species</th><th>Socio-Economic</th><th>Decision Type</th><th>Consequence/Impact</th><th>Likelihood</th><th>Risk Rating</th><th>ALARP Tools</th><th>Acceptability</th></tr>
<tr><td>Presence of facility and subsea infrastructure modifying marine habitats.</td><td></td><td>X</td><td>X</td><td></td><td>X</td><td></td><td></td><td>A</td><td>F</td><td>-</td><td>-</td><td rowspan="2">PJ</td><td rowspan="2">Broadly acceptable</td></tr>
<tr><td>Subsea operations, inspection, maintenance and repair activities resulting in disturbance to seabed.</td><td></td><td>X</td><td>X</td><td></td><td>X</td><td></td><td></td><td>A</td><td>E</td><td>-</td><td>-</td></tr>
</table>

Description of Source of Impact

Seabed disturbance associated with the Petroleum Activities Program can occur during operations and activities including:

- physical presence of the facility and subsea infrastructure
- scour, spans, and flowline movement inherent in design
- subsea IMR activities.

Subsea infrastructure occurs throughout the Operational Area. Subsea equipment has been installed historically subject to separate EPs. Installation and historical operations have described the benthic footprint/ disturbance. The physical footprint of existing subsea infrastructure is described in this section for completeness.

The facility also provides hard substrate habitat from the sea surface through the water column to the seabed (e.g. jackets and risers), as well as along the seabed (e.g. pipelines, flowlines, manifolds, etc.).

The presence of subsea infrastructure may result in localised scouring around the infrastructure due to currents, subsurface waves and seabed sediment fluid dynamics. Scour around subsea infrastructure may necessitate IMR activities as part of integrity management practices.

Flowline movement may occur as per design and within integrity margins along the flowline corridors. Normal flowline operational movement occurs due to factors such as flowline buckling, walking and varying metocean conditions. Lateral movement can occur within the flowline corridor. Management of flowline buckling and walking may necessitate IMR activities

Refer to MEE-02 Pipeline and Riser Loss of Containment which includes controls to limit scour and flowline movement within integrity requirements. To maintain the integrity of subsea infrastructure, Woodside may be required to undertake routine subsea IMR activities. Activities that constitute IMR may impact the benthic environment in the vicinity of the activity. IMR activities identified as impacting the benthic environment include:

- inspections – localised sediment resuspension by ROV
- marine growth removal – localised resuspension of sediment; removal of marine biota from subsea infrastructure
- sediment relocation – localised modification of benthic habitat and sediment resuspension
- span rectification, pipeline protection and stabilisation (including piling) – localised modification of benthic habitat within footprint of area subject to rectification/protection/stabilisation
- jumper and umbilical replacement – localised modification of benthic habitat in the vicinity of the jumper/umbilical
- spool repair/replacement – localised modification of benthic habitat in the vicinity of the spool.

The area of benthic habitat predicted to be impacted varies depending on the nature and scale of the IMR activity. Span rectification activities are considered to be IMR activities with the greatest potential to modify benthic habitats, due to the alteration of the existing soft sediment habitat to hard substrate. Woodside's operational experience on the NWS indicates these activities are typically restricted to relatively short (tens of metres) linear sections of pipeline, with areas of up to approximately 200 m^2 impacted.

Impact Assessment

Scour may result in localised impact to soft sediment benthic habitats, typically on the scales of metres to tens of metres. Soft sediment benthic habitats are very widely represented in the Operational Area and more broadly. Impacts to the environment from scour around subsea infrastructure are expected to be localised, with no significant impact to benthic habitats in the Operational Area.

Flowline movement is limited to within design and integrity envelopes, and may result in slight, localised impact to soft sediment benthic habitats, typically on the scales varying between meters to tens of metres laterally along the flowline corridors.

IMR activities can be categorised into two potential impacts:

- direct physical disturbance of benthic habitat
- indirect disturbance to benthic habitats from sedimentation.

Water and Sediment Quality

Indirect seabed disturbance may include localised and short-term decline in water quality due to suspended sediment concentrations resulting in sediment deposition caused by IMR activities. However, sediment loads are not expected to be significant due to the relatively small footprint for each activity (described above, and in Section 3.10).

Each discrete IMR activity near the seabed is likely to cause a single brief disturbance resulting in a transient plume of suspended sediment. This plume will subsequently be deposited down current as particles settle out. Such localised and short term events may affect small areas of the seabed and consequently, impact the associated biota (typically sparsely distributed infauna and sessile fauna). Given the expected nature and scale of resuspension resulting from IMR activities, impacts such as smothering or burial are not expected. Rather, impacts are likely to be restricted to increased ingestion of inedible sediments by filter feeders. Biota in the region are well adapted to periodic turbidity events caused by cyclones and tidal movements. As such, impacts from turbidity caused by IMR activities are not expected to have any lasting effect on benthic biota.

Benthic Habitats

The benthic habitat within the Operational Area is predominately soft sediment (Section 4.4.3) with sparsely associated epifauna, which is broadly represented throughout the NWSP and NP Provinces (Section 4.5.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure).

Direct seabed disturbance, including permanent modification of benthic communities, may result as a consequence of IMR activities such as span rectification, pipeline protection and stabilisation (including piling). These activities typically disturb a small area (typically < 200 m2) of soft sediment habitat, which is broadly represented in the Operational Area and wider NWMR region.

Artificial Habitat

The presence of the riser platform and subsea infrastructure provides hard substrate for the settlement of marine organisms; the availability of hard substrate is often a limiting factor in benthic communities and the presence of the platform, subsea infrastructure, including IMR activities (e.g. installation of concrete mattresses, etc.) and export pipeline provides a location for the settlement of these benthic communities. Over time, these hard substrates are expected to be colonised by sessile benthic biota (e.g. sponges, gorgonians, etc.). For example, pipeline infrastructure has been shown to support more diverse fish assemblages and benthic biota (McLean et al. 2017). These communities are relatively diverse compared to the open water and soft sediment habitats in the broader Operational Area. IMR activities may disturb these new communities; however, it is expected that recolonisation will occur.

The provision of artificial habitat associated with the riser platform and subsea infrastructure will have either no adverse environmental impact or a low level of positive environmental impact through increasing biological diversity.

Values and Sensitivities

<u>Ancient Coastline at 125 m Depth Contour</u>

The Operational Area overlaps approximately 9 km2 of the 16,190 km2 Ancient Coastline, which is about 0.06% of the KEF. The Operational Area represents a 1500 m2 buffer around the Pluto subsea infrastructure to facilitate vessel operations; the potential for seabed disturbance is much more localised (i.e. within tens of metres of the subsea infrastructure).

Benthic habitat surveys in the region (including within the Ancient Coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (AIMS 2014b, RPS 2011). Such habitats are widely distributed in the NWMR. No significant escarpments, species of conservation significance, emergent features or areas of high biological productivity characteristically associated with the Ancient Coastline at 125 m KEF have been observed in the Operational Area. As noted in Section 4.7, the geomorphic feature associated with this KEF is represented worldwide and represents the coastline during a previous glacial period. These impacts are discussed in relation to filter feeders above. Therefore, potential impacts to this regional-scale KEF are expected to be negligible.

Continental Slope Demersal Fish Communities Seabed disturbance will have no adverse environmental impact on this KEF and the presence of the riser platform and subsea infrastructure may provide habitat for demersal fish communities potentially having a low level positive environmental impact. Montebello Australian Marine Park A small portion of the Operational Area overlaps the Montebello Marine Park. The Marine Park includes values associated with the shallow shelf environment, however no pinnacle or terrace seafloor features are found within the Operational Areas. Direct loss of sediments in the Marine Park may be possible if IMR activities include the placement of materials on the seabed. In addition, indirect impacts may occur as a result of sedimentation. These impacts are discussed in relation to soft sediment benthic habitats above.
Summary of Control Measures
• All vessels used for IMR/heavy lift activities will be DP capable. • Monitoring and maintenance of subsea infrastructure to manage scour and flowline movement within integrity envelope.

Routine and Non-Routine Acoustic Emissions: Generation of Noise during Routine Operations

Impacts Evaluation Summary													
Source of Impact	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Noise generated within the Operational Area from: • facility and associated infrastructure • vessels • subsea IMR activities • helicopters.						X		A	F	-	-	LCS GP PJ	Broadly acceptable

Description of Source of Impact

The facility, vessels, IMR activities and helicopters will generate noise both in the air and underwater, due to the operation of machinery noise, propeller movement, and infrequent non-routine activities such as piling. Typical noise levels for these sources are provided in **Table 12-1**, with more detailed descriptions provided below. This noise will contribute to, and can exceed, ambient noise levels which range from around 90 dB re 1 sound pressure level (SPL) under very calm, low wind conditions, to 120 dB re 1 µPa SPL under windy conditions (McCauley 2005).

Table 12-1: Indicative source characteristics of underwater noise associated with the Petroleum Activities Program as reported in †Jiménez-Arranz et al. (2017) and by ‡McCauley (2005) and §McCauley (2002)

Acoustic Noise Sources	Estimated SPL (dB re 1 µPa SPL) @1 m unless otherwise stated	Frequency Range (kHz)
Vessels (Continuous)		
Support and HLV using DP‡	182	Broadband
IMR Activity Noise (Pulsed)		
Multibeam Echo Sounder (MBES)†	210–247	12–675
Side Scan Sonar (SSS)†	200–234	9–675
Sub-bottom Profiler (SBP) (Pinger)†	167–212	4–12
SBP (Chirp)†	161–205	2–23
SBP (Boomer)†	205–225	0.3–6
Piling	187.7–197.12 dB re 1 µPa^{2}s (SEL) (dependent on pile penetration depth)	< 1
Wellhead, Flowlines and Subsea Infrastructure (Continuous)		
Wellhead§	113	Broadband
Choke valve§	155	Broadband
Production platforms		
Riser platform†	110–130 @100 m	Broadband (mainly < 100 Hz)

** Range provided was not measured at the noise source; therefore, this should be used as an indicative estimate only and can not be used to estimate exposure thresholds closer to the source.*

Vessels

The main source of noise from vessels (platform support, subsea support, accommodation support and HLV) relates to the use of DP thrusters (i.e. cavitation from thruster propellers). Thruster noise is typically high intensity and broadband in nature, with sound pressure levels of 137 dB re 1 µPa at 405 m from a typical offshore support vessel holding station in strong currents (McCauley 1998). McCauley (2005) measured underwater broadband noise up to approximately 182 dB re 1 µPa at 1 m (SPL) from a support vessel holding station in the Timor Sea; it is expected that noise levels up to this level may be generated by vessels using DP during the Petroleum Activities Program. Thruster noise from vessels holding station is typically the most intense underwater noise source from vessel activities; other sources of underwater noise from vessels (e.g. main engines when underway, machinery noise transmitted through the hull, etc.) are typically considerably lower intensity noise (McCauley 1998). Note that vessels undertaking the Petroleum Activities Program inherently minimise the use of DP, and there is little potential to reduce DP use further.

For planned operations and maintenance activities, vessels are expected to be in the field operating 24 hours per day for approximately fourteen days every five to six times per year. However, vessels will be present for longer durations or at a higher frequency during pigging operations, corrective maintenance and interventions, major/shutdown maintenance, contingent manning. A HLV will be required for installation of the water handling unit; the vessels will be holding station outside the 500 m PSZ until conditions are appropriate for the installation to take place, the vessel will only be present within the PSZ during the heavy lift.

Subsea IMR Activities

Acoustic Survey

Acoustic survey may be undertaken as part of IMR activities, including SSS, MBES and SBP surveys and piling. These methods are typically used infrequently (e.g. SSS generally used for up to five days every four years); these acoustic sources are not constantly active during these infrequent IMR activities. Indicative source characteristics for typical acoustic survey equipment are provided in **Table 12-1**.

Piling

Piling may be undertaken as an IMR activity to stabilise the pipeline and flowlines, the schedule for piling activities is currently subject to many variables but it is likely to last between 10 and 20 days if required and include a maximum of approximately 10 piles in water depths greater than 600 m. A drivability analysis specific to the proposed piling locations has estimated it will take about 15 minutes to drive each pile. The frequency bandwidth for most of the energy in pile driving sounds is typically below 1000 Hz and overlaps the same hearing bandwidth of marine fauna, particularly, fish (McCauley and Kent, 2008, and Vagel, 2006 in McCauley and Kent, 2008).

If impact piling is required, they may be installed with either hydraulic or water driven hammers. The number and size of the piles are expected to be within the below parameters:

- number: up to 10
- length: 28 to 34 m
- diameter: 2.5 m
- wall thickness: 50 mm
- hammer size: 500 kJ
- water depth: 600–800 m.

Helicopters

Helicopter engines and rotor blades are recognised as a source of noise emissions, which may constitute a source of environmental risk resulting in behavioural disturbance to marine fauna. Activities relevant to the Operational Area will relate to the landing and take-off of helicopters on the riser platform (which coincides with routine intervention maintenance visits) and potentially support vessels. During these critical stages of helicopter operations, safety takes precedence.

Helicopter flights are at their lowest (i.e. closest point to the sea surface) during these periods of take-off and landing from heli-decks, which constitutes a relatively short phase of routine flight operations.

Wellhead, Pipelines and Subsea infrastructure

The noise produced by an operational wellhead was measured by McCauley (2002). The broadband noise level was very low, 113 dB re 1 µPa, which is only marginally above rough sea condition ambient noise. For a number of nearby wellheads, the sources would have to be in very close proximity (< 50 m apart) before their signals summed to increase the total noise field (with two adjacent sources only increasing the total noise field by three dB). Hence for multiple wellheads in an area, the broadband noise level in the vicinity of the wellheads would be expected to be of the order of 113 dB re 1 µPa. This would drop very quickly to ambient conditions on moving away from the wellhead, falling to background levels within < 200 m from the wellhead.

Based on the measurements of wellhead noise discussed in McCauley (2002), which included flow noise in flowlines, noise produced along a flowline or the export pipeline may be expected to be similar to that described for wellheads, with the radiated noise field falling to ambient levels within a hundred metres of the flowline. Woodside has undertaken acoustic measurements on noise generated by the operation of choke valves associated with the Angel facility (JASCO

2015) similar to the design employed across Pluto subsea valves. These measurements indicated choke valve noise is continuous, and the frequency and intensity of noise emitted is dependent on the rate of production from the well. Noise intensity at low production rates (16% and 30% choke positions) were approximately 154–155 dB re 1 µPa, with higher production rates (85% and 74% choke positions) resulting in lower noise levels (141–144 dB re 1 µPa). Noise from choke valve operation was broadband in nature, with the majority of noise energy concentrated above 1 kHz.

Platform Machinery

Production platforms have machinery mounted on decks raised above the sea, hence, most noise is transmitted to the marine environment from air (i.e. power generation and operational flaring). Machinery noise on-board the riser platform may be radiated into the underwater environment via the jacket legs and risers, which may act as transducers. Monitoring programs have indicated that underwater noise from platforms is typically very low or not detectable (Jiménez-Arranz et al., 2017; McCauley, 2002).

The flare system will generate noise from combustion. Noise from flaring represents a health and safety risk to personnel, and noise from flaring was considered in the design of the facility to manage the occupational health and safety risks associated with noise (e.g. height specification of flare tower). Noise from flaring is emitted at the top of the flare tower, which has a flare boom length of 87 m. Noise from the tip of the flare is not constrained and will spread spherically in all directions.

Gales (1982) assessed noise from 18 oil and gas platforms, including 11 bottom-standing fixed platforms during production operations (i.e. consistent with the Pluto riser platform). The study found the strongest noise levels were relatively low frequency (< 100 Hz, and mostly between 4 and 38 Hz), with sound levels of 110 to 130 dB re 1 µPa @100 m (Gales, 1982). Noise from the platforms was found to be lower than levels recorded from support vessels, with a cumulative increase in overall underwater noise of 20–30 dB from the noise produced by a support vessel operating in the vicinity of an operations platform (Gales, 1982).

Noise emitted from machinery on the riser platform is limited relative to other operating facilities due to its NNM status, smaller size and the lack of processing facilities on the riser platform. Therefore, it is likely that the range provided by Gales (1982) is a conservative estimate. Noise from the riser platform is not expected to significantly increase during the installation or from operation of the water handling unit given the nature and duration of the installation and commissioning activities. In summary, noise emissions generated by the facility is expected to be minimal.

Impact Assessment

Underwater Noise

The Operational Area of the Petroleum Activities Program is located across the continental shelf, and extends into the continental slope of the NWMR. The riser platform lies near the edge of the continental shelf in 85 m water depth, with production flowlines extending to wells located on the continental slope in waters depths of up to 962 m. The export pipeline extends from the riser platform to the boundary between Commonwealth and WA State Waters, in an average water depth of approximately 60 m.

The fauna associated with this area will be predominantly pelagic species of fish, with migratory species such as turtles, birds, whale sharks and cetaceans present in the area seasonally. In particular, a number of EPBC listed marine species have BIAs which overlap the Operational Area, which are discussed below. Two KEFs also overlap the Operational Area. Fauna associated with the Ancient Coastline at 125 m KEF and Continental Slope Demersal Fish Communities KEF, such as demersal fish, may also be impacted upon by noise emissions. While the Ancient Coastline at 125 m KEF may be associated with outcroppings of hard substrate, no evidence of significant reefs associated with such outcroppings has been found in the Operational Area. Note some demersal fish are also likely to be associated with subsea infrastructure such as the export pipeline (McLean *et al.*, 2017).

Elevated underwater noise can affect marine fauna, including cetaceans, fish, turtles, sharks and rays in three main ways (Richardson *et al.*, 1995):

(1) by causing direct physical effects on hearing or other organs, including:
    a. mortality/potential mortal injury resulting from exposure to noise
    b. permanent threshold shift (PTS) – permanent reduction in the ability to perceive sound following exposure to noise
    c. temporary threshold shift (TTS) – temporary reduction in the ability to perceive sound following exposure to noise, with hearing returning to normal.

(2) by masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)

(3) through disturbance leading to behavioural changes or displacement from important areas.

The potential impacts of anthropogenic noise on marine mammals have been the subject of considerable research; reviews are provided by Richardson *et al.* (1995), Nowacek *et al.* (2007), Southall *et al.* (2007a), Weilgart (2007) and Wright *et al.* (2007).

To inform the assessment, the continuous source impact thresholds provided in were considered in relation to the credible sources of acoustic emissions.

Table 12-2: Continuous Sources - Impact threshold for environmental receptors based on *Southall et al.

(2007), National Marine Fisheries Services (NMFS, 2005) and †Popper et al. (2014)

Receptor	Mortality and potential mortal injury	Impairment			Behaviour
		PTS	TTS	Masking	
Low-frequency cetaceans*	n/a	198 db re 1 µPa^{2}s M-weighted SEL	183 db re 1 µPa^{2}s M-weighted SEL	-	120–160 dB re 1 µPa rms SPL
Mid-frequency cetaceans*	n/a	198 db re 1 µPa^{2}s M-weighted SEL	183 db re 1 µPa^{2}s M-weighted SEL	-	120 dB re 1 µPa rms SPL
High-frequency cetaceans*	n/a	198 db re 1 µPa^{2}s M-weighted SEL	183 db re 1 µPa^{2}s M-weighted SEL	-	120dB re 1 µPa rms SPL
Fish: no swim bladder†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder not involved in hearing†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder involved in hearing†	(N) Lo and w (I) Low (F) Low	170 dB rms SPL for 48 hrs	158 dB rms SPL for 12 hrs	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low

Note: a range of sound units are provided in the table above, reflecting the range of studies from which this data has been derived. The difference in units presents difficulty in reliably comparing threshold values. Where practicable, the threshold values have been compared with indicative sound sources levels of the same sound unit types to facilitate comparison. The sound units provided in the table above include:

- *M-weighted sound exposure level (SEL): a weighted sound metric that emphasises the audible frequency bands for the receptor groups – low, mid and high frequency cetaceans. SEL units are time integrated and best suited for continuous noise sources, such as vessels holding station or continuous machinery noise.*
- *Root mean square (rms) sound pressure level (SPL): root mean square of time-series pressure level, useful for quantifying continuous noise sources (as per SEL point above).*
- *Relative risk (high, medium and low) is given for fish (all types), turtles, eggs and larvae at three distances from the source defined in relative terms as near (N), intermediate (I) and far (F) (Popper et al. 2014).*

Vessel Noise

Vessels holding station are considered to be the predominant noise source related to the Petroleum Activities Program, including the HLV which will be used to install the water handling unit. Using the thruster noise measured by McCauley (1998) as an indicative value for the potential thruster noise generated by vessels during the Petroleum Activities Program and the thresholds presented in **Table 12-2,** the potential for noise-induced mortality of cetaceans, fish, sea turtles and eggs/larvae is not considered credible. However, other impacts such as PTS, TTS, masking and behavioural impacts may occur. Using a simple cylindrical geometric spreading equation[3] to estimate transmission loss (TL) of thruster noise at 182 dB re 1 µPa at 100 Hz (**Table 12-3**).

Potential impacts may include:

- Cetaceans: Potential behavioural disturbance out to approximately 1 km for low frequency cetaceans (e.g. humpback whales) and 10 km for mid and high frequency cetaceans (e.g. coastal dolphins), likelihood of TTS

[3] $TL = 20\log_{10}(R) + \alpha R$ where:

TL is transmission loss (in dB), *R* is the range between source and receptor, and α is the frequency-specific absorption coefficient (0.001 at 100 Hz) (Fisher and Simmons 1977) for typical seawater on the North West Shelf (temperate 25 °C, salinity of 35 PSU and pH of 8).

is considered not to be credible, given individuals would need to be directly next to the noise source.

- Fish: Potential masking and behavioural disturbance at near and intermediate range; likelihood of TTS is considered not to be credible given fish would move away from the source. Site attached fish (e.g. demersal fish) are not expected to be exposed to underwater noise above impact thresholds given water depths in the area where these fish may be more prevalent (i.e. the Ancient Coastline at 125 m KEF and Continental Slope Demersal Fish Communities KEF).
- Turtles: Potential masking and behavioural disturbance at intermediate and far range, likelihood of TTS is considered not to be credible given turtles would need to be directly next to the noise source.

Note the estimates in **Table 12-3** are considered to under-estimate TL, and are, hence, inherently conservative, due to:

- use of low frequency (100 Hz) component of thruster noise signature; note thruster noise is typically broadband in nature, with much of the noise energy at frequencies > 100 Hz, which are absorbed more rapidly in seawater
- use of high intensity thruster noise (i.e. thruster operating at full power); most time using thrusters is at lower than full power, with concomitant reduction in cavitation noise intensity.

Table 12-3: Estimated sound transmission loss for a 182 dB re 1 μPa source at 100 Hz frequency

Range (m)	Transmission Loss	Received Noise (dB re μPa)
100	40.1	~141.9
500	54.5	~127.5
1000	61.0	~121.0

Fauna such as cetaceans, fish, and turtles are capable of moving away from potential noise sources, and there are no constraints to the movement of these fauna within the Operational Area.

Cetaceans

Given the migration corridor BIAs for pygmy blue whales and humpback whales overlap the Operational Area (pygmy blue whale BIA overlaps the facility section of the Operational Area and humpback whales BIA overlaps the export pipeline section of the Operational Area), there is the potential for these species to be exposed to underwater noise from vessels associated with the Petroleum Activities Program when they are present in the region during seasonal migrations. However, as the underwater noise levels that may be generated by DP vessels and IMR activities (e.g. piling) are below those resulting impairment or mortality, only behavioural impacts are credible. Impacts are expected to be limited to localised avoidance of the noise source as there are no physical barriers in or near the Operational Area that may prevent cetaceans from moving away from vessels.

Aerial surveys of humpback whales show the majority of humpback whales migrate within continental shelf waters along Western Australia (Double *et al.*, 2010, 2012; Jenner *et al.*, 2001). Humpback whales are expected to transit the export pipeline section of the Operational Area during their annual north and south migrations between May and November, where vessel activity will be limited to during intermittent IMR activities. These activities are relatively short-term and occur relatively infrequently and, therefore, are unlikely to impact humpback whales.

Pygmy blue whales are likely to be present when migrating north between April and August and south between October and December. Tagging studies of pygmy blue whales showed tagged animals were typically in water depths of > 1000 m. Pygmy blue whales are expected to transit the subsea hydrocarbon gathering system section of the facility and are unlikely to occur within proximity to the riser platform.

Mid and high frequency cetaceans are known to show behavioural disturbance at a range of received noise levels (Southall *et al.*, 2007a). Mid- and high frequency cetaceans may exhibit short-term behavioural responses to increased levels of underwater noise, such as avoidance or attraction. This is expected to occur mainly within the export pipeline and flowline section of the Operational Area during IMR activities, but is unlikely to significantly impact these species (e.g. spotted bottlenose dolphins).

Fishes

Fish may temporarily be displaced from the immediate vicinity of a noise source; however, they would be expected to behave normally once the noise emissions ceased. A foraging BIA for whale sharks overlaps the Operational Area, and the species may be seasonally present (particularly between March and July) during their annual migration to and from the aggregation area off Ningaloo Reef. Whale sharks are not considered to be particularly vulnerable to underwater noise, and they do not have a swim bladder (considered to increase the vulnerability of a fish to noise related impacts). Potential impacts to whale sharks from continuous noise is are expected to consist of no more than a short-term temporary displacement from noise sources while transiting the Operational Area.

Demersal and pelagic fish species will be present in the Operational Area, including fish communities associated with the Continental Slope Demersal Fish Communities and Ancient Coastline at 125 m Depth KEFs. Impacts to fish are expected to be localised, of short duration, and restricted to behavioural responses such as avoidance of noise sources.

Turtles

Noise interference is listed as a key threat to all threatened marine turtles identified as potentially occurring within the Operational Area. Turtles may occur in the Operational Area although the area does not contain any known significant foraging habitat (i.e. no emergent islands, reef habitat or shallow shoals/banks). A flatback turtle internesting buffer BIA overlaps both sections of the Operational Area, and internesting BIAs for green, hawksbill and loggerhead turtles overlap the export pipeline section. The BIAs for flatback, green and hawksbill turtles have also been designated as habitat critical to the survival of the species in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia, 2017); however, these areas are likely to hold the same significance as the existing BIAs with slightly differing spatial areas.

Turtles may exhibit behavioural responses when exposed to underwater noise, such as diving. Vessel noise is not expected to result in impairment or mortality of individuals, or any other lasting effect.

Subsea IMR Activities

Acoustic Survey

Underwater noise from MBES and SSS will attenuate rapidly in the water column due to the relatively high frequency of noise emissions from these sources. No impacts to sensitive fauna are expected to occur as a result of these sources. SBP are typically lower frequency than MBES or SSS, and acoustic emissions from sub-bottom profilers may propagate further in the water column. Based on typical source levels and frequencies for sub-bottom profilers and the geometric spreading equation present in vessel noise above noise energy from a sub-bottom profiler will reach 160 dB re 1 μPa rms SPL within approximately 250 m of the source, and 120 dB re 1 μPa rms SPL within approximately 1250 m of the source.

Piling Activities

An underwater acoustic modelling study of pile driving noise was commissioned by Jasco Applied Sciences for piling activities associated with the the Pluto Flowline Restraint Pilling (Quijano et al., 2018). This study has been utilised to inform the risk assessment for underwater noise associated with piling and considered the geoacoustic properties of the proposed piling locations, engineering specifications and drivability analysis of the proposed piles, including pile diameter of 2.5 m, wall thickness of 50 mm and a 500 kJ hammer.

Four possible piling locations were identified, PA1, PA2, PB1 and PB2, with water depths ranging from 740–762 m. The deepest site, PA2, was selected as the modelling location (**Figure 12-1**), as this is considered the worst case scenario for acoustic modelling, as the deeper water location has far greater propogation ranges due to the reduced attenuation associated with the interaction of acoustic energy with the SOFAR channel of the sound speed profile. Piles are expected to be 31.8 m long, and driven 30 m into the seabed . Impact piling sound depends on the length of the pile within the water column and soil resistance/pentration rate. At the start of piling, most of the pile is in the water column, so sound levels can be high because of the relatively large source exposed to the water column. Near the end of piling, most of the pile is buried in the sediment; therefore, a small section of the pile is exposed to the water column, However, the pile penetration per-strike is usually less than at the start of piling, which can cause higher sound levels due to stronger stress-wave reflections at the pile toe. JASCO therefore modelled impact piling for three penetrations: 0–10, 10–20, and 20–30 m. The drivability assessment provided by Woodside was used to derive the penetration rate (**Table 12-4**).

The modelling approach determined per-strike SEL for three stages of pile driving (i.e., penetration depths). Several noise impact thesholds, however, depend on accumulated SEL over many strikes. The accumulated SEL, therefore, depends on the total number of strikes. The total number of strikes to install a pile are shown in **Table 12-4**. Total driving time was estimated assuming continuous piling at a rate of 40 strikes/min.

Table 12-4: Total number of strikes and driving time for each pile type. Strikes are broken down into stages corresponding to the three modelled penetrations

Pile	Modelled penetration (m)	Penetration rate (mm/strike)	Penetration range for accumulated SEL (m)	No. of strikes	Total no. of strikes	Time for full penetration (min)
PA2	10	67.2	0–10	46	548	13.7
	20	55.1	10–20	182		
	30	31.3	20–30	320		

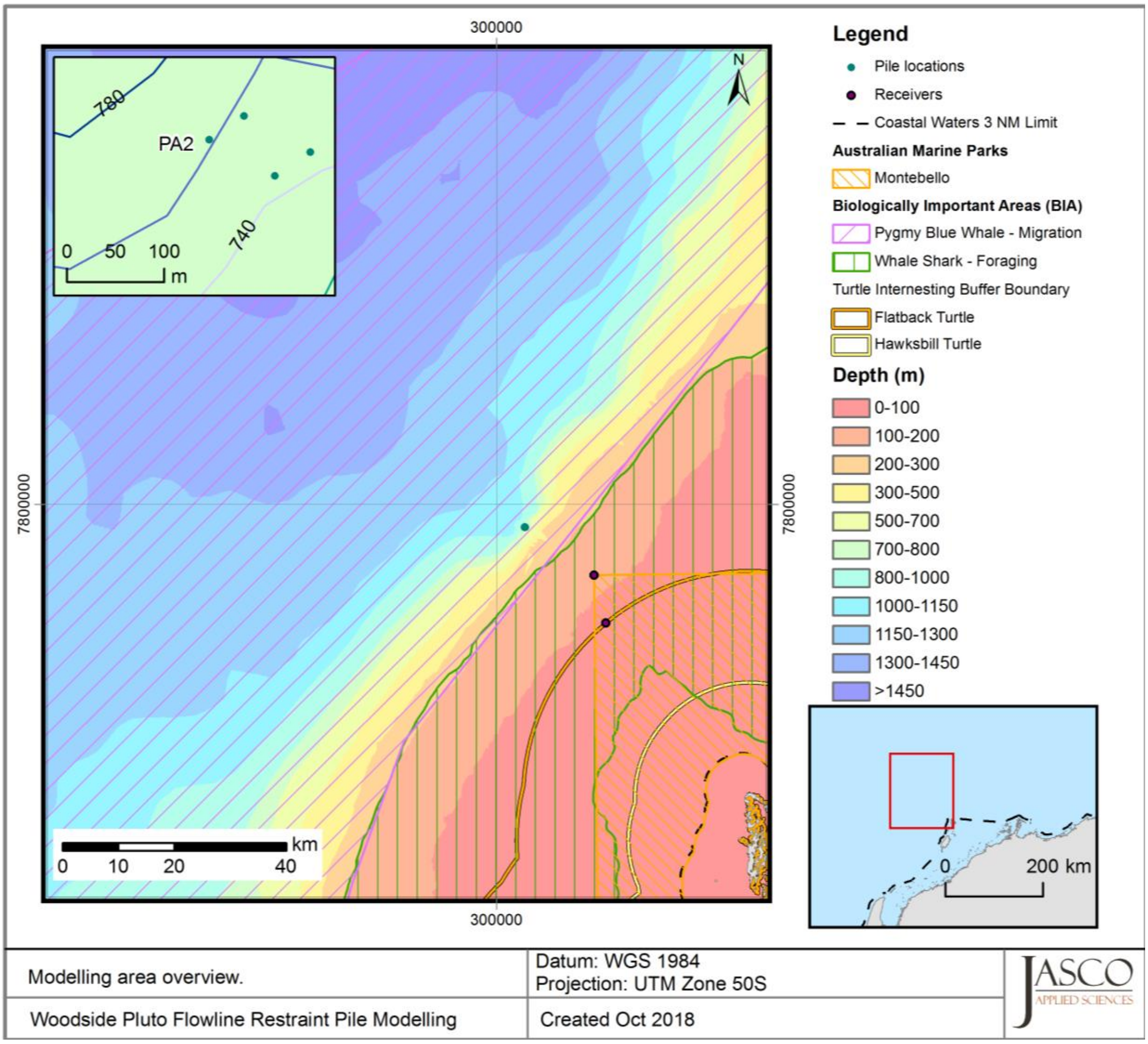

Figure 12-1: Modelling sites and features. Modelling was conducted at the location of pile PA2, near the 760 m bathymetry contour

Since the piles are distributed and directional sources, they cannot be accurately approximated by a point source with corresponding source levels. It is possible to compare the maximum modelled levels at short distances from the piles. **Figure 12-2** shows the 1/3-octave-band levels for the receiver with highest SEL at the closest horizontal range (10 m), for all modelled pile types and penetrations. The levels above 1000 Hz are extrapolated using a 20 dB/decade decay rate to match acoustic measurements of impact pile driving of similarly-sized piles (Illingworth & Rodkin 2007, Matuschek and Betke 2009). The modelled results at a distance of 10 m are included to provide comparative results to other pile driving reports, such as Illingworth & Rodkin (2007) and Denes et al. (2016).

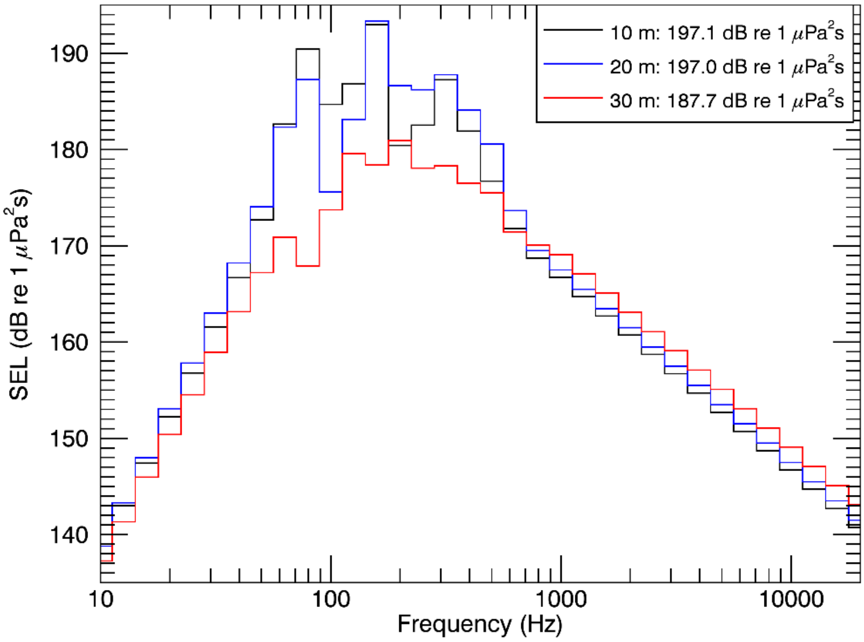

Figure 12-2: One-third-octave-band levels for the receiver with highest SEL at 10 m horizontal range for impact pile driving after high-frequency extrapolation.

Legend items indicate the modelled pile penetration (Table 12-4.)and the broadband SEL.

Potential Impacts to Marine Mammals from Piling

The potential for anthropogenic sounds to impact marine mammals is largely dependent on whether the sound occurs at frequencies that an animal can hear well, unless the sound pressure level is so high that it can cause physical tissue damage regardless of frequency. Auditory (frequency) weighting functions reflect an animal's ability to hear a sound (Nedwell and Turnpenny 1998, Nedwell et al. 2007). Auditory weighting functions have been proposed for marine mammals, specifically associated with PTS thresholds expressed in metrics that consider what is known about marine mammal hearing (e.g., SEL (L_E)) (Southall et al., 2007; Finneran, 2016). Marine mammal auditory weighting functions published by Finneran (2016) are included in the NMFS (2018) Technical Guidance for use in conjunction with corresponding PTS (injury) onset acoustic criteria, and have been applied for this piling modelling assessment (**Table 12-5**).

Table 12-5: The SPL (unweighted, L_p, and LF-weighted, $L_{p,LF}$) SEL_{24h} ($L_{E,24h}$) and PK (L_{pk}) thresholds for acoustic effects on marine mammals. Injury is defined as permanent threshold shift (PTS).

Hearing group	Behaviour	NMFS (2018)			
		PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160 (L_p) (NMFS 2013)	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196
Low-frequency cetaceans and migrating pygmy blue whales	160 (frequency-weighted SPL) – 90% response probability Modified Wood et al. (2012)	-			

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

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

L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s.

Subscripts indicate the designated marine mammal auditory weighting.

An extensive review of behavioural responses to sound was undertaken by Southall et al. (2007, their Appendix B). Southall et al. (2007) found varying responses for most marine mammals between a SPL of 140 and 180 dB re 1 µPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit step functions. Absence of controls, precise measurements, appropriate metrics, and context dependency of responses (including the activity state of the animal) all contribute to variability. Therefore, unless otherwise specified, the relatively simple sound level criterion for potentially disturbing a marine mammal applied by NMFS has been used. For impulsive sounds, this threshold is 160 dB re 1 µPa SPL for cetaceans (NMFS 2013).

Wood et al. (2012) proposed a graded probability of response for impulsive sounds using a frequency weighted SPL metric. They defined behavioural response categories for sensitive species (including harbor porpoise and beaked whales) and for migrating mysticetes. The migrating mysticete category has been applied in this analysis to pygmy blue whales, in particular the migration BIA, to assess behavioural response to impulsive sounds (**Table 12-6**). The Wood et al. (2012) approach has been updated to consider the frequency weighting from NMFS (2018).

The maximum distance at which the NMFS (2013) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded was within 20.13 km of the piling location ($R_{95\%}$; **Table 12-6**). For comparison the maximum distances to an LF-weighted 160 dB re 1 µPa (SPL) 90% probability of response for migrating mysticetes from Wood et al. (2012), was 10.56 ($R_{95\%}$; **Table 12-6**). These maximum radii were associated with the first 46 strikes (10 m penetration depth). As the pile reached deeper penetration depths of 20 m and 30 m, the cetacean behavioural response distance decreased to approximately to 12 km and 7 km, respectively.

Table 12-6: Maximum 95% ($R_{95\%}$) horizontal distances (in km) from the piles to modelled maximum-over-depth marine mammal behavioural response thresholds. Radii are also maximised over the modelled pile penetrations.

Threshold	10 m penetration depth	20 m penetration depth	30 m penetration depth
	$R_{95\%}$ (km)	$R_{95\%}$ (km)	$R_{95\%}$ (km)
NMFS (2013) Marine mammal behaviour SPL: 160 dB re 1 µPa	20.13	12.52	7.07
LF-weighted 160 dB re 1 µPa ($L_{p,\,LF}$) †	10.56	10.35	2.7

† 90% probability of response for migrating mysticetes, Wood et al. (2012).

Table 12-7 presents the SEL_{24h} results relevant to marine mammals for the proposed pile driving operations. It should be noted that these thresholds all assume maximum over depth and assume the animal is not moving. Sound propagation for this piling activity is strongly driven by refracting properties of the sound speed profile and bathymetric features. **Table 12-8** presents the results of the PTS and TTS to marine mammal associated with a single exposure PK values.

Table 12-7: Maximum-over-depth distances (in km) to SEL_{24h} based marine mammal PTS and TTS thresholds NMFS (2018)

Hearing group	PTS		TTS	
	Threshold for SEL_{24h} (dB re 1 µPa²·s)	*$R_{95\%}$ (km)*	*Threshold for SEL_{24h} (dB re 1 µPa²·s)*	*$R_{95\%}$ (km)*
Low-frequency cetaceans	183	1.42	168	26.95
Mid-frequency cetaceans	185	–	170	0.13
High-frequency cetaceans	155	0.57	140	10.43

A dash indicates the threshold is not reached.

Table 12-8: Maximum (R_{max}) horizontal distances (in m) from the pile to PTS and TTS PK levels for marine mammals

Hearing group	PTS	Penetration			TTS	Penetration depth		
	PK threshold (dB re 1 µPa)	*10 m*	*20 m*	*30 m*	*PK threshold (dB re 1 µPa)*	*10 m*	*20 m*	*30 m*
Low-frequency cetaceans	219	14	14	<10	213	121	58	32
Mid-frequency cetaceans	230	<10	<10	<10	224	<10	<10	<10
High-frequency cetaceans	202	416	355	190	196	774	667	342

The noise generated by sources located below 100 m depth experience downward refraction due to the strong sound speed gradient between depths 100–800 m. This effect is illustrated in **Figure 12-3** which shows a sound channel for depths below 300 m which prevents some of the piling-generated noise to reach the surface for ranges greater than 5 km. To highlight the strong impact of the sound speed profile on sound propagation, **Figure 12-4** shows per-strike SEL for the same radial as in **Figure 12-3**, but using an ideal sound speed profile with constant speed of 1510 m/s. In this case, sound spreads throughout the entire water column in a more even fashion.

Figure 12-3 highlights the importance of animat modelling (outlined below) when assessing the cumulative impact on mammals with diving behaviour, because it is evident that for ranges >5 km, the most significant sound exposure will be limited to the fraction of diving time for which the animal remains below ~300 m depth during the 13.7 minutes estimated to install a pile. This exposure will also be limited to certain ranges (e.g. 2.5–7 km, 16–21 km in **Figure 12-3**).

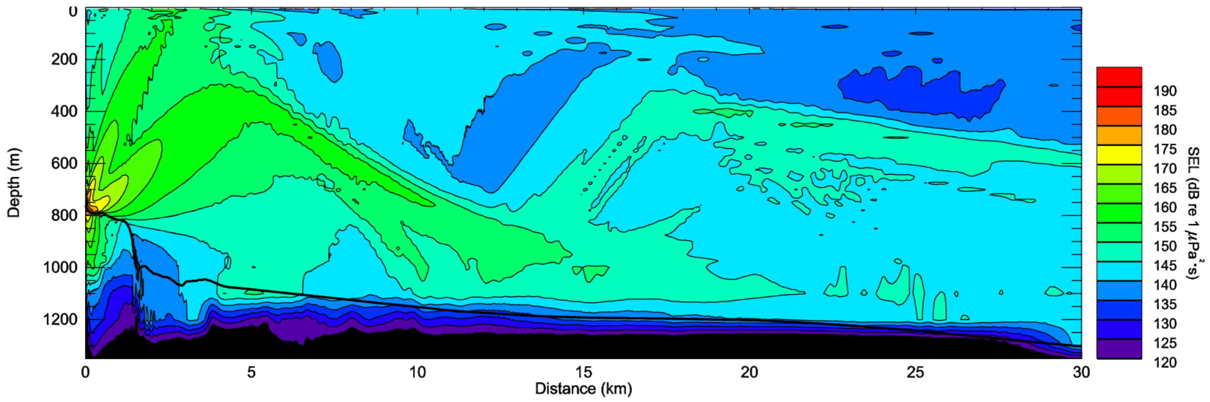

Figure 12-3: Predicted unweighted per-strike SEL for 10 m penetration as a vertical slice. Levels are shown along a single transect of azimuth 315°. Notice the sound channel below 300 m depth, which is formed by the downward refractive sound speed profile. The seabed outline is shown as a thick black line.

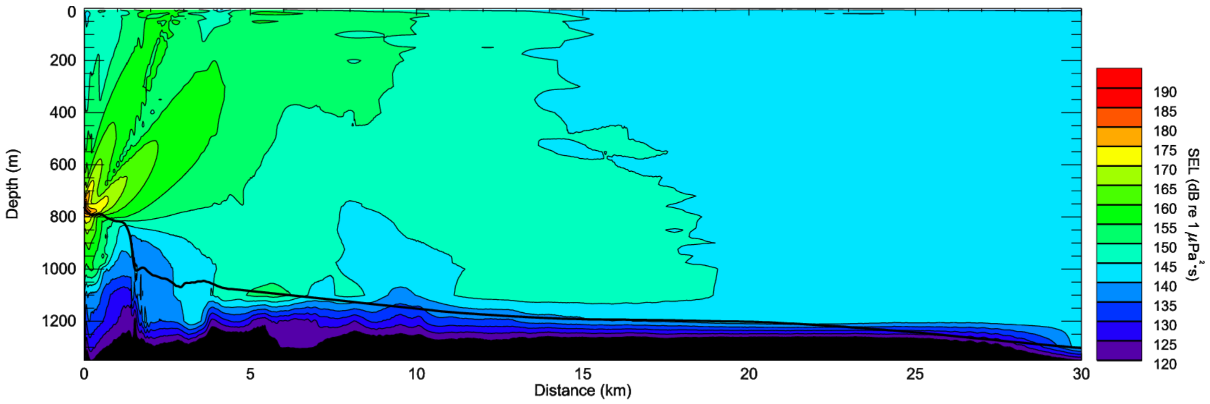

Figure 12-4: Predicted unweighted per-strike SEL as a vertical slice corresponding to an ideal isovelocity environment. Levels are shown along a single transect of azimuth 315°. Compare the characteristics of noise propagation to those of a downward-refracting sound speed profile (Figure 12-3). The seabed outline is shown as a thick black line.

Animal Movement and Exposure Modelling (pygmy blue whales)

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of Pygmy Blue Whale animats (as virtual marine mammals) to sound arising from the pile driving. Sound exposure models like JASMINE integrate the predicted sound field with biologically meaningful movement rules for each marine mammal species (here: pygmy blue whales), resulting in an exposure history for each animat in the model. Inside JASMINE, the sound source mimics the proposed pile driving activity pattern. Animats are programmed to behave like the marine animals that may be present in the area. The parameters used for forecasting realistic behaviours (e.g. diving, foraging, aversion, surface times) are determined and interpreted from marine mammal studies (e.g. tagging studies) where available, or reasonably extrapolated from related species. An individual animat's sound exposure levels are summed over a specified duration, such as 24 hours or the entire simulation, to determine its total received energy, and then compared to the threshold criteria. This methodology provides a scientifically robust way of more accurately assess the potential impacts to Pygmy Blue Whales associated with undertaking the piling activity in the most sensitive period, specifically during the Pygmy Blue Whale migration.

Pygmy Blue Whale Movement Behaviour to Inform Modelling

The JASMINE model requires detailed behavioural information on how the modelled species moves in the water column. Detailed, fine‑scale diving behaviour of a migrating pygmy blue whale was derived from Owen et al. (2016) who equipped an animal off the west coast of Australia with a multi‑sensor tag. These data revealed areas of high residence identified using the horizontal movement data; the analysis of the dive data showed that the depth of migratory dives was highly consistent over time and unrelated to local bathymetry. Blue whales are known to primarily migrate and feed in the first few hundred metres of the water column (Croll et al., 2001; Goldbogen et al., 2011) with the deepest dive being reported from a pygmy blue whale being 506 m (Owen et al. 2016). Dives were identified as migratory, feeding or exploratory behaviour. The mean depth of migratory dives (82% of all dives) was 13 m, and the whale spent 94% of observed time and completed 99% of observed migratory dives at water depths of less than 24 m. A total of 21 feeding dives were identified during the duration of the tag deployment (one week) with a mean maximum depth of 129 ± 183 m (range 13–505 m). The mean maximum depth of exploratory dives (107 ± 81 m, range 23–320 m) was similar to the mean maximum depth of feeding dives (129 m) and did not appear to be related to seafloor depth.

Pygmy Blue Whale Density Estimates to Inform Modelling

McCauley and Jenner (2010) provided the first census data for pygmy blue whales migrating along the coastline and estimated a (sub) population size of 662–1559 whales (mean: 1110). They used passive acoustic detections from noise loggers deployed at several sites along the coast of Western Australia; with the site closest to the modelling site located north of the Montebello Islands. It is believed that pygmy blues whales are focussed near the continental shelf edge during their migration to/from Indonesian waters. The observations in McCauley and Jenner (2010) suggested most pygmy blue whales pass along the shelf edge out to water depths of 1000 m but centred near the 500 m depth contour. The boundaries of the BIA are designed to reflect this general migratory pattern. The area considered in this animat simulation was greater than the acoustic modelling region to provide a buffer zone around the sound fields to account for the possibility of animats moving into and out of the modelled sound fields. The simulation considered an area of 180×180 km^2 for a total scenario area of 32,400 km^2. The spatial overlap between the simulation area and the BIA is 17,157 km^2.

The acoustic detection data published by McCauley and Jenner (2010) revealed a maximum of three pygmy blue whales on a single day passing through the area during their southward migration (November to late December). The listening range of the noise logger was estimated to be 120 km. Based on an average swimming speed for the southbound pygmy blue whales of five knots (9.26 km/hr), McCauley and Jenner (2010) calculated a transit time through the area of 0.54 days. The number of animals detected per day equates to an estimated density in the area of 0.0031207 animals per km^2. As not all animals are emitting calls during their migration, this density estimate has to be corrected for the percentage of animals calling ('calling rate'). Given the uncertainty in pygmy blue whales, McCauley and Jenner (2010) proposed an estimate of 8.5% to 20% calling pygmy blue whales, however a conservative value of 8.5% calling animals was used for this modelling to estimate pygmy blue whale density. The resulting estimated density of 0.006241 animals/km^2 allows calculating the number of pygmy blue whales potentially exposed to sound levels exceeding the exposure thresholds based on the animat modelling results. Based on the spatial extent of the overlap between the scenario area and the BIA the estimated number of pygmy blue whales in the entire simulation area is 107 animals (**Table 12-9**).

Table 12-9: Estimated density of pygmy blue whales in the piling modelling simulation area

Species	Number of animals detected (animals/day)	Listening area* (km^2)	Calling rate* (%)	Estimated density (animals/km^2)	Estimated abundance in simulation area
Pygmy blue whale	3	11309.7	8.5	0.006241	107

** McCauley et al. (2010) – note that McCauley et al. (2010) provided a range of 8.5–20% for the percentage of the population that are calling.*

Results of Animat Modelling

Given the proposed piling locations overlap the pygmy blue whale BIA and peak migration months, in order to provided a robust impact assessment of the potential impacts to migrating Pygmy Blue Whales, a detailed animal behavioural model was incorporated into acoustic piling modelling. This animal simulation model did not account for soft starts or shutdowns which have been applied as controls for this activity, therefore the model is considered conservative.

JASMINE predicted that during pile driving no pygmy blue whales will be exposed to levels exceeding the threshold for behavioural disturbance using the NMFS (2013) criterion of 160 dB re 1 µPa (SPL). The modelling predicts that no pygmy blue whales would be exposed to acoustic levels exceeding threshold for the onset of PTS. The low levels of exposure, relative to the larger ranges to threshold (from maximum-over-depth), are explained by the depth dependence of the acoustic propagation coupled with the depth preference of pygmy blue whales.

The exposure criteria for impulsive sounds were used to determine the number of animats exceeding the exposure criteria. Model simulations were run with animat densities of two animats/km^2 to generate a statistically reliable probability density function for each species. To evaluate potential injury and behavioural disruption, exposure results were summed over a 24 h period.

After the number of animats exposed to levels exceeding thresholds was calculated, the exposure numbers were adjusted by the species' density estimate of 0.006241 animal per km^2 to determine the number of real-world individual animals with the potential to exceed the pre-selected model thresholds. The estimated number of individual cetaceans predicted to potentially receive sound levels above the exposure criteria in the pile driving animal movement and exposure simulation area is shown in **Table 12-10**.

Table 12-10: The real-world number of pygmy blue whales within the simulation area estimated to potentially experience sound levels above-threshold exposure criteria during pile driving activities. Estimates related to both behavioural disruption (Wood et al. 2012, NMFS 2013) and injury criteria (NMFS 2018) are given for a single day; values are rounded to the nearest integer.

Species	Injury: PK, L_{pk}	PTS† Frequency weighted SEL 183 dB ($L_{E, LF, 24h}$)	Behaviour: Max. unweighted 160 dB SPL	90% Behavioural Response: 160 dB ($L_{p,LF}$)
Pygmy blue whale	0	0	0	0.3

$L_{p,LF}$ denotes low-frequency weighted sound pressure level and has a reference value of 1 µPa.
L_p - denotes sound pressure level and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s.
†The model does not account for shutdowns.

As a proportion of the estimated population, the number of pygmy blue whales potentially exposed sound levels exceeding the thresholds for behavioural disturbance and injury within the simulation area are provided in **Table 12-11.** The percentages are calculated as the counts of potentially exposed animals divided by the estimated local population size of pygmy blue whales.

Table 12-11: Percentage of the pygmy blue whale population estimated to potentially be exposed to sound levels above behavioural disturbance and injury thresholds within the simulation area. The population is estimated to include 1559 animals.

Species	Percentage of population Injury: PK, L_{pk}	Percentage of population Injury: Frequency weighted SEL (L_E)	Percentage of population Behaviour: max. unweighted 160 dB
Pygmy blue whale	0.00%	0.00%	0.00%

Summary of Impacts to Marine Mammals from Piling

Piling activities will occur in water depths greater than 600 m and are therefore outside known humpback migratory depths and defined migratory BIA. Acoustic modelling of the piling activity has confirmed the received level at the closest Humpback Migratory BIA boundary will be approximately 140 dB re 1 µPa, which is significantly below the published behavioural response threshold of 160 dB re 1 µPa. Accordingly, there is unlikely to be any potential impacts to migrating humpback whales and no further controls necessary.

A detailed assessment of the potential impacts to Pygmy Blue whales using both acoustic modelling and animat modelling was undertaken, as the proposed piling zone overlaps the pygmy blue whale BIA. The modelling results confirmed there is no credible chance of injury from the proposed piling activity, and this assumes no shutdown or soft-start controls. Additionally, for each individual pile, animat modelling has confirmed the number of animals expected to result in behavioural disturbance is zero when applying the industry standard NMFS (2013) Marine mammal behaviour, SPL: 160 dB re 1 µPa threshold. Accordingly, there are not expected to be any potential impacts to pygmy blue whale individuals or the population as a result of undertaking the proposed piling activity during the peak pygmy blue migration.

Given the limited number and short duration of piling activities, and the proposed precautionary controls, predicted noise from piling is not expected to cause any impacts to cetaceans at a population level.

Potential Impacts to Fish, Fish Eggs, and Fish Larvae from Piling

Table 12-12 lists relevant effects thresholds from Popper et al. (2014) for pile driving. In general, any adverse effects of impulsive sound on fish behaviour depends on the species, the state of the individual exposed, and other factors. For turtle injury, a PTS of 232 dB re 1 µPa (PK), Finneran et al. (2017) has been applied as it represents updated information compared to the information presented in Popper et al. (2014).

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, an exposure evaluation time must be defined. Southall et al. (2007) defines the exposure evaluation time as the greater of 24 hrs or the duration of the activity. Popper et al. (2014) recommends a standard period of the duration of the activity; however, the publication also includes caveats about considering the actual exposure times if fish move. Integration times in this study have been applied over the time a single pile was driven, since only one pile is expected to be driven per day.

Table 12-12: Criteria for pile driving noise exposure for fish, adapted from Popper et al. (2014)

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	*TTS*	*Masking*	
Fish: No swim bladder (particle motion detection)	> 219 dB SEL_{24h} or > 213 dB PK	> 216 dB SEL_{24h} or > 213 dB PK	>> 186 dB SE L_{24h}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	>> 186 dB SE L_{24h}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	186 dB SEL_{24h}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae	> 210 dB SEL_{24h} or > 207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Peak sound pressure level dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s.

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

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

Considering the defined 24 hr period of exposure, fish (including sharks) could experience temporary threshold shift (TTS) from the proposed pile driving project. It is predicted that this could occur within 2.5 km of the piling location, assuming no behavioural avoidance (**Table 12-13**). Injury is expected to occur within 247 m for the most sensitive fish group (Swim bladder involved in hearing) (**Table 12-14**).

Table 12-13: Maximum-over-depth distances (in km) to SEL_{24h} based fish criteria. Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

Marine animal group	Threshold for SEL_{24h} (dB re 1 µPa²·s)	Maximum-over-depth	
		R_{max} (km)	$R_{95\%}$ (km)
Fish mortality and potential mortal injury			
I	219	–	–
II Fish eggs and larvae	210	0.05	0.05

III	207	0.12	0.11
Fish recoverable injury			
I	216	0.02	0.02
II, III	203	0.21	0.19
Fish TTS			
I, II, III	186	2.49	2.09

A dash indicates the threshold is not reached.

Table 12-14: Maximum (*R*max) horizontal distances (in m) from the pile to peak mortality and potential mortal recoverable injury thresholds for fish, turtles, fish eggs, and fish larvae

Marine animal group	PK (dB re 1 µ Pa)	Penetration depth		
		10 m	*20 m*	*30 m*
Fish: No swim bladder	213	121	58	32
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	247	175	114

Sumary of potential Impacts to Fish, Fish Eggs, and Fish Larvae from Piling

Most pelagic and open water fish species (including whale sharks) are expected to swim away when impulsive noise, such as pile driving, reaches levels at which it may cause physiological effects. The scombroid fishes such as tuna, billfish and marlin are considered hearing generalists with poor hearing sensitivity based on physiological structure of the inner structure (as documented for the bluefin tuna, Song et al., 2006). It is considered extremely unlikely that scombroid fishes in the vicinity of piling activities will stay within the area long enough to experience sound exposure levels that will cause either high-level behavioural effects (fright/flight) or physiological effect such as hair cell damage . It is estimated that low-level behavioural effects (avoidance) may take place <2 km from the piling activities and potential injury sustained within 247 m for the most sensitive fish group (swim bladder involved in hearing). Taking a conservative maximum zone of effect of 2 km radius around the piling location, the spatial ‘footprint’ of potential effect is extremely small when compared to the wider open water area which scombroid fishes use (Galaxea, 2010). Any other potential effects are further mitigated by the fact that the zone of effect is confined spatially and temporally, given the short duration of exposure at each piling location and extended period of no acoustic exposure in between piling activities.

It is expected that the potential effects to whale sharks (Rhincodon typus) associated with hammer pile driving noise will be the same as for other fish. Given whale sharks do not have swim bladders, they are categorised as a fish that is less sensitive to noise (Fish: no swim bladder), and therefore unlikely to be impacted by piling noise unless at close distances to the piling location (Popper et al., 2014). For example, a whale shark would need to be within less than 121 m from the source for a single pulse exposure to received potential injury levels. Soft start procedures and piling shutdown exclusion zones of 200 m will also be implemented for whale sharks to reduce any potential risk of noise exposure.

<u>Potential Impacts to Turtles from Piing</u>

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds, but the received levels were unknown and the NSF (2011) PEIS maintained the earlier NMFS criteria level of 166 (SPL) for behavioural response.

Both SPL thresholds of 166 dB re 1 µPa (NMFS) and 175 dB re 1 µPa for behavioural disturbance were included in this analysis.

Based on the results of hammer piling noise modelling (**Table 12-16)**, distances of behavioural effects (166 dB re 1 µPa RMS) are expected to be limited to within 8.54 km from the piling impact location and assumed injury (232 dB re 1 µPa PK) within less than 10 metres. The use of soft-start (or ramp-up) procedures will act to prevent the situation where the pile driving could be suddenly started up at full power with turtles nearby. Additionally, given the piling noise source is stationary, individuals would be expected to implement avoidance measures before entering ranges at which physical damage may occur. The hammer piling activities are proposed to be undertaken in water depths greater than 600 m, which does not overlap with any marine turtle BIA. The piling modelling has estimated that received levels at the closest marine turtle BIA boundary (Flatback internesting) will be 148 dB re 1 µPa, well below the conservvative 166 dB re 1 µPa turtle behaviour threshold. Accordingly, there are expected to be no impacts to marine turtle populations as a result of the proposed piling activity.

Table 12-15: Maximum 95% ($R_{95\%}$) horizontal distances (in km) from the piles to modelled maximum-over-depth turtle behavioural response thresholds. Radii are also maximised over the modelled pile penetrations.

Threshold	10 m penetration depth	20 m penetration depth	30 m penetration depth
	$R_{95\%}$ (km)	*$R_{95\%}$ (km)*	*$R_{95\%}$ (km)*
Turtle behaviour, SPL: 166 dB re 1 µPa (NSF 2011)	8.54	7.17	2.62
Turtle behaviour, SPL: 175 dB re 1 µPa	1.06	0.86	0.39

Table 12-16: Maximum (R_{max}) horizontal distances (in m) from the pile to peak injury thresholds (PTS and TTS) for turtles adopted from Finneran et. al. (2017)

Marine animal group	PK (dB re 1 µ Pa)	Penetration depth		
		10 m	*20 m*	*30 m*
Turtle PTS	232	< 10	< 10	< 10
Turtle TTS	226	< 10	< 10	< 10

Summary of Potential Impacts to Marine Turtles from Piling

The hammer piling activities are proposed to be undertaken in water depths greater than 600 m, which does not overlap with any marine turtle BIA. The piling modelling has estimated that received levels at the closest marine turtle BIA boundary (Flatback internesting) will be 148 dB re 1 µPa, well below the conservative 166 dB re 1 µPa turtle behaviour threshold. Accordingly, there are expected to be no impacts to marine turtle populations as a result of the proposed piling activity.

Helicopter Noise

Noise levels for typical helicopters used in offshore operations (Eurocopter Super Puma AS332) at 150 m separation distance has been measured at up to a maximum of 90.6 dB (BMT Asia Pacific, 2005). Water has a very high acoustic impedance contrast compared to air, and the sea surface is a strong reflector of noise energy (i.e. very little noise energy generated above the sea surface crosses into and propagates below the sea surface (and vice versa) – the majority of the noise energy is reflected). The angle at which the sound path meets the surface influences the transmission of noise energy from the atmosphere through the sea surface; angles ±> 13° from vertical being almost entirely reflected (Richardson *et al.*, 1995). Given this, and the typical characteristics of helicopter flights within the Operational Area (duration, frequency, altitude and air speed), the opportunity for underwater noise levels that may result in behavioural disturbance to marine fauna are not considered to be credible.

Wellheads, Pipelines and Platform Machinery Noise

Given the low levels of noise emitted by subsea infrastructure such as wellheads, choke valves, pipelines and the platform jacket legs, no impacts to marine fauna from these noise sources are expected. Measurements of noise generated by choke valves indicate it is relatively high frequency (> 1 kHz) and hence, will attenuate over relatively short distances in the water column.

Flare noise, like helicopter noise, is generated in the atmosphere and has limited potential to propagate in the sea due to the high acoustic impedance of water. Additionally, the height of the flare tower and the unconstrained propagation of noise from the flare in the atmosphere means the potential for impacts to fauna at or near the sea surface is inherently highly unlikely, with no lasting effect and will be highly localised.

Summary of Control Measures

- Maintaining helicopter separation from cetaceans as per EPBC Regulations 2000 – Part 8 Division 8.3 (Regulation 8.07), which includes the following measure:
  - Helicopters shall not operate lower than 1650 feet or within a horizontal radius of 500 m of a cetacean known to be present in the area, except for takeoff and landing
- Have a dedicated, experienced and trained Marine Fauna Observer (MFO) on-board the support vessel to observe for marine fauna during any subsea hammer piling activities.
- No hammer piling at night.
- If using subsea hammer – 'soft start' procedure will be applied at commencement of piling.

Routine and Non-Routine Discharges: Discharge of Hydrocarbons and Chemicals during Subsea Operations and Activities

Impacts Evaluation Summary													
Source of Impact	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Discharge of subsea control fluids.		X	X		X			A	F	-	-	LCS GP PJ	Broadly Acceptable
Discharge of hydrocarbons remaining in subsea infrastructure and equipment as a result of subsea intervention works.		X	X		X			A	F	-	-		
Discharge of chemicals remaining in subsea infrastructure and equipment or the use of chemicals for subsea IMR activities.		X	X		X			A	F	-	-		
Discharge of minor fugitive hydrocarbons/chemicals from subsea equipment.			X					A	F	3	M		

Description of Source of Impact

Hydrocarbons and chemicals may be discharged as a result of planned routine and non-routine operations and activities, for:

- Operational discharge including:
  - discharge of subsea control fluids – subsea control fluid is used to control subsea and well-head valves remotely from the facility. It is an open-loop system, designed to release control fluid from the subsea system
  - potential non-routine subsea fluid discharges associated with umbilical system/MEG supply line losses/weeps
  - discharge of minor fugitive hydrocarbon from subsea equipment (e.g. seal weeps/bubbles).
- IMR activities including:
  - discharge of residual hydrocarbons in subsea lines and equipment as a result of subsea IMR activities
  - discharge of residual chemicals in subsea lines and equipment or the use of chemicals for subsea IMR activities (including pigging).

Subsea Control Fluids

Subsea control fluid is used to control well-head valves remotely from the facility. Control fluid is supplied to valves via an open-loop system, designed to release control fluid during operation (e.g. upon valve actuation) up to ~2 m^3/day use across the subsea system. Subsea control fluid may also be discharged during IMR activities (e.g. leak detection and SCM change outs).

Hydrocarbons

Potential discharges associated with spool or subsea valve replacement activities are difficult to accurately determine without detailed engineering and activity specific planning which incorporates risk reduction and mitigation considerations. A typical release associated with spool replacement may be approximately 100 L of hydrocarbon. IMR activities may also result in small gas releases associated with isolation testing and breaking into containment. During operations there is the potential for discharge of minor fugitive hydrocarbons (predominantly gas bubbles) from subsea equipment, such as from umbilicals/control lines, well equipment, valves, and flowline and pipeline seals.

Chemicals

Chemicals present in or introduced into subsea infrastructure (e.g. MEG, corrosion inhibitors, biocides, scale inhibitors, etc.) which may be discharged from subsea lines, HFL and equipment. Chemical may also be introduced into subsea infrastructure during IMR activities. These chemicals are used and discharged intermittently in small volumes. Small quantities of chemicals may remain in the flushed infrastructure, which may be released to the environment after disconnection . During operations there is the potential for minor discharge of chemicals from subsea equipment, such as from umbilicals / MEG supply lines, well equipment, valves, and flowline and pipeline seals.

The use of operational chemicals is restricted to that needed to complete a required task. All operational (process and non-process) chemicals are selected in accordance with the requirements of the chemical selection process.

Impact Assessment

There is the potential for slight, short term decrease in water quality and adverse effects on marine biota as a result of planned routine and non-routine hydrocarbon and chemical discharges. However, planned discharges of hydrocarbons and chemicals are minor and are minimised as far as practicable, e.g. via flushing off the lines back to the riser platform and through implementation of the chemical selection process. Discharge locations are normally associated with the subsea valves (subsea control fluid) or at disconnection points in subsea infrastructure.

Subsea Control Fluids

Subsea control fluids are selected in conformance with the chemical selection process. The subsea control fluid currently in use at the facility is HW443, which is water-based and has an OCNS rating of D with a substitution warning. The substitution warning is a result of the fluorescein ye which is approximately 150 ppm within the product. The dye is used to support leak detection and subsea IMR troubleshooting. The substitution warning is due to the low biodegradability of fluorescein; however, the product is non-toxic and does not have a potential to bioaccumulate. Subsea control fluids are discharged from subsea valves at or near the seabed in relatively small volumes. Once released, control fluids are expected to mix rapidly in the water column and become diluted.

Impacts from the release of subsea control fluids are considered to be localised to the immediate vicinity of the release location with no lasting effect, based on:

- the relatively small volumes of discharges
- the low sensitivity of the receiving environment
- the rapid dilution of the release.

Hydrocarbons

The small quantities of hydrocarbons that may be released during IMR activities that break containment of isolated subsea infrastructure or fugitive releases, will be buoyant, and float upwards towards the surface. Given the water depth, pressure, and the small volumes released, these hydrocarbons are not expected to reach the sea surface. Rather, the release will disperse and dissolve within the water column. While recognising the potential ecotoxicity and physical effects of released hydrocarbons (refer to **Unplanned Hydrocarbon or Chemical Release: Hydrocarbon Release during Bunkering, Refuelling and Chemical Release during Transfer, Storage and Use, Rupture of Chemical Supply Lines** for a discussion of the potential environmental impacts of hydrocarbon releases), the low release volumes, dispersion and dissolution is expected to result in hydrocarbon contamination decreasing to background levels rapidly. As such, impacts from routine and non-routine releases of hydrocarbons are assessed as being highly localised with no lasting effect.

Chemicals

The small quantities of chemicals that may be released during IMR activities and through weeps will disperse within the water column and be localised to the immediate vicinity of the release location.

Impacts from routine and non-routine discharges of chemicals will be localised to the immediate vicinity of the release location with short-lasting impacts. This is based on:

- the low potential for toxicity and bioaccumulation (MEG is considered PLONAR**)**
- the relatively small volumes/rates of discharges
- the low sensitivity of the receiving environment
- the rapid dilution of the release.

Values and Sensitivities

<u>KEFs</u>

There are two KEFs which overlap the Operational Area; Ancient Coastline at 125 m Depth Contour and Continental Slope Demersal Fish Communities. No significant escarpments, species of conservation significance, emergent features or areas of high biological productivity characteristically associated with the Ancient Coastline at 125 m KEF have been

observed in the Operational Area. Therefore, potential impacts to these regional-scale KEFs are expected to be negligible. <u>Montebello Australian Marine Park</u> A small portion of the Operational Area overlaps the Montebello Marine Park Multiple Use Zone. The Marine Park includes values associated with the shallow shelf environment, however no pinnacle or terrace seafloor features are found within the Operational Area. Any impacts in the Marine Park will be negligible as described above.
Summary of Control Measures

• Chemical Selection and Assessment Environment Guideline:
  ○ Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected, no further control required.
  ○ If chemicals with a different OCNS rating, sub-warning or non OCNS rated chemicals are require, chemicals will be assessed in accordance with the procedure prior to use
• Flushing subsea infrastructure where practicable during IMR disconnection activities to reduce volume/ concentration of hydrocarbons released to the environment.
• Monitoring subsea control fluid use, investigating material discrepancies, and using control fluid with dye marker to support identification of potential integrity failures

Routine and Non-Routine Discharges: Produced Water

Impacts Evaluation Summary														
Source of Impact	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/ Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Discharge of produced water during routine and non-routine operations.		X	X		X	X		B	E	-	-	LCS GP PJ RBA	Broadly Acceptable

Description of Source of Impact

Produced water (PW) consists of formation water (derived from a water reservoir below the hydrocarbon formation) and condensed water (water vapour present within gas/condensate that condenses when brought to the surface). Currently PW (predominantly consisting of condensed water) is piped back onshore to the Pluto LNG Plant for processing, reuse and discharge. Reservoir modelling indicates that formation water and therefore total volumes of PW will increase within the five-year duration of this EP as the reservoir depletes. Forecast volumes will exceed the onshore processing and treatment capacity. A number of options have been considered to dispose of the predicted additional PW. The selected option is installation of, a water handling module on the existing riser platform to treat and discharge PW offshore. Water production from each reservoir is not expected to occur initially as the reservoir ages wells will begin to cut water. It is difficult to anticipate with high confidence when wells will begin to produce water from each reservoir.

Separation of water from reservoir fluids is not 100% effective and therefore, PW often contains small amounts of naturally occurring contaminants including dispersed oil, dissolved organic compounds (aliphatic and aromatic hydrocarbons, organic acids and phenols), inorganic compounds (e.g. soluble inorganic chemicals or dissolved metals) and residual process chemicals (including MEG on a non-routine basis). Potential environmental impacts of PW discharge include changes in water quality, sediment quality and biota potentially reducing ecosystem integrity. The ratio of PW to hydrocarbon and therefore volume of PW each well produces is expected to increase over the field life. It is difficult to anticipate with high confidence when the volumes will require offshore discharge but is predicted to commence in 2021. The maximum possible daily discharge is 3500 m^3/day (constrained by process equipment capacity); actual discharge rates during the Petroleum Activities Program fluctuate in line with production rates however are expected to be well below the maximum capacity. Note that prior to commissioning of the water handling module, no PW will be discharged; therefore, this impact and associated requirements would not be applicable.

Monitoring and Management Framework

Overview

This section describes the monitoring and management framework for PW discharges that has been developed to support the monitoring of PW discharges from offshore assets. In the absence of any Commonwealth guidelines, the State waters Technical Guidance: Protecting the quality of Western Australia's marine environment (EPA, 2016) has been considered and is consistent with the principles of the National Water Quality Management Strategy.

Environmental values are defined as particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and that require protection from the effects of pollution, waste discharges and deposits (ANZECC & ARMCANZ, 2000). The relevant environmental values considered are:

- ecosystem integrity – maintaining ecosystem processes (primary production, food chains) and the quality of water, biota and sediment.
- cultural and spiritual – in the absence of any specific environmental quality requirements for protection of this value, it is assumed that if water quality is managed to protect ecosystem integrity, this value is achieved in line with the guideline.

The relationship between key elements of ecosystem integrity, indicators and relevant monitoring activities undertaken on a routine and non-routine basis are shown in **Figure 12-5**. As per EPA guideline (2016) key elements to maintain ecosystem integrity have been identified as water quality, sediment quality and biological indicators (biota). By limiting the changes to these key elements to acceptable levels there is high confidence ecosystem integrity is maintained. For each of these elements an indicator has been identified and monitoring designed to identify changes. Monitoring changes in water quality and sediment quality as well as investigating potential toxicity via WET testing and implementing management to maintain acceptable levels of changes is standard industry practice in Commonwealth and State waters. The relevant indicators to understand changes in key elements and therefore potential for impact to ecosystem integrity are physio-chemical stressors; toxicants in water; biological indicators and toxicants in sediment. A number of trigger values for each indicator have been defined and are monitored to detect changes. Trigger values serve as an early warning that potential changes beyond the acceptable limits may occur. Further investigation is then required to confirm whether there is potential to exceed the acceptable limit of change. An approved mixing zone protects 99% of species, as calculated using the ANZECC/ARMCANZ (2000) statistical distribution methodology on the results of direct toxicity assessment using sub-lethal chronic endpoints. The protection of 99% of species maintains a high level of ecological protection and represents no detectable change from natural variation (as per ANZECC/ARMCANZ (2000)).

The approved mixing zone boundary for the facility is 1300 m. The justification for these limits of change being “acceptable” is provided in the impact assessment section.

Given the proximity of the discharge point to the Montebello Marine Park Multiple Use Zone (~400 m from the facility) the acceptable limit at the boundary of the Multiple Use Zone is to protect 95% of species, as calculated using the ANZECC/ARMCANZ (2000) statistical distribution methodology on the results of direct toxicity assessment using sub-lethal chronic endpoints. The ANZECC/ARMCANZ (2000) guidelines state “a 95% level of protection, should be sufficient to protect the ecosystem.”

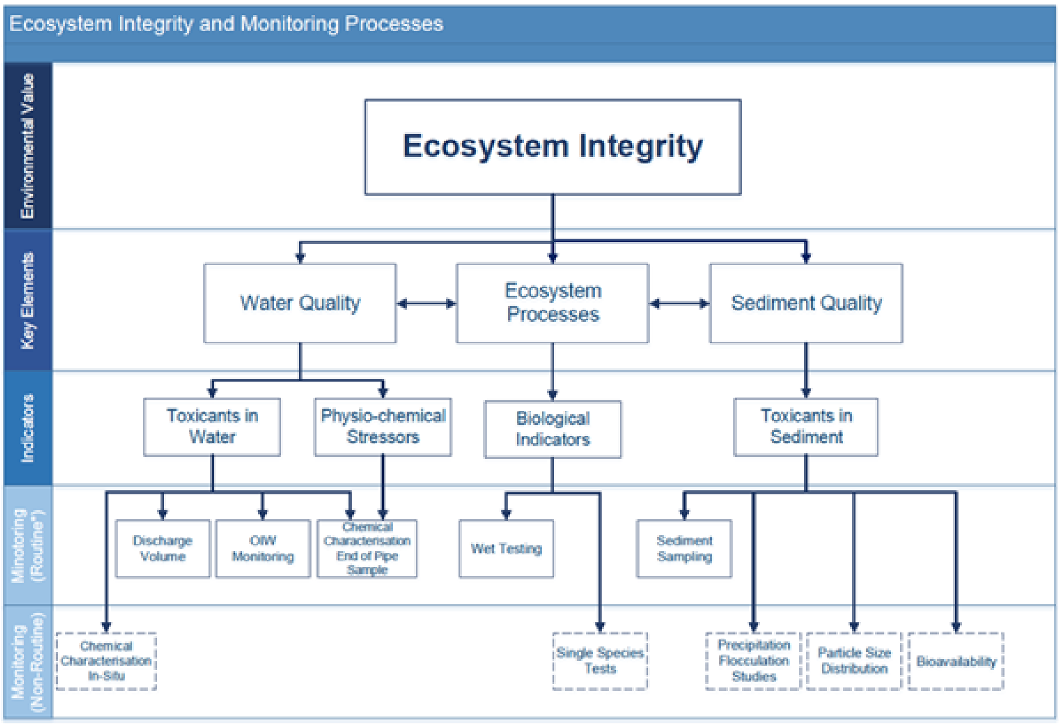

Figure 12-5: Ecosystem integrity and monitoring process

Operational Monitoring

OIW monitoring during routine operations is undertaken via an online analyser. Online analyser information is sent via transmitter instantaneously and reported to the control system (CS) and is also captured within the process historian database (PHD). The CS facilitates visibility in the Pluto onshore control room, for manual or automated process control changes to be made, and/or annunciate alarms (e.g. high oil in water specification). PHD information is available onshore for analysis and trending. During each intervention visit approximately eight-weekly basis or six times per year operators manually sample PW and undertake manual analyser QC checks either at the onshore lab or on the facility. The exact methods are still subject to design and the development of operating procedures.

Any discrepancies that are identified between instrument readings and CS/PHD that are outside of expected tolerance are investigated to determine the cause.-Two analysers are planned to be installed on the facility. If an analyser is faulty or breaks down, any anomalies that are identified are investigated to determine the cause and may be addressed by corrective maintenance during the next intervention visit.

Loss of Signal Management

If there is a loss of signal from both OIW analysers, operators attempt to troubleshoot remotely and monitor process stability for changes. If analysers cannot be restored and there are no observable changes to a stable operating process, low water cut, and high confidence of results below 30 mg/L, the next intervention visit will include reinstatement of the analyser operation if the next planned intervention is within seven days. If the next planned intervention is greater than seven days away, a 'react' visit takes place to repair the analysers.

If there is a lack of certainty around results risking OIW measurements exceeding 30 mg/L for more than six consecutive hours, and a risk of OIW exceedance (24-hour rolling average) is anticipated, the asset may undertake a 'react' visit via helicopter to verify results. A react visit if required is deployed to the platform within 16 hours, weather and time-of-day permitting.

High OIW Management

If the analyser is online and the OIW measurement exceeds 30 mg/L for more than six consecutive hours, and the risk of OIW exceedance (24-hour rolling average) is anticipated, the asset may undertake a 'react' visit via helicopter to verify results. A react visit if required will be deployed to the platform for the visit within 16 hours, weather and time-of-day permitting.

For both Loss of Signal and High OIW Management, Woodside will develop a Standard Operating Procedure, similar to the equivalent procedure for NNM Angel Platform. It will display decision criteria to allow clear interpretation and facilitate compliance with OIW standards. Any EPS breaches are reported as Recordable Incidents.

Baseline Monitoring

As per EPBC Act condition requirements for the Pluto Gas condensate field (EPBC 2006/2968, condition 1(c) ii), Woodside will undertake a baseline monitoring program which will include water, sediment, biological and physical monitoring. As PW has not been discharged from the riser platform previously, baseline monitoring as described in **Table 12-17** is proposed. Results collected as part of the baseline monitoring will be used to identify pre-existing variability. and assist in confirming recovery of environmental quality if an impact has occurred. The assessment would typically be used to decide whether ambient conditions meet the guidelines prior to discharge of PW. If levels of contaminants in water/sediment quality do not meet the guideline values during baseline sampling, a review of quality assurance and quality control, methodology and possible sources of contamination is undertaken to determine if the results are reliable, or if any factors have occurred that may compromise the integrity of the monitoring or data. If baseline data are higher than relevant guidelines a review would be undertaken to determine if values for routine monitoring are appropriate, site specific guideline values should be derived or if other monitoring studies would be utilised.

Field monitoring is undertaken in accordance with a sampling and analysis plan that details timing, locations and objectives of monitoring. Baseline information is gathered using a gradient approach from the platform with sites within the approved mixing zone and beyond the boundary of the approved mixing zone (including sites within the Marine Park). The use of a gradient approach is consistent with the approach for routine and non-monitoring at Woodside's offshore facilities and sampling will include consistent methods and analytes to provide comparable data sets. A gradient sampling design removes the problem of selecting a reference site and temporal impacts, while being more powerful at detecting changes due to disturbances (Ellis and Schnieder 1997). Indicators selected for baseline monitoring are aligned with Figure 12-5.

Table 12-17: Baseline monitoring

Indicator	Baseline Monitoring	Description
Toxicants in water Physio chemical stressors.	Chemical characterisation insitu (water)	Collect data that represents existing levels of toxicants and physio-chemical properties in the water column for comparison against guidelines.
	Water column profiling (physical)	Collect data on the physical characteristics of the water column to identify features (thermoclines, haloclines) that may affect mixing.
Biological Indicators	Drop Camera (biological)	Confirm that benthic habitat is typical of the NWS shelf and well represented by other surveys in the vicinity the platform both within the approved mixing zone and the Montebello Multiple Use Zone.
Toxicants in Sediment	Sediment sampling (sediment)	Collect data that represent existing levels of toxicants and physio-chemical properties in the sediment for comparison against guidelines.
	Particle Size Distribution (physical)	Collect data on the physical characteristics of the seabed to identify features that may affect accumulation.
	Bioavailability (if required)	Sample collected during sediment sampling should be of sufficient volume that further analysis can be completed if required.

Other indicators as proposed by the EPA 2016 guideline were considered: specifically, biodiversity, abundance and biomass of marine life. These indicators are subject to temporal variation therefore should this information be collected during baseline and post discharge comparison would not provide clarity on whether variation was natural over time or as a result of petroleum activities. Should routine monitoring indicate potential for impact, the OMDAMP defines further investigations (described below) that may be undertaken. Field monitoring using a gradient approach is effective post discharge in comparing biodiversity, abundance and biomass in contaminated and non-contaminated areas without being subject to temporal variation. Therefore, it is not proposed to monitor these indicators during baseline.

As stated in the EPA guideline (2016) for a discharge with a known dilution gradient around an outfall, and where baseline concentrations have been accurately quantified, it may be more cost effective to measure concentrations of the contaminants of concern in the wastewater and then calculate the expected concentrations of the contaminants at the boundaries of the surrounding zones, using the predicted worst case dilution factor, to determine compliance. A field validated model has been used to derive dilutions at a range of distances from the platform, hence, the baseline monitoring program above focuses identifying existing levels of toxicants in the water column and sediment.

Consultation was undertaken with the Director of National Parks (DNP) as described in Section 7. DNP will be notified at least 10 days prior to monitoring activities occurring within the Montebello Marine Park, and on conclusion of those activities. Woodside will provide DNP with baseline monitoring results from within the marine park.

Initial Monitoring

Initial samples of PW will be collected during the first intervention visit after reaching steady state conditions (at the end of the commissioning, optimisation and validation period, as defined below) when the facility is operating (i.e. not during shutdown conditions) to characterise the discharge stream. PW samples should represent normal operations, so sampling should only be undertaken during periods of normal production for the facility. Sampling should as far as reasonably practicable provide a representative sample. Representative samples are taken at a time when all PFW-producing wells are online (or as many as reasonably possible) with a consideration of chemicals that may be present in the discharge stream. Monitoring includes the following:

- Chemical characterisation to identify if toxicants with the potential to bioaccumulate exceed the 80% species protection guideline value at end of pipe. If toxicants with the potential to bioaccumulate are predicted to exceed guideline values at end of pipe further investigations are required as described in the monitoring and management framework.
- WET testing will be conducted (in parallel with chemical characterisation) to verify 99% species protection safe dilutions for comparison with the approved mixing zone. If 99% safe dilutions are not predicted to be achieved at the boundary of the approved mixing zone, further investigations are required as described in the monitoring and management framework.
- If 99% safe dilutions are not predicted to be achieved at the boundary of the marine park, further investigations are required as described in the monitoring and management framework. WET testing will be conducted (in parallel with chemical characterisation) to verify 95% species protection safe dilutions for comparison with the Marine Park boundary.
- Settling velocity and particle size distribution analysis will be conducted updated to ascertain the potential for contaminants to flocctuate and settle out of solution and impact sediment quality. The results of these studies will inform if non-routine sediment sampling is required prior to the next routine monitoring event.

Quarterly chemical characterisation and single species testing (initial sampling plus three events) is proposed during the first 12 months after reaching steady state conditions, to develop a robust understanding of variability in effluent toxicity. Results of chemical characterisation and single species toxicity tests will be compared against Offshore Marine Discharges Adaptive Management Plan[4].OMDAMP trigger values. Exceedances of trigger values require further investigation including multiple lines of evidence. Further investigations confirm the trigger value has been exceeded, a review of single species testing is conducted and if required additional WET testing. The single species test proposed is bacteria (Vibrio fischeri, Microtox® luminescence 5-min) this test is consistent with other Woodside PW discharging facilities and targets the lowest trophic level and most sensitive species. Initial monitoring will be conducted in accordance with the OMDAMP and where appropriate routine monitoring triggers, methodologies and standards applied (e.g requirements for WET testing) to ensure consistency and comparability of data.

Routine Monitoring

PW is monitored and managed in accordance with the OMDAMP. The OMDAMP details trigger values, routine monitoring assessment against trigger values, analytical methods and actions when a trigger value is exceeded.

The trigger values are applied through a risk-based approach that is intended to capture any uncertainty around the level of impact by staging monitoring and management responses according to the degree of risk to ecosystem integrity. The approach provides a level of confidence that management responses are not triggered too early (i.e. when there is no actual impact) or too late after significant or irreversible damage to the surrounding ecosystem” (EPA 2016). Routine monitoring applicable to the facility, is undertaken to compare against trigger values (described in **Table 12-18**).

[4] The OMDAMP is reviewed annually. As such, it is important to note the OMDAMP information presented in this EP is subject to update to reflect new methodologies and adaptive management. Any changes in the OMDAMP are subject to the Change Management requirements.

Unacceptable changes in water quality can be detected early and can indicate the potential for an impact prior to it occurring. WET testing confirms if there is a potential for impact on biota. It is not appropriate to monitor for changes in species composition, diversity, etc., as there are limited receptors in the direct impact zone (a surface buoyant plume), Such changes may be detected after an impact occurs, and therefore are not considered appropriate for early detection.

PW samples should represent normal operations, so sampling should only be undertaken during periods of normal production for the facility. Where possible, samples are taken at a time when all PFW-producing wells are online (or as many as reasonably possible) with a consideration of chemicals that may be present in the discharge stream. The WET tests are undertaken on a broad range of taxa of ecological relevance for that accepted standard test protocols are well-established. WET tests are mainly focused on the early life stages of test organisms, when organisms are typically at their most sensitive to contaminants and are designed to represent local trophic level receptors. A minimum of eight toxicity tests are carried out with each PW sample during WET testing. The toxicity tests include a range of tropical and temperate Australian marine species and are selected based on their ecological relevance, known sensitivity to contaminants, availability of robust test protocols and known reproducibility and sensitivity as test species for assessing PW in marine environments. Specific tests are listed in the OMDAMP however other tests can be exchanged over time if tests are not available, or become obsolete, however, preference would be for tests that mimic the receiving environment as closely as possible (i.e. for most facilities this would be tropical, marine water tests) and for at least eight mainly chronic tests (Warne et al. 2015). The dilutions required to protect 99% and 95% of species is calculated using the ANZECC/ARMCANZ (2000) statistical distribution methodology on the results of direct toxicity assessment using sub-lethal chronic endpoints. The protection of 99% of species maintains a high level of ecological protection at the boundary of the approved mixing zone. The protection of 95% of species at the boundary of the Montebello Marine Park protects ecosystem integrity.

Woodside samples sediment at facilities every six years; therefore, the next routine sampling event is planned for 2026 and is outside the scope of this EP. Routine sediment sampling is not included in this revision of the EP as baseline monitoring will include sediment sampling prior to discharge (in 2020) and steady state discharge of PW will occur in 2021 at the earliest. The next routine monitoring event will be undertaken in parallel with other facilities in 2026. Given the maximum discharge period under this EP is approximately three years or less and the lack of PW benthic impacts detected at other Woodside facilities which have been discharging for many years, additional sediment sampling is not considered to provide additional benefit. Settling velocity and particle size distribution analysis is proposed as part of the initial monitoring of representative discharge to confirm potential for sediment impacts. Results of these studies will inform if non-routine sediment sampling is required prior to the next routine monitoring event in 2026.

Table 12-18: Trigger values used during routine monitoring

Routine Monitoring	Trigger Value	Frequency
Chemical characterisation End of pipe sample – toxicants	Results that are predicted to be higher than the 99% species protection guideline value at boundary of approved mixing zone. Results from the earlier toxicity year or above the toxicity year when no guideline value as available.	Annual.
	Results that are predicted to be higher than the 95% species protection guideline value at boundary of the marine park. Results from the earlier toxicity year or above the toxicity year when no guideline value was available.	Annual if 99% safe dilutions are not achieved by the boundary of the marine park
	Toxicants with the potential to bioaccumulate are predicted to be higher than the 80% species protection guideline value at end of pipe	Annual if initial monitoring indicates 80% guideline values for toxicants with the potential to bioaccumulate are not met at end of pipe.
Chemical characterisation End of pipe sample – physio chemical	Results that are predicted to be higher than the 99% species protection guideline value at boundary of approved mixing zone.	Annual.

WET testing	The 99% species protection safe dilutions derived from the WET testing species sensitivity distributions are not predicted to be achieved at boundary of approved mixing zone.	Three yearly. Conducted in parallel with annual chemical characterisation
	The 95% species protection safe dilutions derived from the WET testing species sensitivity distributions are not predicted to be achieved prior to the boundary of marine park zone.	Three yearly. Conducted in parallel with annual chemical characterisation if 99% safe dilutions are not achieved by the boundary of the marine park.
Review of continuous operational monitoring results	Increases in the average monthly OIW concentration by 5 mg/L for more than six consecutive months or by 10 mg/L for two consecutive months.	Monthly.
Discharge volume	Monthly mean discharge volume is equal to or below level required to meet approved mixing zone based on WET testing.	Monthly review.

Note: earlier toxicity year means the year in which the most recent WET test occurred.

If a trigger value is not met, it triggers uncertainty around whether the environmental value is being protected and further investigation is required (**Figure 12-6**).

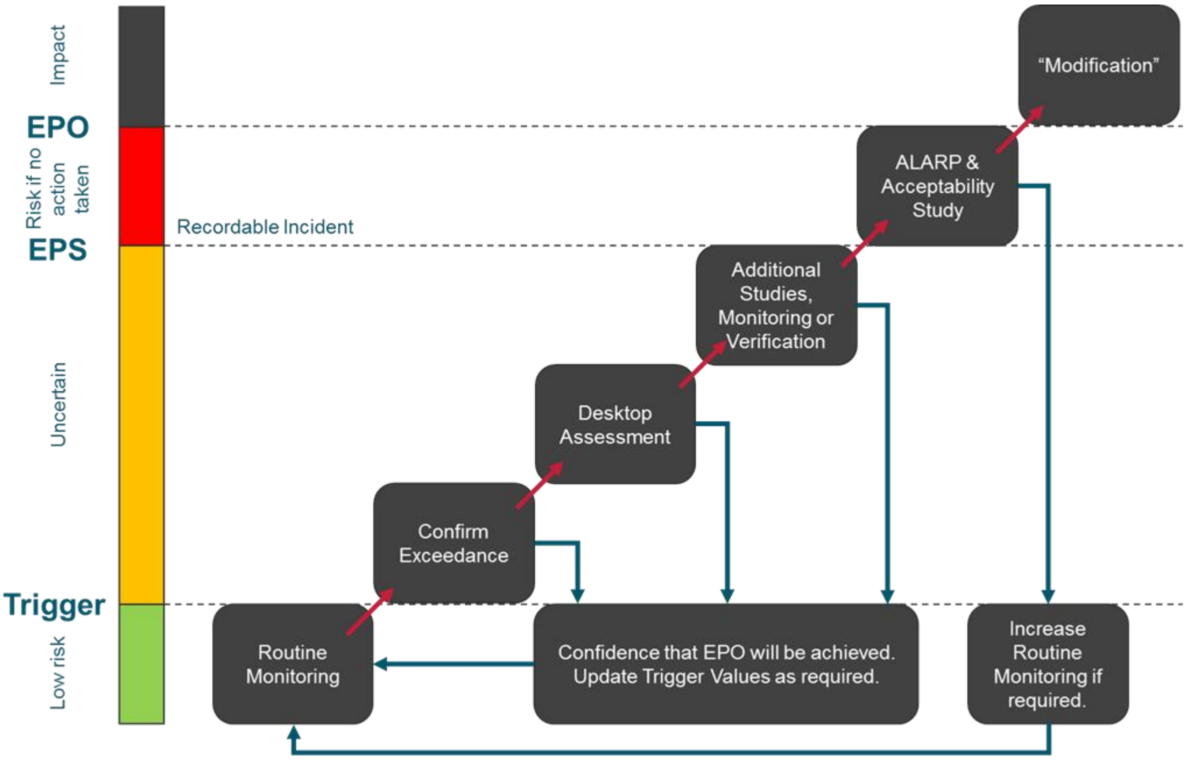

Figure 12-6: Routine monitoring and adaptive management framework for produced water

Further Investigations

Detectable exceedances in trigger values may occur without impacting ecosystem integrity. To provide confidence that ecosystem integrity has been achieved, further investigation will be required in the form of a desktop study to initially assess the exceedance in context of available data (multiple lines of evidence) and confirm if there is potential for impact to the environmental value. A desktop assessment is necessary before undertaking any additional infield monitoring. This ensures monitoring programs are designed and implemented to provide robust findings based on good survey design.

A range of methods can be used to detect trigger value exceedances (e.g. relative percentage difference, control charts, multivariate analysis, etc.) depending on the dataset available. An appropriate method is selected as described in the OMDAMP due to the variable nature of environmental data. If critical data is not available, the desktop study will identify potential data gaps and may recommend additional non-routine studies and/or monitoring to ensure the assessment is appropriately undertaken. The purpose of the 'further investigations' step is to provide certainty that the EPS has been achieved, if a trigger value has been exceeded. The key investigation steps are described below:

1. **Confirm the trigger value has been exceeded** – Review quality assurance and quality control, methodology and possible sources of contamination to determine if the results are reliable, or if any factors have occurred that may compromise the integrity of the monitoring or data.
2. **Desktop assessment to understand whether the EPS is at risk** – If a trigger value is confirmed to be exceeded, multiple lines of evidence are considered including historical and current data from routine and non-routine monitoring and studies. This assessment shall consider whether there is adequate evidence to demonstrate that acceptability criteria have been met and ecological integrity is not at risk (EPS not breached). If the desktop assessment determines that the existing body of evidence is insufficient, it shall outline what additional monitoring or studies are required. The desktop assessment is needed before undertaking all additional infield monitoring. It ensures monitoring programs are designed and implemented to provide robust findings based on good survey design. Potential additional monitoring/studies may include but is not limited to:
   - single species test (collected annually in parallel with routine chemical characterisation should further investigation be required)
   - dilution modelling and or studies
   - settling velocity analysis
   - metal bioavailability
   - scanning electron microscopy and particle size distribution analyses
   - in-situ water quality chemical characterisation.

   Routine monitoring activities may be required ahead of schedule and additional monitoring not listed (including benthic may be undertaken as appropriate. Field monitoring (routine and non-routine) is undertaken in accordance with a plan that details timing, locations and objectives of monitoring.
3. **Conduct additional studies to confirm the EPS is not at risk** – Monitoring results provide additional lines of evidence to determine whether there is a risk to ecosystem integrity due to unacceptable changes in water quality sediment, or biological indicators. Given the significant health, safety and technical risks, monitoring of the receiving environment is typically only considered when all other sources of evidence are insufficient to demonstrate that ecological integrity is not at risk. The OMDAMP provides detailed guidance on the steps and actions required to be undertaken if a trigger value is exceeded and this may include additional non-routine monitoring to verify that ecological integrity is maintained.

If environmental impact is deemed to be within acceptable limits of change the desktop assessment may consider a review of trigger values to ensure they are appropriate. If potential impacts to ecosystem integrity outside of the acceptable limits are identified, there is potential to impact ecosystem integrity; an ALARP/ Acceptability Study is required to determine what additional controls can be implemented to ensure the impacts are not realised. An EPS breach is a Recordable Incident, that is reported and managed.

ALARP/Acceptability Study

An ALARP/Acceptability study is conducted once it has been determined, as a result of further investigations, that there is potential for an impact that exceeds the acceptable limits of change. The ALARP/Acceptability study shall be conducted in accordance with the ALARP Demonstration Procedure, to determine additional controls that may be necessary to reduce the potential impacts. Additional management measures (controls) may include technology or process upgrades, reservoir management. Woodside will implement the additional controls identified in the ALARP/Acceptability study, that are required to give confidence that the acceptable limits on environmental impact can be achieved. Field validation of model assumptions, and additional monitoring to assess whether impacts have been realised using a gradient monitoring design, will be considered.

Impact Assessment

Potential impacts of PW discharge include:

- changes to water quality
- toxicity to biota
- changes to sediment quality.

To understand potential impacts from PW discharges, Woodside has undertaken a suite of comprehensive in-situ testing and sampling representing long-term operational periods from its offshore production facilities and has committed to sampling at Pluto prior to and after discharge. The details of this testing and resultant understanding of potential environmental impacts are outlined below.

Potential Impacts to Water Quality

Potential impacts to water quality are to be assessed through chemical characterisation of PW and monitoring of ongoing discharge volumes. Variability is managed via the Monitoring and Management Framework.

Although reservoir fluids are available from the current production at the Pluto LNG Plant onshore, these are not deemed to be representative of PW characteristics at the offshore facility. The export trunkline transports hydrocarbons, condensed water and rich MEG to the Pluto LNG Plant onshore. There is significant difference between the natural compositions of PW associated with the reservoir compared to that condensed from the gas. Condensed water has low levels of dissolved salts while PW from the reservoir contains high levels of salts. The presence of residual process chemicals further complicates any comparisons between onshore and offshore PW. Given the natural difference onshore PW samples are deemed to not be representative for the purposes of this assessment. It is not possible to collect a sample of PW that is representative of the discharge prior to treatment facilities operating.

The discharge stream is expected to comprise primarily of PW from the Pluto reservoir. No PW is anticipated from the Pyxis reservoir and minimal volumes are anticipated from Xena reservoir. Naturally Occurring Radioactive Materials (NORM's) have not been detected previously. Given PW will continue to be primarily from the Pluto reservoir increased NORMs are not expected and increased monitoring above that described in **Unplanned Discharges: Hazardous and Non-hazardous Waste Management** is not proposed.

Woodside has successfully managed impacts from PW from six facilities via the OMDAMP and intends to implement this Monitoring and Management Framework to manage variability in PW at this facility.

Chemical Characterisation of PW (Physio-chemical and Toxicants in Water)

During appraisal drilling for the Pluto project, samples of the formation water were obtained from three wells at various locations and depths within the reservoir with trace elements measured from each well in order to establish a basis for the process design (**Table 12-19**). The reported concentrations of metals **(Table 12-20**) were based on the highest levels measured from any of the three wells sampled (two Pluto, one Xena). The concentrations of metals within the three wells were highly variable. Metals with the potential to bioaccumulate (e.g. lead, mercury) were an order of magnitude lower in the other two wells compared to the worst case well used for the basis of design. Mercury concentrations measured from the three wells were 0.03, <0.002 and 0.00 mg/L. Lead concentration measured from the three wells were 0.11, 0.03 and <0.02 mg/L. During routine operations a number of wells will be produced at any given time therefore the produced water will be comprised of formation water from a number of wells. The maximum toxicant concentrations from a single well will be diluted by wells with lower concentrations resulting in lower concentrations prior to discharge. Therefore, it is expected that lower concentrations will originate in the produced water than presented in **Table 12-20** and that these lower concentrations will be below the guideline values. The formation water will also be diluted by condensed water in the process further reducing concentrations. There have been no further opportunities to analyse PW from the reservoir to date. Dilutions to reach ANZECC 99% species protection guideline values are provided where applicable. No ANZECC guideline values are available for the ions listed within **Table 12-19**, as such dilution requirements are not listed.

Table 12-19: Pluto Development Basis of Design Data Predicted PW Characteristics

Ions	Concentration (mg/L)
Calcium	125
Magnesium	22
Iron, Fe (Soluble)	2
Sodium	6960
Potassium	1000
Strontium	15
Barium	28
Chloride	10434
Sulphate	10
Bicarbonate	1303
Acetate	1259
Organic Acid	500

Table 12-20: Pluto Development Basis of Design Reservoir Metal Characteristic Concentrations. Values exceeding ANZECC/ARMCANZ 99% species protection guideline values for marine water shaded in grey

Metal and Metalloid	ANZECC Guideline Value (mg/L) [a]	Concentration Range (mg/L)		Dilutions Required to achieve 99 % guideline value based on High Concentration
		Low	High	
Silver	0.0008 (mod)	-	< 0.02	0–25
Aluminium	0.0021 [b]	0.46	7. 23	3443
Arsenic	[c]	< 0.008	0.08	-
Cadmium	0.0007 (high)	< 0.001	0.01	14.32
Chromium	0.0077 (III) (moderate) 0.00014 (VI) (high)	< 0.02	0.07	16500
Cobalt	0.001 (very high)	0.01	0.10	100
Copper	0.0003 (very high)	0.26	1.30	866–4333
Manganese	0.13 [d]	0.03	2.00	15
Nickel	0.007(high)	0.48	2.98	426
Lead	0.0022 (low)	0.03	0.11	50
Zinc	0.007 (very high)	0.54	0.66	94
Mercury	0.00014 (very high)	< 0.002	0.03	214
Selenium	c	-	0.06	-

a 99% species protection guideline value (ANZECC/ARMCANZ 2000) ranking of moderate and high reliability is shown in parenthesis.
b Golding et al. (2015) and draft submission paper to the Council of Australian Government's Standing Council on Environment and Water (SCEW).
c No guideline value or low reliability guideline value only available.
d Draft submission paper to the Council of Australian Government's Standing Council on Environment and Water (SCEW 2014).

The metal concentrations in the PW of the other Woodside offshore facilities are either lower than the ANZECC/ARMCANZ (2000) 99% species protection guideline values or between the 99% and 95% species protection guideline values at end of pipe. However initial monitoring is proposed to confirm toxicants with the potential to bioaccumulate are below 80% species protection at end of pipe.

The composition of PW is complex and may consist of additional components such as volatile aromatic compounds Benzene, Toluene, Ethylbenzene, Xylenes (BTEX) and Polycyclic Aromatic Hydrocarbons (PAHs), concentrations of which vary throughout the field life. The composition of PW will be verified by initial monitoring.

There is potential for slight, localised decrease in water quality at the discharge location and within the mixing zone with potential adverse effects on marine biota. Within the approved mixing zone impacts to pelagic fish are expected to be limited to avoidance of the localised area of the plume and short-term, localised decline in planktonic organisms in the immediate vicinity of the discharge plume.

Discharge Volumes

The maximum expected discharge rate is 3,500 m^3/day (integrity limit). The average daily PW discharge rate is expected to be significantly less than the maximum rate as demonstrated on other Woodside facilities. However, as the total volume of PW is expected to increase as the field ages, environmental impacts have been assessed against maximum expected discharge rates.

Residual Process Chemicals

Residual process chemicals may be present in the PW stream. Process chemicals are subject to Woodside's chemical selection and approval process. The largest chemical by volume, MEG is rated OCNS Group E (lowest hazard) and is considered PLONOR. Chemicals will decrease the water quality in the immediate area of the release (i.e. surface waters at the release location); however, the consequence is expected to be temporary and localised due to dilution with the PW stream and the open ocean mixing environment, distance from sensitive receptors and relatively low volumes. Depending on the chemical released, the toxicity and/or potential to bioaccumulate may potentially result in impacts to sediment quality, pelagic fish or other marine species in the vicinity of the discharge.

Potential Impacts to Biological Indicators

Upon achieving steady state PW processing, chemical characterisation and WET testing of the PW will be completed in order to establish actual toxicity and to verify the approved mixing zone as per **Table 12-20**.

WET Testing

Most treated PW has low to moderate toxicity (Neff et al. 2011), with actual toxicity of discharge dependant on the chemical constituents of the PW and any added process chemicals, the level of treatment and dilution with condensed water prior to release, and the dilution of the discharge as it mixes with sea water. Most hydrocarbons in PW are considered non-specific narcotic toxins with additive toxicities; therefore, the toxicity of a PW will, in part, depend on the total concentration and range of bioavailable hydrocarbons (Neff, 2002).

WET testing is undertaken to allow for interactions between toxicants and take into account toxicants that cannot readily be measured or are not known to be present in the sample. For the WET testing a range of tropical and temperate Australian marine species are selected based on their ecological relevance, known sensitivity to contaminants, availability of robust test protocols, and known reproducibility and sensitivity as test species.

The results are combined by plotting a species sensitivity distribution to derive safe dilutions (50% confidence), that are calculated from the species protection triggers following the Warne et al. (2015) revised method for deriving ANZECC guideline values for toxicants, to obtain estimates of safe dilution. WET testing conducted on Pluto condensate was found to have a moderate to high chronic aquatic toxicity based on the no observable effect concentrations of the loading rates of each test (GESAMP, 2002). The partitioning of contaminants between PW and condensate is unknown for the Pluto reservoir, therefore using the toxicity of the Pluto condensate as a surrogate for PW discharge is not appropriate. Woodside has extensive operational experience with PW characterisation from gas condensate facilities on the North West Shelf of Western Australia. Actual 99% and 95% species protection safe dilutions will be provided from initial monitoring WET testing to verify the approved mixing zone is being achieved. Recent WET testing data collected in 2017 (**Table 12-21)** from existing operating facilities was reviewed to estimate the 99% species protection safe dilutions and define an approved mixing zone. The dilutions from the Goodwyn platform were used for this assessment, as this facility produces predominantly formation water rather than condensed water.

Table 12-21: Actual 99% species protection safe dilutions at Woodside's other PW discharging facilities

Facility	PNEC concentrations (PC99)
Angel	1 in 164
Goodwyn Alpha	1 in 2,000
North Rankin Complex	1 in 3,130
Okha	1 in 345

Determination of Mixing Zone

The principal aim of the dispersion modelling was to quantify the likely extents of the near-field and far-field mixing zones and therefore the potential impact of the PW to the marine environment. Three modelling methods were integrated to simulate the potential dispersion, an oceanic hydrodynamic model (HDROMAP) for current data, a near-field discharge model (PDS surface discharge model), and a far-field advection and dispersion model (MUDMAP) (APASA, 2017). The dispersion of contaminants will depend, initially, on the geometry and hydrodynamics of the discharge itself, where the induced momentum and buoyancy effects dominate over background processes. This region is generally referred to as the near-field zone and is characterised by variations over short time and space scales. As the discharge mixes with the ambient waters, the momentum and buoyancy signatures are eroded, and the background, or ambient, processes become dominant.

The far-field modelling expands on the near-field work by allowing the time-varying nature of currents to be included, and the potential for recirculation of the plume back to the discharge location to be assessed. The near-field simulations consider steady-state unidirectional currents, while the far-field simulations account for currents that vary in speed and direction over time and space, far field modelling represents minimum dilutions achieved 95% of the time. Validation of the current data used for the modelling was performed using infield current measurements located approximately 30 km to the southwest of the Pluto riser platform location, two point current measurements nearest to the surface, at depths of approximately 10 m and 70 m were used to evaluate the modelled current data. The outcome of the comparison was good agreement at all current speeds, and the modelled data product was suitable for PW discharge modelling. Validation of tidal predictions was performed using the model output and independent predictions of tides. All comparison demonstrated that the model produces a very good match to the known tidal behaviour for a wide range of tidal amplitudes and clearly represents the varying diurnal and semi-diurnal nature of the tidal signal.

The dilution modelling results are based on the maximum design flow rates of 3,500 m^3/day representing the worst-case load to the environment. At lower actual discharge rates, dilutions levels are expected to be achieved closer to the discharge point than those predicted by the modelling due to reduced loading to the environment.

Near Field

Modelling indicated that, irrespective of season, given the elevation of the discharge above the water surface, the plume will initially plunge downward in to the water column creating a turbulent mixing zone. Once the initial jet momentum ceased, the plume would remain sufficiently buoyant to rise to the surface to continue to mix with ambient waters, though at a slower rate. As a result of the mixing during the initial plunge and buoyant rise, the salinity and temperature of the discharge plume are predicted to reach background levels over a short distance.

During low current speeds, the discharge will plunge the deepest (~11.5 m below sea level) and resurface closest to the riser platform (within approximately 10–11 m), with average dilution levels of 1:137–1:142 predicted at the end of the near-field zone. Under medium and high currents, the plunge depth becomes progressively shallower (approximately 7.5 m and 5.5 m below sea level, respectively) due to the increasing deflection of the plume as it enters the water. The subsequent resurfacing of the plume under medium and high currents occurs around 32 m and 63 m from the riser platform discharge location, respectively, regardless of season. Average dilution levels at the end of the near-field zone under medium and high currents are predicted to be 1:235–1:237 and 1:277–1:283, respectively. Under all current conditions, the plume is predicted to resurface and remain in the upper layer of the water column (5–10 m).

Far Field

The far-field modelling for all simulations indicated that the discharge plume would drift horizontally with the currents prevailing in the near-surface layer while undergoing vertical and horizontal dispersion. Variable and patchy concentrations were predicted within the plume, attributable to large variation in current flows past the discharge point. The annual dilutions are provided below in**Figure 12-7**, generally the overall plume footprints were observed to vary between seasons, with a noticeable north t o north-westerly drift during the summer months and a south to south-westerly drift during the winter months. In the transitional months, more variation in the transport patterns was evident.

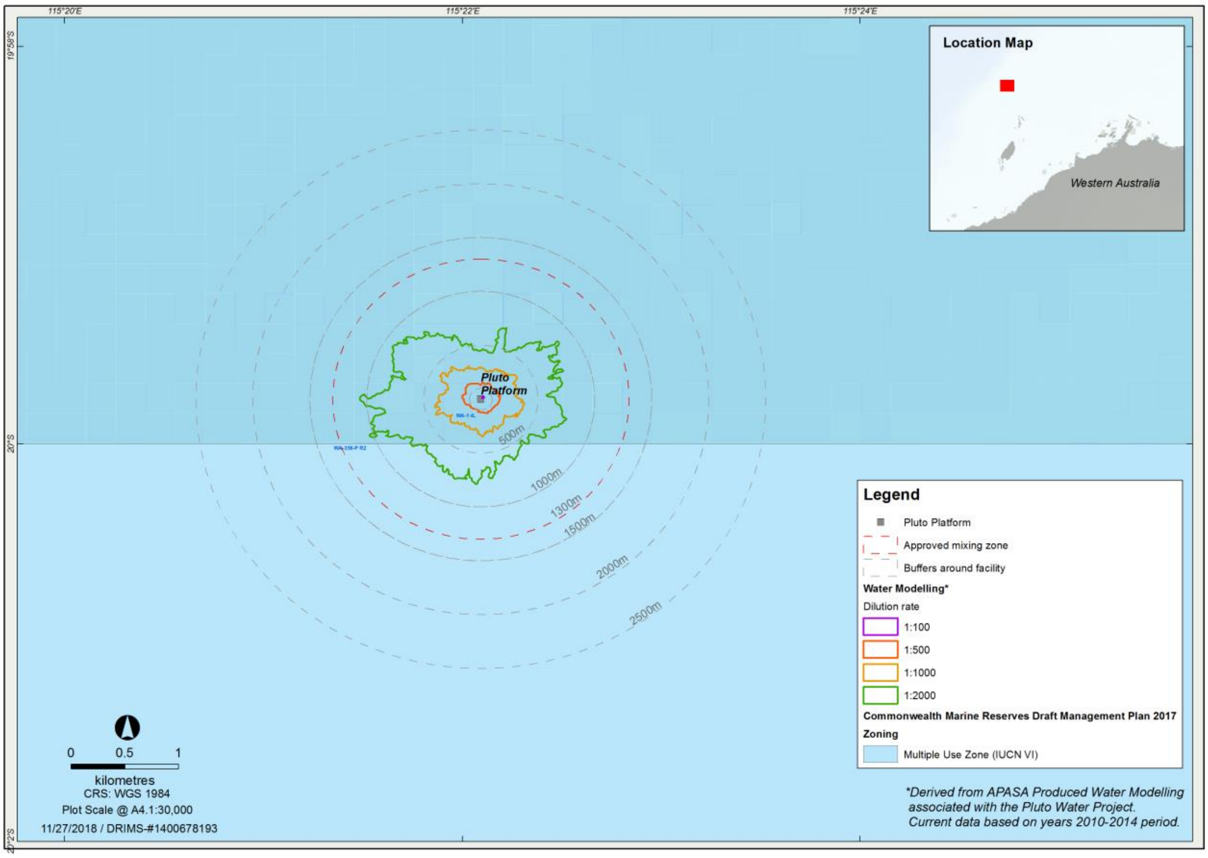

Figure 12-7: Annual dilution contours for a 3,500 m^3 discharge from the Pluto Riser Platform

Modelling shows 2,000 dilutions can be achieved at maximum discharge rates in all conditions at 1300 m; therefore, this has been selected as the approved mixing zone boundary. This approved mixing zone will be reviewed and potentially reduced after results of initial monitoring are received. Additionally, modelling predicts that 95% species protection safe dilutions can be achieved at the AMP boundary under all conditions. PW discharge rates are likely to vary up to a maximum rate of 3,500 m^3 per day throughout field life.

Bioaccumulation

Bioaccumulation refers to the amount of a substance taken up by an organism through all routes of exposure (water, diet, inhalation, epidermal). The Bioaccumulation Factor is the ratio of the steady-state tissue concentration and the steady-state environmental concentration (assuming uptake is from food and water). The test developed to measure the ability of a substance to bioaccumulate, namely, the octanol-water partition (Pow), is based on the preferential partitioning of lipophilic organic compounds into the octanol phase. Partitioning into octanol can be correlated with the attraction for such compounds to the fatty tissue (lipid) of organisms.

Bioaccumulation of BTEX compounds has been observed to occur in the laboratory, only at concentrations far in excess of that discharged from facilities on the NWS (for example refer to Berry, 1980); hence it is unlikely that BTEX would bioaccumulate at the exposure concentrations that may be experienced by biota around the Pluto facility. Baseline characterisation of the PW discharge will verify BTEX levels in the PW from the facility.

In contrast to BTEX compounds, PAH compounds have high Pow values indicative of the potential for bioaccumulation (Vik et al, 1996). Neff and Sauer (1996) based on available literature for laboratory and field studies investigating the bioaccumulation of PAHs. The bioaccumulation values for PAHs in marine organisms collected near PW discharges in the Gulf of Mexico reported by Neff and Saur (1996) indicate that the highest bioaccumulation factor was in the tissues of bivalve molluscs and the lowest in the muscle tissue of fish.

The most comprehensive field study assessing bioaccumulation of hydrocarbons and metals from PW discharged into offshore waters is that by Neff et al (2011). At the request of the United States Environmental Protection Agency (USEPA), the Gulf of Mexico Offshore Operators Committee sponsored a study of bioconcentration of selected PW chemicals by marine invertebrates and fish around several offshore production facilities discharging more than 731 m^3 per day of PW to outer continental shelf waters of the western Gulf of Mexico (by comparison Pluto discharges will be up to 3500 m^3/day). The target chemicals identified by USEPA included five metals (As, Cd, Hg, 226Ra and 228Ra), three volatile Monocyclic Aromatic Hydrocarbons (MAH), benzene, toluene, and ethylbenzene, and four semi-volatile organic chemicals, phenol, fluorene, benzo(a)pyrene, and di (2-ethylhexyl) phthalate. Additional MAH (m-, p-, and o-xylenes) and a full suite of 40 parent and alkyl-PAH and dibenzothiophenes were also analysed by Neff et al (2011) in PW, ambient water, and tissues at some platforms.

Concentrations of MAH, PAH, and phenol as determined by Neff et al were orders of magnitude higher in PW than in ambient seawater. There was no evidence of MAH or phenol being bioconcentrated. All MAH and phenol were either not detected (> 95% of tissue samples) or were present at trace concentrations in all invertebrate and fish tissue samples. Concentrations of several petrogenic PAHs, including alkyl naphthalene's and alkyl dibenzothiophenes, were slightly, but significantly higher in some bivalve molluscs, but not fish, from discharging than from non-discharging platforms. These PAH could have been derived from PW discharges or from tar balls or small fuel spills. Concentrations of individual and total PAH in mollusc, crab, and fish tissues were well below concentrations that might be harmful to the marine animals or to humans who might collect them for food at offshore platforms (Neff et. al., 2011).

It is expected that bioaccumulation is unlikely to result in increased levels of BTEX in biota surrounding the riser platform; however, there may be an elevation in PAH levels. Given the similarity of the chemical characterisation of PW discharges from Woodside facilities to those elsewhere in the world including those in the Gulf of Mexico (Rob Phillips Consulting 2016), the results from Neff et al (2011) can be used to infer the very low potential for adverse bioaccumulation effects to marine organisms, or to humans, if they were to consume any affected fish, molluscs or crabs found on upper near-surface legs of the facility.

The potential environmental impact associated with bioaccumulation of PW constituents in the water column is considered to be slight and a localised effect on a small number of non-threatened species in waters immediately surrounding the facility. The potential risk to fisheries is further reduced to ALARP as a result of negligible exposure given the PSZ that prohibits fishing from or near the platform. Given the nature of the PW discharge from the riser platform, the potential for bioaccumulation of PW contaminants (in particular BTEX) is considered to be minor and restricted to sessile organisms growing on the legs of the platform.

Potential Impacts to Sediment Quality

Toxicants in Sediments

Accumulation of PW contaminants in sediments depends primarily on the volume/concentration of particulates in PW discharges or constituents that sorb onto seawater particulates the area over which those particulates could settle onto the seabed (dominated by current speeds and water depths) and re-suspension, bioturbation and microbial decay of those particulates in the water column and on the seabed.

Baseline sediment surveys will be completed as described in baseline monitoring section prior to the discharge of PW from the riser platform. The benthic habitat within the approved mixing zone is predominantly soft sediment with sparsely associated epifauna, which is broadly represented throughout the NWS Province. Benthic communities of soft sediment are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). Benthic grab sampling in the vicinity of the continental slope region of the Operational Area revealed a sparse abundance, high variability and high diversity of infauna dominated by polychaetes with other fauna including nemerteans and sipunculids and crustaceans (mainly amphipods) (SKM, 2007). Higher, albeit low, infauna density was reported at the shelf break (200 m) compared to deeper areas on the continental slope.

Within the approved mixing zone potential impacts to sediment quality may result in localised impacts to benthic communities. The potential extent of such impacts is extremely small in relation to the extent of the soft sediment habitats that are broadly represented within the Operational Area and the wider NWS Province. As such, impacts to benthic communities are expected to be localised with no lasting effect. There is no history of drilling with oil based muds at the riser platform, it is assumed that contaminants are unlikely to be present in the sediment surrounding the platform.

The PW plume is predicted to be buoyant, due to lower salinity and/or higher temperature than surrounding seawater. Therefore, potential contaminants in the PW discharge may be introduced into sediments around the riser platform through precipitations of soluble contaminants and flocculation and sedimentation of the particles in the PW plume. Studies into potential sediment accumulation from PW discharge have been undertaken by Woodside (Jacobs 2016). The study found that the PW at all facilities had very small amounts of solid material, with very little potential of settling or flocculation due to small particle sizes.

Initial monitoring is described above and includes settling velocity and particle size distribution to confirm potential for precipitation and flocculation.

Dr Graeme Hubbert categorised particulate behaviour based on oceanographic experience and mathematical calculations using settling rates and resuspension velocities for various particle sizes. He determined that particles of a size 1 to 5 μm would never permanently settle out of the water column, and that particles of a size 5 to 40 μm would not permanently settle out of the water column, unless they were in very deep water (> 5000 m) or in areas where hydrodynamic conditions were very weak and did not continuously resuspend the particles.

It is anticipated PW will not impact sediment quality to an unacceptable level; however, this will be verified via initial monitoring and results considered and managed by the OMDAMP. Should initial routine monitoring indicate the potential for impact to sediment quality to an unacceptable level, it will be necessary to undertake further investigations. This may include additional chemical characterisation, sedimentation studies, non routine sediment sampling and/or bioavailability testing.

Impacts to Australian Marine Parks and KEFs

The facility is located 416 m from the boundary of the Multiple Use Zone (IUCN Category VI) of the Montebello Marine Park. This zone is managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species**.**

The approved mixing zone overlaps 0.05% (1.6 km^2 of the 3412 km^2) Multiple Use Zone. Potential to impact the values of the Montebello Marine Park are expected to be very localised and are considered below.

Table 12-22: Values of the Montebello Marine Park

Value	Potential Impact
Ancient Coastline at the 125-m depth contour	The KEF is located approximately 6.5 km from the PW discharge point and is outside of th approved mixing zone (**Figure 12-10**). Modelling predicts the PW will form a buoyant plum extending less than 1,300 m from the discharge point, therefore, no contact and no impac to biological indicators associated with the KEF are expected from the plume. Potential fo impacts are monitored and managed to the approved mixing zone boundary; therefore, no impacts to the KEF situated outside the approved mixing zone are anticipated.
Species including species listed as threatened, migratory, marine or cetacean under the EPBC Act	A number of threatened migratory, marine or cetacean species may be in the approved mixing zone. Species are primarily migratory and are not anticipated to spend long durations within the approved mixing zone. Toxicants are expected to rapidly dilute and ar not considered to cause acute toxicity. By monitoring and managing water quality and sediment quality impacts to the approved mixing zone boundary, no impacts are expected to threatened migratory, marine or cetacean species.
BIA flatback turtle internesting buffer around the Montebello Islands (Oct – Mar)	The Montebello Islands, located approximately 41 km from the PW discharge, are the nearest emergent land and potential nesting habitat (minor) for flatback turtles. During internesting turtles remain close to the nesting beach or rookery (DOEE, 2017). Typically, internesting habitat is located immediately seaward of designated nesting habitat (DOEE, 2017). The approved mixing zone is within the Pilbara flatback turtle 60 km interesting buffer zone (October – March) however given the approved mixing zone is over 40 km fro the nearest nesting beach internesting turtles are not anticipated to remain in the approve mixing zone for prolonged periods of time or in large numbers. Chronic discharge is identified as a moderate risk threat in the Recovery Plan for Marine Turtles for the Pilbara flatback population (DOEE, 2017). Given the localised area of impact, 95% species protection safe dilutions will be achieved by the boundary of the marine park and the distance to nesting habitat no impacts are expected to this value (**Figure 12-9**).
BIA foraging for whale sharks along the 200 m isobath, with seasonally high use (April–June)	The 200 m isobath is located about 17 km outside the approved mixing zone. Given the localised area of impact and that whale sharks are transiting the area, no impacts are expected (**Figure 12-9**).
BIA breeding habitat for seabirds	There is no nesting habitat within the approved mixing zone, therefore aggregations of breeding birds are unlikely to be present in the approved mixing zone. Foraging areas are located outside the approved mixing zone. No impacts are expected to this value (**Figure 12-9**).
BIA pygmy blue whale migration corridor (northern migration April to August; southern migration October to January) from	The pygmy blue whale migration is thought to follow deep oceanic routes (DEWHA, 2008) In the NWMR, pygmy blue whales migrate along the 500 m to 1000 m depth contour on th continental slope where they are likely to opportunistically feed on ephemeral krill aggregations (DEWHA, 2008). Given the BIA is located outside the approved mixing zone and that PW forms a surface buoyant plume, no impacts are expected to this value.

Indonesian Waters to southwest Australia	
Cultural Values	Cultural and spiritual values have been identified by the monitoring and management framework. In the absence of any specific environmental quality requirements for protection of this value, it is assumed that if water quality is managed to protect ecosystem integrity (95% species protection safe dilutions), this value is achieved in line with the EPA technical guideline.
Heritage values	No international, Commonwealth or national listings apply to the Montebello Marine Park currently. The Western Australia Barrow Island and the Montebello–Barrow Island Marine Conservation Reserves are outside of the approved mixing zone and therefore are not predicted to be impacted. Two historic shipwrecks, the Trial and Tanami, are located about 30 km outside of the approved mixing zone and therefore are not impacted by PW (**Figure 12-8**).

Information about the adaptive management program in place to address changes in routine discharge rates and other factors that may alter the assessment of risk is outlined within the OMDAMP. The Montebello Marine Park special protection zone for benthic habitat and sanctuary zone boundaries are located approximately 36 km to the south of the riser platform. As such, there are no impacts anticipated in these zones.

There are no impacts anticipated to the values of the Montebello Marine Park (including natural, cultural, heritage and socio-economic values). Wider water quality and sediment impacts are considered in respective sections above. Discharges are monitored and managed to achieve a 95% species protection safe dilution to protect ecosystem integrity via the OMDAMP at the AMP boundary.

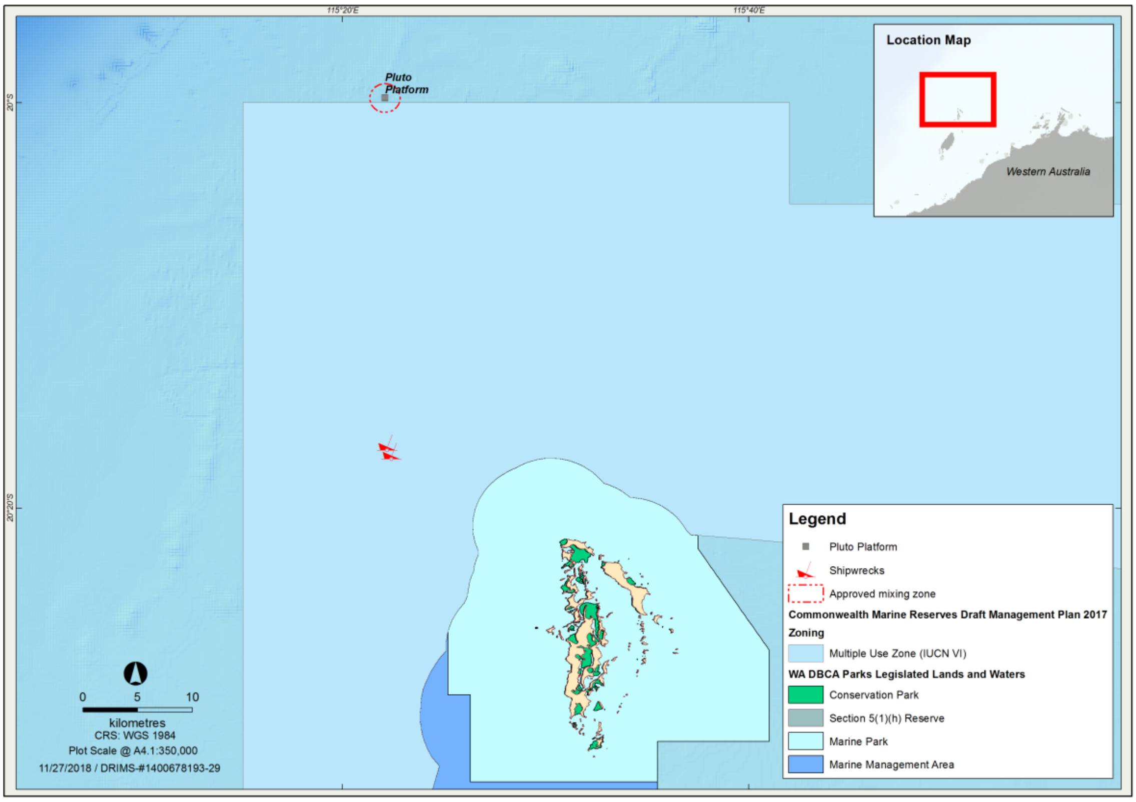

Figure 12-8: Montebello Marine Park Zones and heritage values

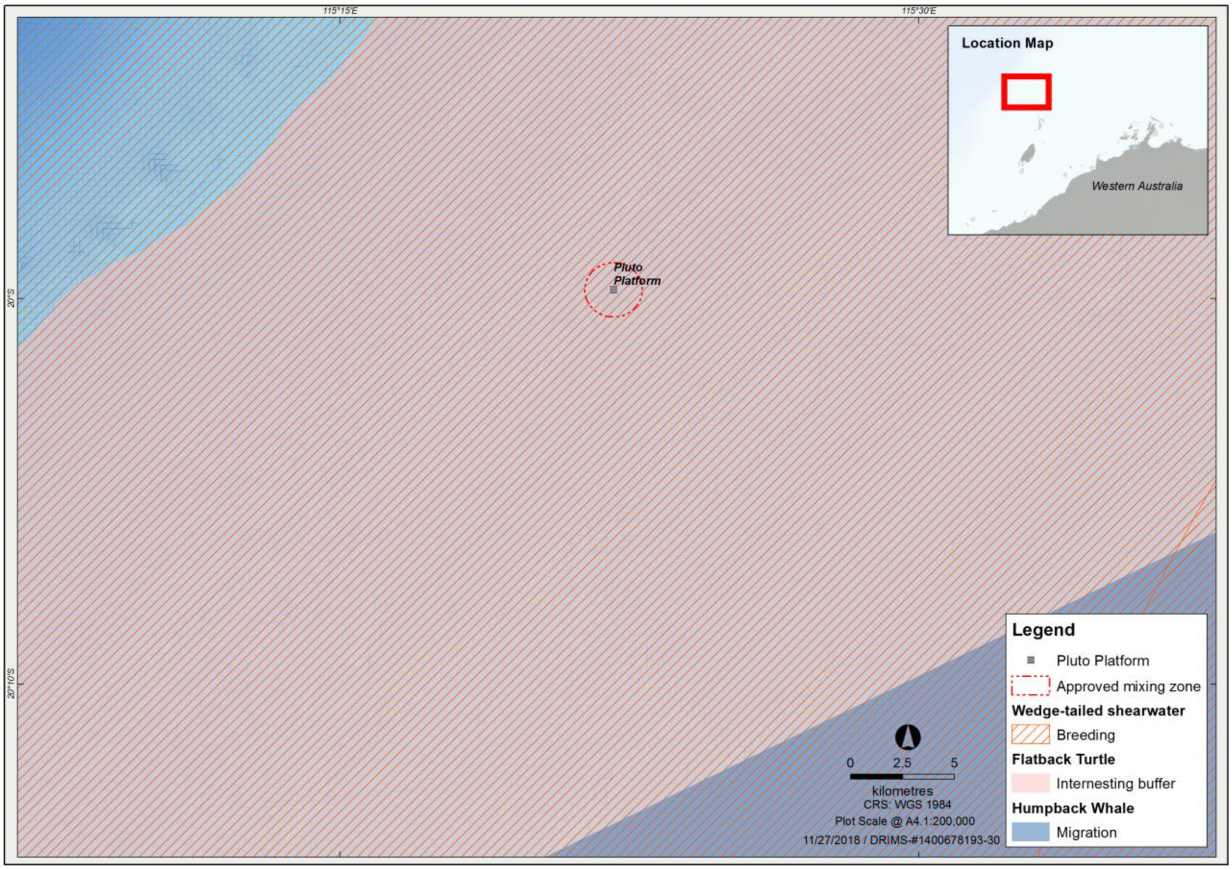

Figure 12-9: Biologically important areas

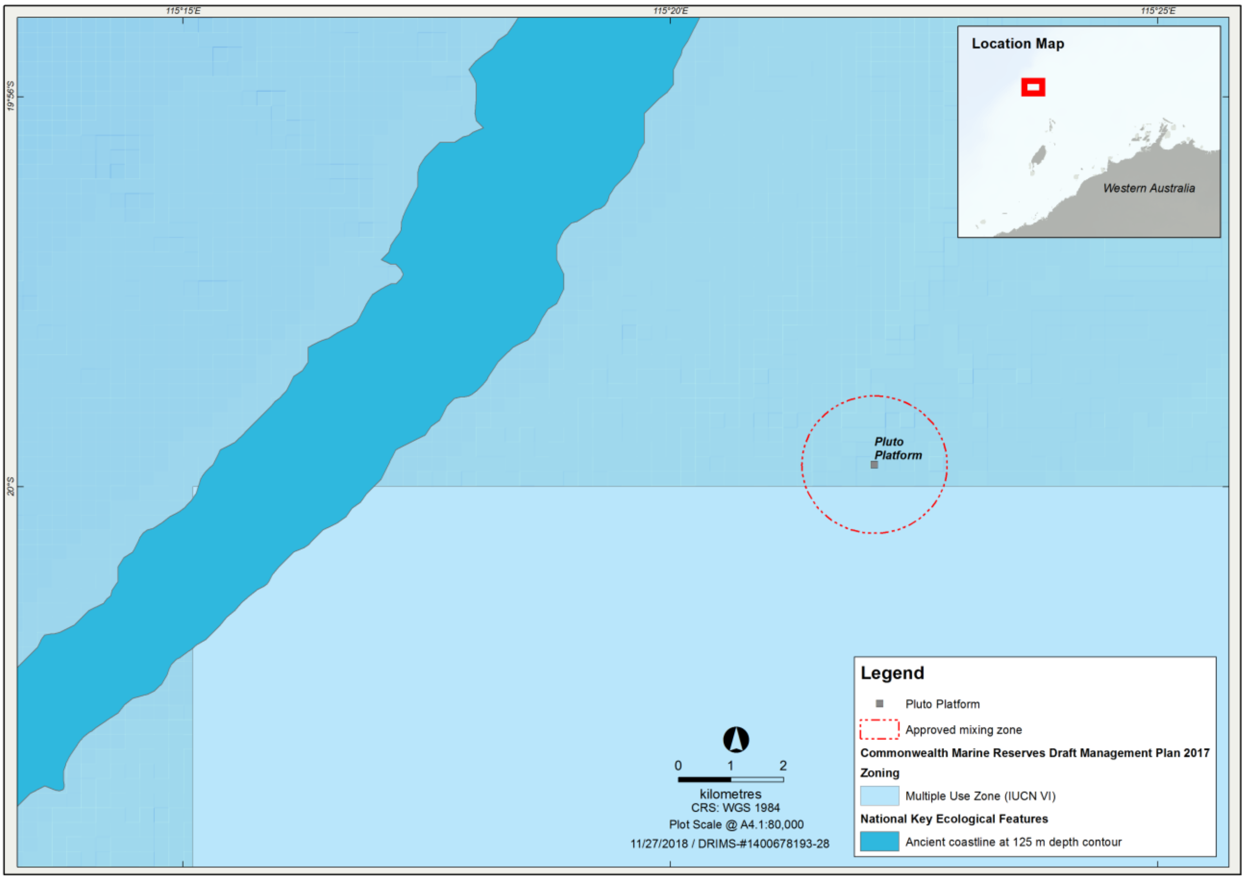

Figure 12-10: Key Ecological Features.

Management and Impact Assessment – Non-Routine Activities

Management during Commissioning of the Water Processing System

During commissioning of the PWHM, there are several variables that will affect OIW levels. These include the unique reservoir water chemistry, water production rate and the use of chemicals.

The uncertainty of the onset of free water from the wells means the Ready For Start Up (RFSU) and PWHM commissioning may not align. The limited accommodation facilities and visitation schedule may limit the expertise available for PWHM commissioning.

Hence, Woodside proposes the following OIW management during commissioning to:

- understand the multiple variables in the PWHM system, without regularly exceeding a low OIW limit. Manual testing will be at least six-hourly, in line with Woodside procedures.
- maintain the flexibility posed by the NNM operation.

Commissioning of the PW system requires flexibility to allow for OIW elevation while the process equipment is commissioned and flow rates vary while the system is optimised. Woodside require that the PW treatment system is commissioned and validated over a period of twelve weeks. This will build operational confidence that process variabilities are understood and can be managed remotely without the need for manual intervention. This is required in order to maintain the NNM philosophy of the platform over the ten week periods between campaign maintenance. The complexities involved in commissioning this process are the limited knowledge of PW chemistry, the pressure drops across the process and impact on separation across each PW treatment stages, the chemical interactions and effectiveness, and the operation of a new technology to Woodside (the HIGF).

In order to provide the required flexibility to get the PW treatment system commissioned and validated over 84 days, the following OIW levels are required during the commissioning period:

- initial commissioning: 50 mg/L 30-day rolling average; 100mg/L instantaneous peak; for the first 30 days of discharge.
- optimisation and validation period: 30 mg/L 30-day rolling average; 50mg/L instantaneous peak; for the following 54 days of discharge.

During the initial commissioning period, defined by the requirement to discharge produced water overboard, manual sampling for OIW will be required until such time the online OIW analysers have been commissioned, calibrated and proven to be operating in line with their functional requirement. The HIGF will also be commissioned during this period, this is new technology to Woodside therefore familiarisation and operational practice will occur during this period. It is proposed that the coalescing filters will be run during this initial commissioning period of at least 30 days, or longer as required, until such time the process has stabilised and an OIW content of 30 mg/L (24-hour rolling average) is regularly being achieved from the outlet of the HIGF. This point triggers the cessation of the continuous use of the coalescing filters and is considered the end of initial commissioning. This additional treatment stage will reduce the OIW concentration and total load discharged to the environment during this period and allow for maximum optimisation of the secondary treatment stage of the PW treatment system.

The following 54 day optimisation and validation period, fulfils the 12-week NNM operating philosophy return period. It is required to optimise the PW treatment system and to understand how it operates and reacts to changes in the process (pressures, chemical concentrations, flow rates). The focus is to minimise chemical injection requirements through process optimisation such that an ALARP position is achieved between process pressures, chemical injection and OIW concentration being discharged. The period is also required to validate the process can be operated and managed remotely via the onshore control room, without the need for manual intervention offshore over ten week unmanned periods. It is expected during the optimisation and validation period the facility will be manned, however the operation of the process will be from onshore, and facility intervention will only occur if troubleshooting is required. During this period there may be a few short term exceedances of the 30 mg/L (24-hour rolling average) specification for routine operational discharges. While troubleshooting of these issues are resolved to reduce the specification to back below 30 mg/L (monthly rolling average) an instantaneous peak discharge specification of 50 mg/L is required.

If the optimisation and validation period extends past 54 days OIW will be managed within the routine operational discharge requirement of 30 mg/L (24-hour rolling average. The system is considered to be in “steady state” when routine discharge commences following the commissioning, optimisation and validation period. Offshore PW discharge may be suspended after the commissioning, optimisation and validation period and onshore discharge undertaken until such time PW volumes require offshore discharge.

Impact Assessment

The PW discharge modelling was based on the system design maximum possible flow rate of 3500 m^3 per day. The maximum design rate is based on a few wells producing water, the rate during commissioning is expected to be significantly less due to only a small number of wells expected to have water present. The OSPAR (2014) dispersed oil concentration of 70 µg/L was used as the PNEC rather than the ANZECC/ARMCANZ (2000) guideline value (low reliability) of 7 µg/L. The PNEC of 70 µg/L derived by Smit et al (2009) is considered more appropriate than the

Tsvetnenko (1998) derived 7 µg/L as all tests used in the Species Sensitivity Distribution (SSD) were chronic as opposed to acute converted to chronic values with an acute chronic ratio (ACR) of 25 as used by Tsvetnenko (1998). Modelling considered minimum dilutions achieved across all months of the year. According to the modelling results, the distance from the discharge location in which the PNEC of 70 µg/l is achieved (1429 dilutions required) is estimated to be up to 700 m. No approved mixing zone is proposed during commissioning. The commissioning discharge will be of short duration (12 weeks) and expected to be of slight short-term impact. use of the coalescing filters during the initial commissioning period will minimise the OIW concentrations being discharged to the environment. The commissioning PW discharge is expected to be of lower flow rate than the maximum design rate of the system. The PW treatment system has its complexities in being commissioned and validated, therefore the timeframes are provided to ensure the system is commissioned correctly to ensure OIW separation can be optimised for ongoing routine operations and the NNM philosophy of the platform can be maintained.
Summary of Control Measures
• Chemical Selection and Assessment Environment Guideline (Woodside Doc No: WM0000MG9905057). o Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected, no further control required. o If chemicals with a different OCNS rating, sub warning or non-OCNS rated chemicals are required chemicals will be assessed in accordance with the guideline prior to use. • Monitoring and management of OIW concentrations in accordance with PARCOM 1997/16 Annex 3 methodology. o Limiting average PW OIW during routine operations to less than 30 mg/L (over a rolling 24-hour period). o Limiting average PW OIW during commissioning activities to less than 50 mg/L (rolling 30-day average) for a single period of 30 days. and less than an average 30 mg/L rolling 30-day average for the subsequent period of 54 days. • During the initial commissioning of the PW treatment system (30 days, or longer if required), tertiary treatment filters will be used until the secondary treatment stage can meet the routine operations OIW discharge specification. • Implementation of the Monitoring and Management Framework for Produced Water. • Online monitoring and/or procedural controls in place to monitor and control PW discharge volume and OIW concentrations, and prevent discharge of PW with high OIW concentrations through OIW analyser, or offspec/outage procedures. • Chemical injection of water clarifier, demulsifier to reduce OIW concentration. • Adopting a secondary treatment stage to reduce OIW concentration. • Adopting a tertiary treatment stage to reduce OIW concentration. • Filters are used during the initial commissioning period to minimise OIW concentration of PW discharged.

Routine and Non-Routine Marine Wastewater Discharges: Discharge of Sewage, Putrescible Waste, Grey Water, Bilge Water, Drain Water, Cooling Water and Brine

Impacts Evaluation Summary													
Source of Impact	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Discharge of sewage, grey water and putrescible waste from vessels to the marine environment.			X					A	F	-	-	LCS GP PJ	Broadly acceptable
Discharge of sewage and grey water from the riser platform to the marine environment.			X					A	F				
Discharge of deck, bilge and drain water from vessels and riser platform to the marine environment.			X					A	F	-	-		
Discharge of reverse osmosis brine and cooling water from vessels.			X					A	F	-	-		

Description of Source of Impact

Sewage, Putrescible Waste and Grey Water

Sewage is not normally produced on the riser platform (i.e. when unmanned). When the riser platform is manned, the sanitary drainage system is a combined black and grey water system with black and grey water discharged to the marine environment via drain caisson. The waste is discharged to the ocean via a dedicated overboard caisson below the water line. Putrescible waste, mainly food scraps, is transported onshore for disposal and is therefore not considered a discharge.

Vessels may also discharge sewage, grey water and putrescible wastes. Sewage onboard vessels is routinely treated (either sewage treatment plant or macerator) prior to discharge.

The volume of sewage and grey-water generated (when manned) is estimated to be in the order 75 L/person/day. The actual volume of discharge will vary depending on personnel levels on the riser platform and vessels. Planned maintenance is about fourteen days, five to six times per year; there will be additional periods of manning during the installation of the water handling unit.

Drain and Bilge Water

Operational non-process discharges, process maintenance drainage and flushing discharges, washdown water and potential spills are contained in the non-hazardous and hazardous open drain systems. These liquids are captured and stored in collection tanks and then transported onshore for disposal. Hydrocarbons, chemicals and liquids collected in the closed drain system are routed to the flare knock-out drum and then pumped into the export pipeline for transfer to shore.

During normal operations, the lines to the hazardous open drains system are plugged and the lines overboard are opened to prevent the collection tank from filling up with rainwater, which could result in liquid spillage (possibly containing hydrocarbons). Plugs are removed, and collection points routed to the inboard tank when work is being undertaken in the area. The non-hazardous open drains system is always routed to the inboard tank as its collection points are protected from rainfall.

Vessels routinely generate and discharge relatively small volumes of bilge water. Bilge tanks receive fluids from many parts of the vessel, including machinery spaces. Bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids or chemicals. Vessels may also discharge drainage water from decks directly overboard or via deck drainage systems; deck drainage may also contain traces of chemicals. Water sources could include rainfall events and/or from deck activities such as cleaning/wash-down of equipment/decks.

Cooling Water and Brine

Cooling water and brine water discharges are limited to support vessels.

Impact Assessment

Sewage, Putrescible Waste and Grey Water

The environmental impact associated with ocean disposal of sewage, grey water and putrescible waste is eutrophication. Eutrophication occurs when the addition of nutrients, such as nitrates and phosphates, causes adverse changes to the ecosystem, such as oxygen depletion and phytoplankton blooms.

Impacts from planned (routine and non-routine) discharges to the marine environment are expected to be localised due to the minor quantities involved and high level of dilution into the open water marine environment of the Operational Area. This is supported by infield monitoring undertaken by Woodside, both around the nearby Goodwyn Alpha (GWA) platform (discharging sewage, putrescible and grey water) as well direct monitoring of sewage discharges from a Mobile Offshore Drilling Rig (MODU). Water quality monitoring around the GWA platform (which is a manned platform) indicates that there was no detectable decrease in oxygen saturation, nutrients or increase in oxygen demand at the GWA platform (BMT Oceanica 2015). In addition, monitoring of sewage discharges has demonstrated that a 10 m^3 sewage discharge reduced to approximately 1% of its original concentration within 50 m of the discharge location (Woodside, 2008).

The Operational Area is located more than 12 nm from land, which exceeds the exclusion zones required by Marine Order 96 (Marine pollution prevention – sewage) 2009 and Marine Order 95 (Marine pollution prevention – garbage) 2013.

Although the NWS Province is characterised as a low nutrient environment (Department of the Environment, Water, Heritage and the Arts 2008) studies of adjacent shelf water have found the area to be "*a highly productive ecosystem in which nutrients and organic matter are rapidly recycled*" (Furnas and Mitchell 1999). The estimated daily loading from sewage and putrescible waste (2.4 to 3.0 kg/day of total nitrogen and 0.38 to 0.43 kg of total phosphorus per day) is not significant in comparison to the daily turnover of nutrients in the area. Vessels are typically moving when in the Operational Area, which facilitates the mixing of sewage, putrescible wastes and grey water from vessels.

The impact of nutrients associated with discharge of sewage, grey-water and putrescible waste is considered to have a localised impact with no lasting effect due to the small mass, relative to daily turnover, and the assimilative capacity of the receiving environment.

Drain and Bilge Water

Drain water from the facility and bilge and deck drainage water from vessels is expected to mix rapidly in the marine environment upon discharge. Given the rapid mixing, relatively small typical bilge and deck drainage water, and expected low levels of potential contaminants, impacts from bilge and deck drainage water from vessels and the facility are assessed as short- term and localised.

Values and Sensitivities

<u>Montebello Marine Park</u>

A small portion of the Operational Area overlaps the Montebello Marine Park therefore vessel discharges may be released within the Montebello Marine Park. Any impacts in the Marine Park will be localised with no lasting effect, as described above. Additionally, discharges from vessels is consistent with the allowable activities in a 'Multiple Use Zone VI', if compliant with MARPOL.

Cumulative Impacts

Given the activities that may be conducted during the Petroleum Activities Program, there is the potential for cumulative impacts from routine discharges of sewage, putrescible waste, grey water, PW, bilge water and drain water due to:

- periodic, repeated discharges at the same location (riser platform) over the course of the Petroleum Activities Program
- cumulative discharges from differing point sources (riser platform and vessels).

Because of the nature of these routine discharges, normal operations are unmanned (and therefore no discharges), the localised spatial extent of impacts and the well mixed receiving environment, the cumulative impacts from these discharges are not considered to result in impacts more than slight short-term impact. Given the highly localised nature of the impacts of routine discharges, no cumulative impacts are expected from similar discharges from other production facilities or support vessels (e.g. Wheatstone).

Summary of Control Measures

- Contract vessels complying with Marine Orders for safe vessel operations:
    - Marine Order 91 (Oil)
    - Marine Order 95 (Pollution prevention – garbage)

  - Marine Order 96 (Pollution prevention – sewage)
- Chemical Selection and Assessment Environment Guideline:
  - Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected, no further control required.
  - If chemicals with a different OCNS rating, sub-warning or non OCNS rated chemicals are require, chemicals will be assessed in accordance with the procedure prior to use
- Maintaining the facility's open hazardous drain system integrity, as far as practicable.

Routine and Non-Routine Atmospheric Emissions: Fuel Combustion, Flaring and Fugitives

Impacts Evaluation Summary													
Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***					
	Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitat***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/Impact***	***Likelihood***	***Risk Rating***	***ALARP Tools***	***Acceptability***
Riser platform internal combustion engines, operational flaring, and fugitive emissions and vessel emissions (including incinerators).				X		X		A	F	-	-	LCS GP PJ	Broadly Acceptable

Description of Source of Impact

Atmospheric emissions will be generated predominantly from the riser platform during the Petroleum Activities Program. Sources include emissions from internal combustion engines (including all equipment and generators), flares and fugitives. Vessel emissions include those from internal combustion engines, fugitives and onboard incinerators. Emissions and combustion products typically include CO_2, water vapour, NO_x, SO_2, methane, refrigerant gases, particulates, Volatile Organic Compounds (VOCs). As the riser platform is not NNM, under standard operations fuel use is generally low and peaks during flowline pigging operations. Fuel use, and therefore emissions, will increase with the installation and operations of the water handling module.

Atmospheric Emissions – Historic and Prior to Water Handling Module

Flaring is the largest source of combustion emissions from the riser platform.

The combustion of hydrocarbon gas by flaring is an essential practice, primarily for safety requirements. Operational flaring is comprised of two elements:

- normal operational flaring associated with flare system purge and pilot and process flows
- non-routine flaring that may result from activities such as planned shutdowns, ESD testing and pigging, and un-planned shutdowns and ESDs, production restarts, equipment outage/failures, subsea flowline depressurisation and well remediation activities.

During normal operations, approximately 530 tonnes of gas are flared per year due to purging and maintenance of a pilot (based on 2016–17, 528 tonnes). Flowline pigging is expected to result in approximately 5000 tonnes of flaring in addition to normal operations During flaring, the burnt gas generates mainly water vapour and CO_2.

Diesel is used for the operation of the crane, generators and survival craft. Diesel usage on the facility (excluding support vessels) in 2016–17 was 330 tonnes, the combustion of which equated to the emission of 894 tonnes of CO_2 equivalents. The installation of the water handling unit will require additional power generation and fuel usage.

Gas flaring has the potential to increase the volumes of greenhouse gases emitted to the atmosphere. Flaring also consumes natural gas, a non-renewable resource. During flaring, the burnt gas generates mainly water vapour and CO_2. The efficiency of the facility flare is estimated to be approximately 98%. Incomplete combustion under certain scenarios may also generate dark smoke.

Incinerators may be used onboard vessels to dispose of flammable domestic wastes such as cardboard. Incinerators are typically used infrequently, with wastes generally segregated and transported to shore for disposal.

The forecast annual emissions from fuel combustion on the facility is been estimated using emissions factors (as per National Pollutant Inventory Emission Estimation Techniques and are presented in **Table 12-23.**

Table 12-23: Estimated: Estimated annual emissions from fuel combustion at the facility (based on FY2016/17)

Emission Type	Estimated annual emissions from flared gas combustion (tonnes) [1]	Estimated annual emissions from flared gas combustion in pigging year (tonnes) [2]	Estimated annual emissions from diesel combustion (tonnes) [3]	Estimated total annual emissions from fuel combustion (tonnes)
CO_2	1,426	14,935	890	2316
CH_4	2.11	33	0.05	2.16
N_2O	0.05	0.8	0.01	0.06
CO_2eq	1,494	23605	894	2388
NO_x	0.79	12.5	17.36	18.15
SO_x	0.00	0.00	0.01	0.01

[1] Based on combustion of 528 tonnes of fuel gas during 2016–17

[2] Based on combustion of 5530 tonnes of flaring (normal year plus flaring due to flowline pigging)

[3]Based on combustion of 330 tonnes of diesel during 2016–17

Atmospheric Emissions – Installation and Operation of the Water Handling Module

It is estimated that between 5000 and 9000 tonnes of gas may be flared per year following installation of the water handling module (**Table 12-24**). Flaring volumes will vary as a result of production rates and non-routine activities, outages and shutdowns. The water handling unit will add the following flaring requirements:

- during the installation of the PW handling unit a partial shutdown of the topsides would require additional flaring potentially resulting in up to 10750 tonnes of gas flared
- process routine flaring (produced from the degasser and the IGF) up to 3540 tonnes/year.

The forecast annual atmospheric emissions from flaring have been estimated using the National Pollutant Inventory (NPI) Emission Estimation Techniques (EET).

Installation of the Water Handling Module will also change the main source of power on PLA from diesel generators to gas engines. These are expected to consume 1,450,000 m^3 tons of fuel gas per year, producing about 250023492 tonnes of CO_2 equivalent.

Some diesel use will continue for operation of the crane and survival craft, but also as an alternative fuel for power generation. Following the installation of the Water Handling Module, emissions from diesel combustion will increase up to a total of 900 tonnes CO_2e per annum).

The estimated emissions during installation and operations of the Water Handling Module are presented in **Table 12-24**.

Fuel Emissions: Internal Combustion Engines and Waste Incinerators

Utility gas is the largest source of combustion emissions from the riser platform. In 2016–17, 528 tonnes of gas was flared on the riser platform, the combustion of which equated to the emission of 1494 tonnes of CO_2 equivalents.

Diesel is used for the operation of the crane, generators and survival craft. Diesel usage on the facility (excluding support vessels) in 2016–17 was 330 tonnes, the combustion of which equated to the emission of 894 tonnes of CO_2 equivalents. The installation of the water handling unit will require additional power generation and fuel usage.

The forecast annual emissions from fuel combustion on the facility is been estimated using emissions factors (as per National Pollutant Inventory Emission Estimation Techniques and are presented in **Table 12-24**. Incinerators may be used on-board vessels to dispose of flammable domestic wastes such as cardboard. Incinerators are typically used infrequently, with wastes generally segregated and transported to shore for disposal.

Table 12-24: Estimated-ed annual atmospheric emissions from installation and operation of the water handling module

Activity	Continuous Flaring during Normal Operation [1]	Continuous Flaring during Start-Up Event [2]	Blowdown [3]	Gas Engine Generator	Diesel Engine Generator
Total Gas (t/yr)	3,537	3,245	94.3	1,450,000 m3	330 kL
CO2 (t/yr)	9,904	9,085	264	2,506	891

CH4 (tCO2e/yr)	354	324	9.43	4.88	1.28
N2O (tCO2e/yr)	106	97	2.83	1.46	2.55
Total CO2e (t/yr)	10,364	9,507	276	2,513	895

[1] There will be continuous flaring of flash gas from produced water degasser during normal operation at a rate of up to 403.8 kg/hr

[2] Continuous flaring will occur during Start-Up condition; which is expected to be on average of 5 times per year for the duration of 9 hours of each event. Sources of continuous flaring are the Production Separator and Oily Water Separator. The maximum rate is used, therefore the estimate is conservative.

[3]Blowdown is expected to occur within a maximum of 15 minutes. This is per-event. Not expected to occur routinely.

Non-Routine Venting of Process Hydrocarbons via Flare System

During normal operations, hydrocarbon gas is flared via the HP and LP flare systems. These systems are maintained to effectively combust hydrocarbons as a critical component for the safe operation of the facility. In the unlikely event that the flares are extinguished or unavailable (such as following a major shutdown prior to system ramp-up), the hydrocarbon gas discharged via the flare system may initially not be combusted during the period required to purge the flare system and re-establish flare ignition. This may result in the short term (days) low-rate release of hydrocarbon gas to the atmosphere. Intermittent venting from the riser platform represents only a minor source of atmospheric emissions and is not considered to pose a risk beyond the routine air emissions described in this section.

Fugitive Emissions

Fugitive emissions can occur from pressurised equipment, and are inherent in design, required for infrequent operational activities, or can be caused by unintentional equipment leaks. Sources can include from valves, flanges, pump seals, compressor seals, relief valves, sampling connections, process drains, open-ended lines, casing, tanks and other potential leakage sources from pressurised equipment. Fugitive emissions are, by their nature, difficult to quantify and the normal approach, as accepted by the National Greenhouse and Energy Reporting Scheme (NGERS), is to indirectly estimate the amount of emissions based on product throughput.

As much of the safe operation of the facility relies on the effective containment of hydrocarbons, the volumes of routine and non-routine fugitive emissions are considered to be small. The DoEE has released technical guidelines for the estimation of greenhouse gas emissions by facilities in Australia, including from fugitive emissions.

Discrete, relatively small volumes of packed gases and charged systems including refrigerant gases are used across the riser platform and vessels which have potential for small volume leaks (typically less than 100 kg per isolatable inventory). Such gases are used in the HVAC and refrigerant systems on board the riser platform and support vessels.

Impact Assessment

Riser platform and vessel routine and non-routine emissions, predominantly routine fuel combustion and flaring have the potential to result in localised, temporary reduction in air quality, generation of dark smoke and contribution to greenhouse gas emissions. Potential impacts of emissions depend on the nature of the emissions, as well as the location and nature of the receiving environment.

Platform design, (including the rapidly dispersive characteristics of the flare and other emissions), the estimated level of pollutants in the emissions, and the absence of elevated background ambient levels have been considered in estimating the potential for interaction with human and environmental sensitivities. The riser platform and Operational Area is in a remote offshore location, with no expected adverse interaction with populated areas or sensitive environmental receptors associated with air emissions.

There is a foraging BIA for the wedge-tailed shearwater overlapping the Operational Area; as such, wedge-tailed shearwaters may occur nearby to the riser platform airshed. The nearest potential seabird roosting habitat on natural emergent land, the Montebello Islands, lies approximately 46 km south of the Operational Area at the closest point. Given, the low numbers of individuals expected potentially within the Operational Area, combined with the highly dispersed nature of air emissions; no adverse impacts to wedge-tailed shearwaters are anticipated due to air emissions.

Potential impacts are expected to be short-term, localised air quality changes, limited to the airshed local to the platform. Air emission impacts are not expected to have direct or cumulative impacts on sensitive environmental receptors, or above National Environmental Protection (Ambient Air Quality) measures.

The flare and potential black smoke resulting from emissions may impact visual amenity. The offshore location of the Petroleum Activities Program is not directly visible from the nearest landfall (Montebello Islands, 43 km south of the Operational Area at the closest point). Hence, no impacts to visual amenity for residential communities are expected. Visual amenity impairment to tourism activities are not expected.

Summary of Control Measures

- Contract vessels compliant with Marine Order 97 (Marine Pollution Prevention – Air Pollution).
- National Greenhouse and Energy Reporting Scheme (NGERS) and National Pollutant Inventory (NPI) reporting
- Monitoring, estimation and reporting of facility fuel and flare emissions (in accordance with NGERS/NPI) to inform optimisation management practices.

- Pursuing cost effective fuel/power substitution:
    - fuel gas used in preference to diesel for power generation.
- Maintaining flare to maximise efficiency of combustion and minimise venting , incomplete combustion waste products and smoke emissions.

Routine Light Emissions: Platform Lighting, Vessel Operations and Operational Flaring

Impacts Evaluation Summary													
Source of Impact	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Light emissions from the riser platform and vessels.						X		A	F	-	-	PJ	Broadly Acceptable
Light emissions from the riser platform during flaring.						X		A	F	-	-		

Description of Source of Impact
When the riser platform is in unmanned mode, lighting is limited to essential navigational and aviation requirements to communicate the presence of the riser platform and vessels to other marine users (i.e. navigation lights). Navigational lights are also located on the facilities tallest structures (i.e. crane boom). Helideck lighting is provided to assist helicopter landing. During manned mode (generally approximately fourteen days five to six times per year), the platform and support vessels have adequate lighting to allow safe working conditions during 24-hour operations. Lights are not normally directed outwards away from work areas except when necessary for safe operations outboard, such as lifting operations, and deployment/retrieval of equipment from IMR activities. The distance to the horizon at which components of the riser platform will be directly visible can be estimated using the formula below: $horizon\ distance = 3.57 \times \sqrt{height}$ Where horizon distance is the distance to the horizon at sea level in kilometres, and 'height' is the height above sea level of the light source in metres. Using this formula, the approximate distances at which the production deck and flare tower top will be visible at sea level are (based on the weather deck height above sea level of 47.4 m and flare tower height of 44 m – given an angle of 30°): • weather deck: approximately 25 km from riser platform • flare tower tip: approximately 34 km from riser platform. During IMR activities, underwater lighting is generated over short periods of time while ROVs are in use, as well as from deck lighting. Given the typical intensity of ROV lights and the attenuation of light in seawater, light from ROVs will be localised to the vicinity of the ROV and vessels.

Impact Assessment
Light emissions can affect fauna in two main ways: • *Behaviour*: many organisms are adapted to natural levels of lighting and the natural changes associated with the day and night cycle as well as the night-time phase of the moon. Artificial lighting has the potential to create a constant level of light at night that can override these natural levels and cycles. • *Orientation*: organisms such as marine turtles and birds may also use lighting from natural sources to orient themselves in a certain direction at night. In instances where an artificial light source is brighter than a natural source, the artificial light may act to override natural cues leading to disorientation. The fauna within the Operational Area are predominantly pelagic fish and zooplankton, with a low abundance of transient species such as marine turtles, birds, whale sharks and large whales transiting through the Area. A higher abundance of marine fauna may transit the export pipeline section of the Operational Area; however, lighting in this region will be restricted to short-term periodic lighting from vessels conducting IMR activities. Additionally, there is no known EPBC listed critical habitat within the Operational Area, although there are a number of BIAs that overlap the Operational Area. Given the lack of significant fauna populations expected to occur within the Operational Area, impacts

from light emissions are considered to be highly unlikely (as outlined below).

Seabirds

The risk associated with collision from seabirds attracted to the light is considered to be low, given there is no critical habitat for these species within the Operational Area and that lighting will be limited, except during intermittent periods when the riser platform is manned and during IMR activities. There is a foraging BIA for the wedge-tailed shearwater overlapping the Operational Area; as such, wedge-tailed shearwaters may occur within the Operational Area. The nearest potential seabird roosting habitat on natural emergent land, the Montebello Islands, lie approximately 32 km south of the Operational Area and 43 km from the riser platform, at their closest points. Foraging wedge-tailed shearwaters may be attracted to artificial light sources to feed upon fish drawn to the light; however, the species feeds predominantly during the day in association with pelagic predators (Catry *et al.*, 2009; Whittow, 1997). The majority of foraging trips are short, with single day foraging trips significantly more common than any other length trip, with birds returning to nesting/roosting sites between trips (Congdon *et al.*, 2005). As such, the numbers of wedge-tailed shearwaters present in the Operational Area at night is expected to be low relative to daylight hours, and any potential changes to behaviour would only affect a relatively low number of birds. Given the species' global distribution and primarily diurnal foraging behaviour, impacts to wedge-tailed shearwaters from artificial lighting are considered to be negligible.

Wiese *et al.* (2001) presented a literature review relating to the effect of light from platforms in the North Sea on seabirds. They noted that seabirds are strongly visually orientated and that large attractions of birds, and in some cases mortality of birds, have often been documented by lighthouses, communication towers, buildings and oil platforms. Injuries can occur through direct collisions and the rate of collision is (they inferred from literature) related to the cross-sectional area of the obstacle, amount of light and number of birds present.

Black (2005) reported on two cases of mass seabird mortalities from striking of ships in the Southern Ocean. In both cases, mortalities occurred when the vessel was at anchor near seabird colonies and conducting night deck operations during periods of reduced visibility. As such, impacts from the presence of vessels on seabirds is expected to be a localised behavioural disturbance to a small number of birds, with no lasting effect. Note significant seabird mortality in relation to fishing vessel operations has been documented (e.g. Sullivan *et al.*, 2006), suggesting interactions with fishing gear (e.g. trawl nets) as the primary source of mortality given birds are strongly attracted to bycatch/baits from fishing vessels. Hence, comparisons of bird mortality between fishing vessels and vessels undertaking the Petroleum Activities Program are not reasonable due to the difference in the nature and scale of the risks and impacts.

In a study of offshore oil platforms in the North Sea, Poot *et al.* (2008) observed that migrating seabirds can be attracted to the lights and flares of offshore oil platforms, particularly on cloudy nights and in between the hours of midnight and dawn. Migratory shorebirds travelling the East Asian-Australasian Flyway transit through the Operational Area en-route to staging areas, before moving onto the mainland south in the spring or Indonesia in the north in the autumn. Migratory birds, have been observed opportunistically roosting on the platform in large numbers. Migrating birds in the region are at, or near, the end of their migration (or staging area), and if attracted will not be facing long-distance journeys directly upon leaving the riser platform.

Large numbers of migratory birds have been observed opportunistically roosting on the facility. If maintenance, process safety and/or health risks are identified associated with the presence of birds, it may be necessary to deter them from roosting on the riser platform by installing bird proofing/exclusion devices. The installation of bird proofing poses the potential risk of entanglement for individual birds. There have been no reported bird injuries or deaths at the facility, and consequently future adverse interactions are considered highly unlikely with no lasting effects on populations or impacts to critical habitat anticipated. If deterrents are installed birds will likely to relocate to previous ranges (i.e. rather than landing on the platform), therefore no lasting effect is anticipated.

Marine Turtles – Hatchlings

Light pollution is listed as a key threat to all marine turtle species identified as potentially occurring within the Operational Area with advice to minimise light. The nearest potential nesting site in relation to the Operational Area are the Montebello Islands, approximately 32 km from the Operational Area, and approximately 43 km from the riser platform. Given this, platform lighting and the tip of the flare tower will not be directly visible from this potential nesting site.

Light emissions reaching turtle nesting beaches is widely considered detrimental owing to interference with important nocturnal activities including choice of nesting sites and orientation/navigation to the sea by post-nesting females and hatchlings (Lorne and Salmon, 2007; Salmon, 2003; Tuxbury and Salmon, 2005). Hatchling turtles use light as a visual cue to orientate themselves towards the sea during the post-hatching dash after emerging from the nest, orientating themselves towards the relatively bright horizon above the sea and away from the relatively dark dunes (Salmon *et al.*, 1995b; Salmon and Witherington, 1995). Artificial light from coastal developments has been identified as potentially disorientating hatchling turtles during the post-hatching movements, with hatchling turtles orientated towards artificial light sources away from the sea (Lorne and Salmon, 2007; Salmon, 2003; Tuxbury and Salmon, 2005). Turtles disorientated by artificial lighting may take longer, or fail, to reach the sea, potentially resulting in increased mortality through dehydration, predation or exhaustion (Salmon and Witherington, 1995).

Once hatchling turtles reach the sea, the primary cue for hatchling turtle orientation is water movement, with hatchlings swimming directly towards oncoming waves (Lohmann *et al.*, 1990; Lohmann and Lohmann, 1992). Hatchling and adult turtles may also use the Earth's magnetic field for larger scale navigation (Lohmann and Lohmann, 1996). As such, hatchling turtles are only likely to be disorientated by artificial light between leaving the nest and reaching the sea.

Given the riser platform NNM status, intermittent presence of vessels and the distance to the nearest landfall (and nearest significant rookeries), artificial light from the riser platform is not expected to be directly visible to hatchling turtles. During IMR activities vessels may come within relative proximity to nesting beaches, mainly within the Dampier Archipelago. However, given the low frequency and large spatial extent at which these activities occur, there is not likely to be significant impacts. As such, the potential for hatchling turtles to become disorientated by artificial lighting is considered remote.

Marine Turtles – Adults

Artificial lighting may affect the location that turtles emerge to the beach, the success of nest construction, whether nesting is abandoned, and even the seaward return of adults (Salmon *et al.*, 1995a, 1995c; Salmon and Witherington, 1995). Such lighting is typically from residential and industrial development overlapping the coastline, rather than offshore from nesting beaches. The facility Operational Area does not contain any known EPBC listed critical habitat for any species of marine turtle, with the nearest potential nesting site (the Montebello Islands) approximately43 km from the riser platform. It is acknowledged that the facility section of the Operational Area overlaps a 40 km internesting buffer BIA for flatback turtles and that marine turtles may occur in low densities in this area. However, no impacts to nesting flatback turtles will occur due to light generated within this section of the Operational Area given the riser platform's NNM status and the distance to the nearest landfall.

Within the export pipeline section of the Operational Area, a higher abundance of turtles may be present. This section of the Operational Area overlaps internesting and internesting buffer BIAs for green, hawksbill and loggerhead turtles. Given the very low occurrence of IMR activities, no impacts to nesting turtles of these species will occur.

Fish

Lighting from activities in the Operational Area may result in the localised aggregation of fish below the source of light, particularly around the riser platform during manned periods. Note fish may also be aggregating around the riser platform due to the habitat provided by the riser platform and subsea infrastructure. These aggregations of fish would be confined to a small area. Any long-term changes to fish species composition or abundance is considered negligible.

Summary of Control Measures

The potential impacts and risks from light emissions is deemed to be ALARP in its risk state. No reasonable additional/alternative controls were identified that would further reduce the impacts without grossly disproportionate sacrifice.

5.7.1 Unplanned Hydrocarbon or Chemical Release: Hydrocarbon Release during Bunkering, Refueling and Chemical Release during Transfer, Storage and Use, Rupture of Chemical Supply Lines

Risks Evaluation Summary													
Source of Risk	**Environmental Value Potentially Impacted**							**Evaluation**					
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (incl. Odour)*	*Ecosystems/Habitat*	*Species*	*Socio-Economic*	*Decision Type*	*Consequence/Impact*	*Likelihood*	*Risk Rating*	*ALARP Tools*	*Acceptability*
Accidental spill of hydrocarbons to the environment during bunkering/refuelling.			X			X		A	D	2	M	LCS GP PJ ER	Broadly Acceptable
Accidental discharge of chemicals to the marine environment from storage, use, bunkering or transfer.			X			X		A	D	1	M		
Accidental release of MEG from the chemical supply lines.			X			X		A	E	2	M		

Description of Source of Risk

Marine Diesel Bunkering/Refuelling

Marine diesel fuel is transferred to the facility and ASV by bunkering. Two key scenarios for the loss of containment of marine diesel during bunkering operations were identified:

- Partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues could spill marine diesel to the deck and/or into the marine environment. This would be less than 200 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break and complete loss of hose volume).
- Partial or total failure of a bulk transfer hose or fittings during bunkering or refuelling, combined with a failure in procedure to shutoff fuel pumps, for a period of up to five minutes, resulting in approximately 8 m^3 marine diesel loss to the deck and/or into the marine environment.

Mechanisms are available to capture diesel from process/piping associated with bunkering and fuel transfers, which overboard when the facility is unmanned, or to the open drains collections tank when the facility is manned. The diesel unloading stations have isolation and vent valves to allow draining of bunkering hoses between uses.

Chemical Transfer, Bunkering, Storage and Use

<u>Transfer and bunkering</u>

Operational process chemicals are transferred to the facility in a dedicated MEG supply line, or transportable containers. Operational non-process and facility maintenance chemicals, such as subsea control fluid, cleaning products, paint, degreaser, etc., are typically transferred to the facility in containers.

Spills have the potential to occur during transfer to the facility (e.g. transport or lifting incidents). Given the small volumes being handled, the worst credible release volumes are relatively small (e.g. the typical largest chemical transfer is via transportable 4-6 m^3 ISO containers of MEG).

Corrosion Inhibitor is proposed to be bunkered similarly to triethylene glycol (TEG) on other Woodside facilities. The supply vessel bulk transfer system will connect to the platform during safe conditions and according to approved procedures. The most likely spill volume of corrosion inhibitor is likely to be less than 0.2 m^3, based on the volume of the transfer hose and the immediate shutoff of the pumps by personnel. However, the worst-case credible spill scenario could result in up to 8 m3 of corrosion inhibitor. This unlikely scenario represents a complete failure of the bulk transfer hose combined with a failure to follow procedures (which require transfer activities to be monitored), coupled with a failure to immediately shut off pumps. It is expected that some of this volume would be contained on the supply vessel.

MEG supply and distribution lines are discussed below.

Storage and Use

Spills of chemicals (including non-process hydrocarbons stored in transportable containers) can originate from stored hydrocarbons/chemicals or equipment on the platform, vessel decks or subsea (refer to **Routine and Non-routine Discharges: Discharge of Hydrocarbons and Chemicals from Subsea Operations and Activities** for an assessment of the impacts of planned chemical discharges).

The chemical planned to be stored in the largest volume on the riser platform is corrosion inhibitor (28 m^3 stainless steel tank associated with the water handling module). Therefore, the worst-case credible chemical spill scenario could result in up to 28 m^3 of corrosion inhibitor being discharged from the riser platform.

Selection of operational chemicals and those used during IMR activities is undertaken in accordance with the Woodside Chemical Selection and Assessment Environment Guideline.

Operational process chemicals are typically stored in dedicated vessels which have similar controls of those related to mitigating hydrocarbon releases (e.g. permanent piping to the process, isolatable by valves and assurance through risk-based inspection in accordance with the Maintenance and Inspection regimes under the Maintain Assets Process.

The riser platform and support vessels also store other non-process chemicals and hydrocarbons, in various volumes. Operational non-process chemicals and facility maintenance chemicals present on the riser platform and support vessels are typically held in low quantities (usually less than 50 L).

Chemical storage areas are typically set up in cabinets, or bunded storage areas to contain any releases to deck from transportable containers (e.g. ISOs, IBCs, barrels, drums, etc.). Releases from equipment are predominantly from the failure of hoses or minor leaks from process components, or spills during refuelling of equipment, which can either be located within bunded/drained areas or outside of bunded/drained areas (e.g. over grating on cranes).

Subsea Support Vessels undertaking IMR activities may also store quantities of chemicals for subsea use. Subsea chemicals are subject to the chemical selection process**.** Accidental releases of small quantities of subsea chemicals may occur (e.g. deck spills). Operational experience indicates potential volumes of such spills is small (< 20 L).

ROV hydraulic fluid is supplied through hoses containing approximately 20 L of fluid. Hydraulic lines to the ROV arms and other tooling may become caught resulting in minor leaks to the marine environment. Small volume hydraulic leaks may occur from equipment operating via hydraulic controls subsea (subsea control fluid). These include the diamond wire cutter, bolt tensioning equipment, ROV tooling, etc.

Six-inch chemical supply and four-inch chemical supply lines

MEG may be released from 6-inch chemical supply and 4-inch chemical supply lines due to a rupture of the lines. The worst case credible spill scenario has been determined to be a loss of containment of lean MEG from the 6-inch chemical supply line due to a rupture caused by external impact (such as a vessel's anchor). If a rupture occurs the likely volume to be released to the marine environment is 35 m^3 through the depressurisation of the MEG pipeline from its operating pressure of 25 MPag to seabed pressure. Additional MEG losses may occur if:

- there are severe tidal movements around the rupture location causing sea water ingress into the chemical supply line and displacing the MEG to the marine environment, or
- there is a downward flow of MEG due to gravity, dependent on the location of the rupture.

In the unlikely event that there is a continuous leak which does not trigger alarms due to flow differential between onshore and offshore, MEG release could be in the order of 30 m^3/day resulting in a worst-case release of 420 m^3, over two weeks, until detection based on consumption trends.

Quantitative Spill Risk Assessment

Surface Spill (Hydrocarbons/Chemicals)

Small diesel spills will rapidly spread on the water surface, with the diesel expected to evaporate and disperse rapidly (National Oceanic and Atmospheric Administration (NOAA) 2006). Woodside has commissioned RPS APASA to model several small marine diesel spills, including surface spill volumes of 8 m^3 in the offshore waters of northwest WA. The results of these models have indicated that exposure to surface hydrocarbons above the 10 g/m^2 threshold defined in **Section 5.4** is limited to the immediate vicinity of the release site, with little potential to extend beyond 1 km. Based on these modelling results, the potential impacts of the credible marine diesel and chemical spill scenarios described above are reasonably expected to occur within 1 km of the release location.

The impact assessment assumes this release location to be the riser platform, as this is where all platform-based and most vessel-based spills will potentially occur. Given the nature and scale of the risk, along with the relatively low sensitivity of the receiving environment, no additional modelling studies were considered necessary to inform the impact assessment of unplanned discharges of hydrocarbons or chemicals during transfer, storage and use.

Hydrocarbon Characteristics

Refer to **Section 5.4** for a description of the characteristics of marine diesel, including detail on the predicted fate and weathering of a spill to the marine environment.

Consequence Assessment

Marine Diesel

Given the low viscosity of marine diesel, along with the high portion of volatile components, a spill of up 8 m^3 of marine diesel during transfer, storage or use would spread and weather rapidly. Environmental receptors at risk would be restricted to those in the vicinity (< 1 km from the release location). The biological consequences of a small volume diesel spill on identified open water sensitive receptors relate to the potential for minor consequences to megafauna, plankton and fish populations (surface and water column biota). Impacts to plankton may include acute toxicity resulting in mortality of planktonic organisms. Given the rapid turnover of plankton communities, these impacts will be short-lived (hours to days). Impacts to fish are expected to be of no lasting effect, as fish species are mobile and expected to avoid the area affected by a marine diesel spill incident. Impacts to larger fauna such as cetaceans and marine turtles may be light fouling, potentially resulting in irritation of sensitive membranes such as the eyes, mouth and digestive system (Helm et al. 2015). Mortality of larger fauna is not expected to occur. No impacts to ecosystem function are expected.

Hydrocarbons may extend into the Multiple Use Zone of the Montebello Marine Park and impacts would be as described above for open ocean receptors. No impacts are predicted to Continental Slope Demersal Fish Communities and the Ancient Coastline at 125 m Depth Contour KEFs. Although, they do overlap the operational, they are outside the predicted spill impact zone.

Slight, short term impacts may occur to other marine users (e.g. commercial fisheries); however, as the worst case marine diesel spill is only 8 m^3, and there is already no fishing within PSZ and limited fishing within the Operational Area it is unlikely that there would be any significant impact to commercial fishers.

Chemicals and Non-Process Hydrocarbons

MEG is considered PLONOR; however, very high concentrations of MEG (> 50%) may cause irritation to sensitive areas of larger marine fauna (e.g. eyes, gills). Woodside undertook ecotoxicity testing on the lean Pluto MEG (90% monoethylene glycol, ~10% demineralised water and 0.05% corrosion inhibitor). Seven tests, comprised of five different species representing five different taxonomic groups (algae, echinoderm, crustacea, molluscs and fish), were used. The toxicity of the MEG was found to be low, 240 mg/l for 99% species protection and 780 mg/l for 95% species protection (SKM, 2014). MEG is water soluble and will dilute rapidly in the marine environment to low concentrations. Impacts may occur as described above if marine fauna are within the mixing zone when the MEG is released. However, given MEG's low toxicity impacts, it is unlikely there would be any measurable effects on marine species resident in the vicinity of the release. The maximum credible spill of MEG is expected to mix rapidly with the local receiving environment with short term environmental impact.

Accidental releases of chemicals (including corrosion inhibitor) or non-process hydrocarbons decrease the water quality in the immediate area of the release; however, the consequence are expected to be minor with a short-term impact given the water depths, the open ocean mixing environment, Operational Area distance from sensitive receptors and relatively low credible release volumes. Depending on the chemical released the toxicity and/ or potential to bioaccumulate may potentially result in impacts to pelagic fish or other marine species in the vicinity of the discharge.

Potential impacts to plankton from an accidental chemical spill may include acute toxicity resulting in mortality of planktonic organisms. Given the rapid turnover of plankton communities and nature and scale of the credible releases, these impacts will be short-lived (hours to days). Impacts to fish are expected to be of no lasting effect, as fish species are mobile and expected to avoid the area affected by an accidental chemical spill. Impacts to air-breathing fauna such as cetaceans, birds and marine turtles, are expected to be restricted to irritation of sensitive membranes such as the eyes, mouth, and digestive system.

Slight, short term impacts may occur to other marine users (e.g. commercial fisheries); however, as there is limited fishing within the Operational Area, it is unlikely there would be any significant impact to commercial fishers.

Summary of Control Measures

- Contract vessels complying with Marine Order 91 (Marine Pollution prevention – oil) for safe vessel operations
- Chemical Selection and Assessment Environment Guideline:
  - Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected, no further control required.
  - If chemicals with a different OCNS rating, sub-warning or non OCNS rated chemicals are require, chemicals will be assessed in accordance with the procedure prior to use
- Diesel bunkering hoses to:
  - have dry break couplings
  - be pressure rated at purchase.
- Implementing bunkering procedures.
- Safely storing chemicals to prevent the release to the marine environment.
- Raising incident reports within event reporting system for unplanned releases.
- Monitoring and maintenance of subsea infrastructure to ensure integrity management
- Monitoring MEG use, investigating material discrepancies, and monitoring flow discrepancy to support identification of potential integrity failures.

- Riser platform drainage system in place to contain and dispose leaks and spills of hazardous liquids.
- Mitigation – hydrocarbon spill response.

Unplanned Discharges: Hazardous and Non-hazardous Waste Management

Risks Evaluation Summary														
Source of Risk	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	
Incorrect disposal or accidental discharge of non-hazardous and hazardous waste to the marine environment.		X	X			X		A	E	2	M	LCS GP PJ	Broadly Acceptable	

Description of Source of Risk
Normal operations on the riser platform and vessels results in a variety of hazardous and non-hazardous wastes. These materials could potentially impact the marine environment, if incorrectly disposed of, lost overboard, or discharged in significant quantities. Non-hazardous wastes include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard, scrap steel. Hazardous wastes include recovered solvents, excess or spent chemicals, oil contaminated materials (e.g. sorbents, filters and rags), contaminated screens from water handling unit (including potentially mercury contaminated screens), batteries, used lubricating oils and potentially material containing NORMs. Sand, sludges may also be periodically generated during well clean-up operations, desanding and vessel maintenance. Waste may also include the removal of redundant equipment from the offshore facility. All waste materials not suitable for discharge to the environment, including hazardous wastes (i.e. liquid and solid wastes), generated on the riser platform are transported to shore for disposal or recycling by Woodside's licenced waste contractor. Material generated onshore from pigging of the export pipeline has been tested in accordance with the relevant procedures and determined not to be classified as NORM therefore NORMs not expected to be encountered.

Consequence Assessment
The potential impacts of solid wastes accidentally discharged to the marine environment include direct pollution and contamination of the marine environment, potentially resulting in slight localised decreased water or sediment quality. Secondary impacts relating to potential contact of marine fauna with wastes resulting in entanglement or ingestion leading to injury and death of individual animals. The temporary or permanent loss of waste materials into the marine environment is not likely to have a significant environmental impact, based on the location of the Operational Area, the types, size and frequency of wastes that could occur and species present.

Summary of Control Measures

- Contract vessels complying with Marine Orders for safe vessel operations:
  - Marine Order 94 (Marine pollution prevention – packaged harmful substances)
  - Marine Order 95 (Pollution prevention – garbage)
- Storing, handling and transporting wastes in accordance with the Waste Management Plan for Offshore Facilities
- If safe and practicable to do so, vessel ROV or crane used to attempt recovery of material environmentally hazardous or non-hazardous solid object/waste container lost overboard.
- Raising incident reports within event reporting system for unplanned releases.

Physical Presence: Interactions with Marine Fauna

Risks Evaluation Summary													
Source of Risk	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Physical presence of support vessels resulting in collision with marine fauna.						X		A	E	1	L	LCS GP PJ	Broadly Acceptable

Description of Source of Risk
When vessels are present in the Operational Area they may present a potential hazard to cetaceans and other protected marine fauna such as whale sharks and marine reptiles. Vessel movements can result in collisions between the vessel (hull and propellers) and marine fauna, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement and reproduction) and mortality. The factors that contribute to the frequency and severity of impacts due to collisions vary greatly due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth) and the type of animal potentially present and their behaviours.

Consequence Assessment

The likelihood of vessel/whale collision being lethal is influenced by vessel speed; the greater the speed at impact, the greater the risk of mortality (Jensen and Silber, 2004; Laist *et al.*, 2001). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots. According to the data of Vanderlaan and Taggart (2007), it is estimated that the risk is less than 10% at a speed of 4 knots. Vessel-whale collisions at this speed are uncommon and, based on reported data contained in the US National Ocean and Atmospheric Administration database, there only two known instances of collisions when the vessel was travelling at less than 6 knots, both of these were from whale watching vessels that were deliberately placed among whales (Jensen and Silber, 2004).

Vessels undertaking the Petroleum Activities Program within the Operational Area are likely to be travelling less than 8 knots; much of the time vessels will be holding station. Therefore, the risk of a vessel collision with marine fauna resulting in death is inherently low. No known key aggregation areas (resting, breeding or feeding) are located within or immediately adjacent to the Operational Area for any protected species. However, the Operational Area overlaps a whale shark foraging BIA, the facility section of the Operational Area overlaps the pygmy blue whale migration BIA and the export pipeline section overlaps the humpback whale migration BIA.

Whale sharks are at risk from vessel strikes when feeding at the surface, or in shallow waters (where there is limited option to dive). Whale sharks may traverse offshore waters, including the Operational Area, during their migrations to and from Ningaloo Reef. A foraging BIA for whale sharks overlaps the Operational Area. However, it is not expected that whale sharks would occur in large numbers, given there is no main aggregation area within the vicinity of the Operational Area, and their presence would be transitory and of a short duration. There are no constraints preventing whale sharks from moving away from vessels (e.g. shallow water or shorelines) within the Operational Area.

Analysis of underwater noise logger data indicated pygmy blue whales are present in waters off North West Cape between October to December (northbound migration) and April to August (southbound migration) (McCauley and Jenner, 2010). Satellite tagging studies have shown pygmy blue whales migrating along the Western Australian coast near the Operational Area in water depths between 200 m and 1000 m, which includes the hydrocarbon gathering system section of the Operational Area (which extends from the riser platform at 85 m to the deepest well at approximately 1000 m).

Humpback whales are seasonally abundant within the overlapping migration BIA during their annual northern and southern migrations, between May and November and August and November, respectively. Although only the export pipeline section of the Operational Area overlaps the humpback whale BIA, aerial surveys undertaken by Woodside have indicated that the greatest density of whales are concentrated in water depths of 200 to 300 m, with the majority of whales typically in depths less than 500 m (RPS Environment and Planning 2010a). As such, humpback whales may occur across the Operational Area during their seasonal migration periods.

Vessel disturbance/strikes are considered key threats to whale sharks and pygmy blue and humpback whales. Relevant conservation advice for whale sharks suggests offshore developments and transit times of large vessels in areas along the northward migration route be minimised. The NNM status of the facility aligns with this advice as vessels (including ASV and HLV) will only be present for short periods in the Operational Area when the facility is manned, during IMR activities or during the installation of the water handling unit. Given this, and the seasonality/overall relatively low density of whale sharks and humpback and pygmy blue whales recorded in proximity to the Operational Area, vessel strikes during the Petroleum Activities Program are considered to be highly unlikely. Considering the typical speeds of vessels within the Operational Area, any collision between vessels and whales would not be expected to result in mortality.

Vessel strikes have also been identified as a threat to marine turtles; however, no explicit management actions are listed in relevant conservation advices or recovery plans. The typical response from turtles on the surface to the presence of vessels is to dive (a potential "startle" response), which decreases the risk of collisions (Hazel *et al.*, 2007). As with cetaceans, the risk of collisions between turtles and vessels increases with vessel speed (Hazel *et al.* 2007). Given the low speeds of vessels undertaking the Petroleum Activities Program, along with the expected low numbers of turtles within the Operational Area, interactions between vessels and turtles are considered to be highly unlikely.

The facility section of the Operational Area overlaps a flatback internesting buffer BIA which extends for 40 km around a nesting BIA at the Montebello Islands and Dampier Archipelago during their summer nesting period. Given the water depth around the facility (between approximately 85 and 1000 m) and absence of potential nesting or significant foraging habitat for turtles (i.e. no emergent islands, reef habitat or shallow shoals/banks) the facility Operational Area is unlikely to represent important habitat for marine turtles.

The export pipeline section of the Operational Area also overlaps the aforementioned flatback turtle internesting buffer BIA, as well as internesting BIAs for green, hawksbill and loggerhead turtles. The BIAs for flatback, green and hawksbill turtles have also been designated as habitat critical to the survival of the species in the Recovery plan for marine turtles in Australia 2017–2027 (Commonwealth of Australia, 2017); however, these areas are likely to hold the same significance as the existing BIAs with slightly differing spatial areas. The export pipeline lies in water depths of 40 to 85 m. No potential nesting or significant foraging habitat for turtles (i.e. no emergent islands, reef habitat or shallow shoals/banks) overlap the export pipeline section of the Operational Area.

Given there are significant nesting sites along the mainland coast and islands in proximity to the export pipeline section of the Operational Area, turtles are likely to transit this area. Individuals may also infrequently forage in some areas of the export pipeline (i.e. flatback turtles), although not in significant numbers given the lack of suitable habitat and distance from emergent land. As vessels are likely to only operate within the Operational Area infrequently during IMR activities and when the facility is manned, interactions with vessels during the Petroleum Activities Program are highly unlikely. Given vessels will be moving at low speeds while in the Operational Area, turtles are likely to avoid collisions with vessels by diving or swimming away from the area.

It is unlikely that vessel movement associated with the Petroleum Activities Program will have a significant impact on marine fauna populations given:

- the low presence of transiting individuals within the facility Operational Area
- low occurrence of vessels operating within the export pipeline Operational Area
- avoidance behaviour commonly displayed by whales, whale sharks and turtles
- low operating speed of the activity support vessels (generally less than 8 knots or stationary, unless operating in an emergency).

Activities are considered unlikely to result in a consequence greater than slight, short-term disruption to individuals or a small proportion of the population and no impact on critical habitat or fauna activity.

Summary of Control Measures

- EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans , which include the following measures:
  - Vessels will not travel greater than 6 knots within 300 m of a cetacean (caution zone) and not approach closer than 100 m from a whale.
  - Vessels will not approach closer than 50 m for a dolphin and/or 100 m for a whale (with the exception of animals bow riding).
  - If the cetacean shows signs of being disturbed, activity support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.

Physical Presence: Introduction of Invasive Marine Species

Risks Evaluation Summary													
Source of Risk	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Invasive species in vessel ballast tanks or on vessels/ submersible equipment.					X	X		A	E	1	L	LCS GP PJ	Broadly Acceptable

Description of Source of Risk

The facility and export pipeline rely on a number of vessels to service routine needs when the riser platform is manned (e.g. transferring material and equipment) and, less frequently, to provide specialist services (subsea IMR activities, ASV etc.). Vessels will also be required during installation of the water handling unit, where a HLV will be in close proximity the riser platform during the heavy lift only. The HLV will mobilise to field and undertake required trials, it will then wait outside the 500 m PSZ for suitable conditions for the installation to take place. IMR activities may take place across the facility section of the operational area in waters of 85–962 m and across the extent of the export pipeline section of the Operational Area, in water depths between 40 to 85 m (i.e. in Commonwealth Waters). Vessels contracted to conduct these activities may be sourced from the local area (Dampier, Port Hedland, etc.) or from further afield, depending on the type of vessel required and availability.

All vessels are inherently subject to some level of marine fouling. Organisms attach to the vessel hull, particularly in areas where organisms can find a good surface (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests, etc.). Organisms can also be drawn into ballast tanks during on-boarding of ballast water as cargo is unloaded or to balance vessels under load. Biofouling organisms can become established in an area through the release of propagules (e.g. eggs or larvae), or by attaching to substrate after becoming detached from the host vessel.

Non-indigenous Marine Species (NIMS) have been introduced into a region beyond their natural biogeographic range and have the ability to survive, reproduce and establish founder populations. Not all NIMS introduced into an area will thrive or cause demonstrable impacts. Indeed, the majority of NIMS around the world are relatively benign and few have spread widely beyond sheltered ports and harbours. Only a subset of NIMS that become abundant and impact on social/cultural, human health, economic and/or environmental values can be considered Invasive Marine Species (IMS).

During the Petroleum Activities Program, the following vessel activities have the potential to lead to the introduction of IMS:

- discharge of ballast water from vessels
- vessel interactions with the facility.

Consequence Assessment

Species of concern vary from one region to another depending on various environmental factors such as water temperature, water depth, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities. IMS are typically species that occur in shallow water, and hence are unlikely to survive in much of the Operational Area; support vessel hulls and sections of riser platform or export pipeline near the sea surface are the only substrates considered suitable for establishment of potential IMS.

Introducing IMS into the local marine environment may alter the ecosystem, as IMS have characteristics that make them superior (in a survival and/or reproductive sense) to indigenous species. They may prey upon local species (which had previously not been subject to this kind of predation and therefore, have not evolved protective measures against the attack), they may outcompete indigenous species for food, space or light and can also interbreed with local species, creating hybrids such that the endemic species is lost.

IMS have also proven economically damaging to areas where they have been introduced and established. Such impacts include direct damage to assets (fouling of vessel hulls and infrastructure) and depletion of commercially harvested marine life (e.g. shellfish stocks). IMS have proven particularly difficult to eradicate from areas, once established. If the introduction is captured early, eradication may be effective but is likely to be expensive, disruptive and, depending on the method of eradication, harmful to other local marine life.

Despite the potential high consequence of the establishment of a marine pest within a high value environment as a result of introduction, unlike coastal or sheltered nearshore waters, the deep offshore open waters of the Operational Area are not conducive to the settlement and establishment of IMS (Geiling, 2014), due to the lack of light or suitable habitat to sustain growth or survival. The Petroleum Activities Program will be undertaken in an open ocean, offshore location away from shorelines, with the majority of activities occurring in waters approximately 85 to 962 m deep around the riser platform and subsea infrastructure. Furthermore, vessels will be used only intermittently due to the riser platform's NNM status.

Activities which may occur in more shallow waters (within Commonwealth Waters) along the export pipeline (approximately 40 to 85 m water depths) will occur infrequently.

The majority of vessels used during the Petroleum Activities Program are also typically sourced from Australia and are not considered high risk for IMS introduction. Given this, the likelihood of introducing/acquiring IMS during the Petroleum Activities Program is considered highly unlikely and considered manageable given ballast water and biofouling controls which will be implemented.

Summary of Potential Impacts to Environment Values

In support of Woodside's assessment of the impacts and risks of IMS introduction associated with the Petroleum Activities Program, Woodside conducted a risk and impact evaluation of the different aspects of marine pest translocation associated with the activity. The results of this assessment are presented in the table below.

The assessment evaluated all potential receptors and pathways between receptors to identify credible risks for the introduction of IMS. From this assessment the only credible pathway identified was the establishment of IMS on the riser platform, with no credible transfer of IMS to a secondary vessel. Woodside has presented the highest potential environmental consequence from this risk as Slight (E) and likelihood as Highly Unlikely (1), resulting in an overall Low risk following the implementation of identified controls.

Table 12-25: Assessment of the impacts and risks of IMS introduction associated with the Petroleum Activity Program

IMS Introduction Aspect	Credibility of Introduction	Consequence of Introduction	Likelihood
Transfer of IMS from infected vessel to and subsequent establishment on the riser platform.	**Credible** There is potential for the transfer of marine pests to occur during transfer of materials/bunkering operations when vessels come within the 500 m exclusion zone around the riser platform.	**Slight (E) – Environment** **Minor (D) – Reputation and Brand** If IMS were to become established on the riser platform, this would potentially result in fouling of intakes (depending on the pest introduced), and would likely result in the quarantine of the platform until eradication could occur (through cleaning and treatment of infected areas), which would be costly to undertake. Such introduction would be expected to have a Minor (D) impact to Woodside's reputation and brand, and close scrutiny of asset level operations or future proposals. The Environmental consequence of introduction of IMS to the riser platform is considered Slight (E) and would relate	**Highly Unlikely (1)** Interactions between the riser platform and support vessels will be limited during the Petroleum Activities Program given its NNM status, and given the 500 m safety exclusion zones which will be adhered too, except during transfer of materials/bunkering activities. Spread of marine pests via transfer from vessels hulls or from ballast water or spawning in these open ocean environments is considered Highly Unlikely (1).

		to localised habitat already established directly on the riser platform.	
Transfer of IMS from infected vessel to, and subsequent establishment on, the riser platform, followed by transfer of IMS to a secondary vessel from the riser platform.	**Not Credible** The risk of subsequent transfer and establishment of IMS is considered so remote that it is not credible for the purposes of the Petroleum Activities Program. The transfer of a marine pest from an infected activity vessel to the riser platform was already considered highly unlikely given the offshore open ocean environment and limited close interactions between vessels and the platform. For a marine pest to then establish into a mature spawning population on the riser platform and then transfer to another support vessel is not considered credible (i.e. beyond the Woodside risk matrix). The Pluto offshore facility is located in an offshore, open ocean, deep environment. Support vessels only spend short periods of time alongside the riser platform (i.e. during materials transfer or bunkering activities). There is also no direct contact (i.e. they are not tied up alongside) during these activities. It's also noted that Woodside has been conducting marine vessel movements between the Pluto offshore facility and WA ports (such as Dampier), for a long period of time and no IMS has been detected in these ports (DoF 2017).		
Transfer of IMS from infected vessel to Operational Area and establishment on the seafloor or subsea infrastructure.	**Not Credible** The Pluto offshore facility section of the Operational Area is in deep offshore open waters in depths between 85 – 1000 m which are not conducive to the settlement and establishment of IMS. Given the depth to the seabed, IMS reaching and		

	becoming established on the seafloor is considered not credible.		
Transfer of IMS from infected vessel to the export pipeline during IMR activities.	**Not Credible** The risk is considered so remote that it is not considered credible for the purposes of the Petroleum Activity Program. The transfer of a marine pest from an infected activity vessel onto the export pipeline is not considered credible (i.e. beyond the Woodside risk matrix). The export pipeline is located in an open ocean environment in depths between 40–85 m. Vessels will only spend short periods of time near the pipeline (i.e. during IMR activities). There is also no direct contact (i.e. the vessel will not be tied to the pipeline) during these activities.		

Summary of Control Measures

- All vessels undertaking ballast water exchange or treating ballast water using an approved ballast water treatment system
- Woodside's IMS risk assessment process will be applied to vessels undertaking the Petroleum Activities Program.
  - Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS Inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced)

Unplanned Hydrocarbon Release: Topside Loss of Containment

Risks Evaluation Summary													
Source of Risk	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon release from topsides process equipment to the marine environment and atmosphere.			X			X	X	A	D	1	M	CLS GP PJ	Acceptable if ALARP

Description of Source of Risk

The facility has a range of topsides process and non-process equipment on the riser platform. A loss of containment from the riser platform topsides includes hydrocarbon inventories that could be released to the environment from pressurised process equipment and piping manifolds and non-process hydrocarbons and chemicals.

Events that could lead to loss of containment from the topsides are:

- corrosion
- erosion
- material defect
- welding defect
- piping/equipment repair/defect
- vibration fatigue failure
- equipment overpressure.

Escalation from MEEs can also potentially lead to Topsides Loss of Containment:

- Loss of Structural Integrity (**MEE-03**)
- Loss of Marine Vessel Separation (**MEE-04**)
- Loss of Control of Suspended Platform Load (**MEE-05**).

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE Failure section below.

Topsides Loss of Containment – Credible Scenarios

Topsides process and non-process hydrocarbon inventories, and therefore, worst case credible spill scenarios, are relatively low for the riser platform in comparison to other facilities on the NWS. The credible loss scenario includes the loss of the usual inventory of condensate in the flare knock out drum (up to 55 m^3) and the loss of the non-process hydrocarbons on the topsides, the largest being diesel in the crane pedestal storage tank (80 m^3). While a number of hydrocarbon release scenarios were determined to constitute MEEs, the consequence assessment for a topsides loss of containment determined this source of risk is not an MEE.

Quantitative Spill Risk Assessment

Diesel spill modelling undertaken for a large diesel spill (105 m^3 released in under ten minutes) at the Greater Western Flank Project (GWF) location near the GWA facility, located 75 km north east of the facility (APASA 2016) was used as an analogue for the topside loss of containment. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volume for a topsides loss of containment.

Hydrocarbons Characteristics

Pluto condensate is more volatile than diesel with the majority (73%) evaporating in the first 12 hours with very little residual hydrocarbons remaining (1%). While marine diesel is a mixture of volatile and persistent hydrocarbons. Additional information on marine diesel is provided below.

Marine diesel is a mixture of volatile and persistent hydrocarbons with low proportions of highly volatile and residual components. In general, about 6% of the oil mass should evaporate within the first 12 hours (boiling point (BP) < 180 °C); a further 35% should evaporate within the first 24 hours (180 °C < BP < 265 °C); and a further 54% should evaporate over several days (265 °C < BP < 380 °C). Approximately 5% of the oil is shown to be persistent. The aromatic content of the oil is approximately 3%.

If released in the marine environment and in contact with the atmosphere (i.e. surface spill), approximately 41% by mass of this hydrocarbon is predicted to evaporate over the first couple of days depending upon the prevailing conditions, with further evaporation slowing over time. The heavier (low volatility) components of the oil tend to entrain into the upper water column due to wind-generated waves but can subsequently resurface if wind-waves abate. Therefore, the heavier components of this oil can remain entrained or on the sea surface for an extended period, with associated potential for dissolution of the soluble aromatic fraction.

The mass balance forecast for the constant-wind case for marine diesel shows that approximately 40% of the oil is predicted to evaporate within 36 hours. Under these calm conditions the majority of the remaining oil on the water surface would weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation of the residual compounds will slow significantly, and they will then be subject to more gradual decay through biological and photochemical processes.

Under the variable-wind case (**Figure 12-11**), where the winds are of greater strength, entrainment of marine diesel into the water column is indicated to be significant. Approximately two days after the spill, around 50% of the oil mass is forecast to have entrained and a further 45% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (< 2%). The residual compounds will tend to remain entrained beneath the surface under conditions that generate wind waves (approximately > 6 m/s).

Biological and photochemical degradation is predicted to contribute to the decay of the floating slicks and oil droplets in the water column at an approximate rate of around 0.50% per day, for an accumulated total of about 3–4% after seven days in each wind case. However, given the large proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay and/or evaporate over time scales of several weeks to a few months. This long weathering duration will extend the area of potential effect, requiring the break-up and dispersion of the slicks and droplets to reduce concentrations below the thresholds considered in this study.

Modelling Outputs

Floating hydrocarbons at 10 g/m^2 may occur up to 10 km from the release site and no entrained or dissolved hydrocarbons were predicted above thresholds (APASA, 2016).

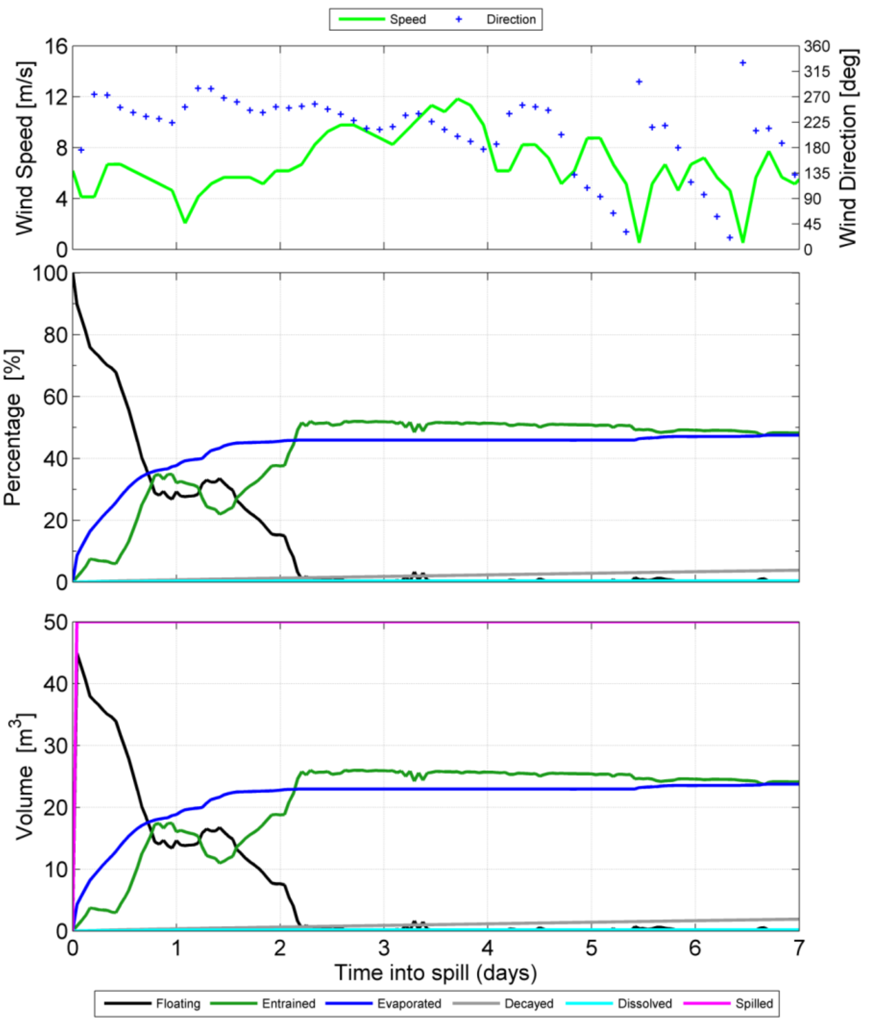

Figure 12-11: Mass balance plot representing, as proportion (middle panel) and volume (bottom panel), the weathering of marine diesel spilled onto the water surface as a one-off release (50 m3 over 1 hour) and subject to variable winds (top panel) at 27 °C water temperature.

Consequence Assessment

Once released to the open offshore setting around the riser platform, the potential for impacts to environmental receptors is limited to those in the open ocean, up to 10 km from the riser platform.

Given the density of the hydrocarbon, this decrease in water quality will be restricted to the top few metres of the water column. As such, impacts to demersal or benthic receptors (e.g. Ancient Coastline or continental slope demersal fish KEF) are not credible.

Water Quality

There may be minor, short-term decrease in water quality in the immediate vicinity of the release location, including the Montebello Marine Park. The soluble fraction of the condensate/diesel may cause acute toxic effects to planktonic organisms. Given the short generation times and high productivity of planktonic communities, this impact will be localised and may have a short-term impact on planktonic species populations.

Air Quality

A topsides release of Pluto condensate will be accompanied by a gas plume. This will largely comprise methane and ethane, which are buoyant and will rise up through the atmosphere. The gas plume is expected to mix and dilute rapidly in the atmosphere. Hence the gas plume has limited potential to impact upon fauna in the vicinity of the release location. Any impacts (such as asphyxiation) will be highly localised and of no lasting effect on species populations.

Species

A range of marine species may be present around the riser platform, such as cetaceans, marine turtles, whale sharks, fishes and birds. These species are widely distributed relative to the potential ZoC that would result from a topsides loss of containment (due to the relatively small volume of hydrocarbons). Many large marine fauna in the region are

migratory, and are seasonally present in the Operational Area, which reduces the likelihood of exposure. Air breathing marine species may be impacted by the reduction in air quality (see Air Quality section above); however, the potential for this impact is very limited. Marine fauna at or near the sea surface may be contacted by hydrocarbons, resulting in oiling. This may lead to impacts such as irritation of sensitive mucous membranes (e.g. eyes, mouth, and digestive tract), matting of feathers (leading to inability to fly and loss of insulation) or clogging of filtering structures (e.g. gills). Pelagic fish may be exposed to spilled hydrocarbons but are expected to avoid areas of high concentrations. Depending on the degree of exposure and the sensitivity of the receptor, these impacts may lead to injury or death. Given the volatile nature of the hydrocarbons and the relatively small release volume, the potential for these impacts is largely constrained to the initial 12 hours immediately after the release. Hence, the potential impacts to species will be localised and of no lasting effect to species populations.
Summary of Control Measures

• Offshore petroleum and Greenhouse Gas Storage (Safety) Regulations 2009. Accepted Safety Case for the facility
• Chemical Selection and Assessment Environment Guideline:
  o Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected, no further control required.
  o If chemicals with a different OCNS rating, sub warning or non-OCNS rated chemicals are required chemicals will be assessed in accordance with the guideline prior to use
• Raising incident reports within event reporting system for unplanned releases.
• Maintaining topsides hydrocarbon-containing infrastructure integrity. Integrity will be managed with the following SCE technical performance standards:
  o P01 – Pressure Vessels
  o P04 – Tanks
• Maintaining Safety Instrumented Systems to prevent hydrocarbon loss of containment. Integrity will be managed with the following SCE technical performance standards:
  o F06 – Safety Instrumented System
• Riser platform drainage system in place to contain and dispose leaks and spills of hazardous liquids.
• Mitigation – hydrocarbon spill response.

Unplanned Hydrocarbon Release: Loss of Well Containment (MEE-01)

Impacts and Risks Evaluation Summary													
Source of Risk	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Release of hydrocarbons resulting from loss of subsea well containment.		X	X	X	X	X	X	B	B	1	M	LCS GP PJ RBA CV SV	Acceptable if ALARP

Description of Source of Risk

Background

A loss of well containment can lead to an uncontrolled release of reservoir hydrocarbons or other well fluids to the environment (well blowout). Woodside has identified a well blowout as the scenario with the worst case credible environmental outcome as a result of this event. Due to the potential consequences, a well loss of containment is considered to be an MEE (MEE-01). A well loss of containment could occur due to a variety of causes including:

- internal corrosion
- external corrosion
- erosion
- overpressure of the annuli
- fatigue
- loss of control of suspended load from vessel operating near subsea wells
- loss of structural integrity.
- A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure bowties.

Loss of Well Containment – Credible Scenarios

The Petroleum Activities Program includes production from a series of subsea wells. To assess the potential consequences, a worst credible hydrocarbon release scenario has been defined for a Pluto well (PLA03). The Pluto well scenario is based on a loss of containment from a well which best represents the overall characteristics of the Pluto reservoir and is a high producing well, thus representing a worst credible volume release and potential environmental impact, for current Pluto and Xena wells. Future wells (Pluto and Pyxis) were considered but the existing PLA03 scenario is considered to be worst case.

The loss of well containment scenario was assumed to have a duration of 77 days. This duration is based on the estimated time required to successfully drill an intervention well. The characteristic of the release scenario is summarised in **Table 12-26**: Summary of worst-case loss of well containment hydrocarbon release scenarios. The characteristics of Pluto condensate was used as the basis in the modelling the loss of well containment scenario; refer to **Section 5.4** for additional information on modelling methods, hydrocarbon characteristics and environmental impact thresholds.

Table 12-26: Summary of worst-case loss of well containment hydrocarbon release scenarios

Scenario	Hydrocarbon	Average Rate (m^3/day)	Duration (days)	Depth (m)	Latitude (D°M'S'')	Longitude (D°M'S'')	Total Hydrocarbon Release Volume (m^3)

Well blowout – PLA03	Pluto condensate	1011	77	831	115°7’54.8”E	19°54’48.2”S	77,861

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in well design and construction. In the company’s recent history, it has not experienced any well integrity events that have resulted in significant releases or significant environmental impacts. The PLA facility has not experienced a worst-case loss of well containment in its operational history.

Decision Type

A decision type ‘B’ has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the Bowtie Methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons as a result of well loss of containment is considered a Major Environment Event (MEE-01). The hazard associated with this MEE is hydrocarbons in reservoirs, wells, wellheads and trees for subsea wells tied-back to the riser platform.

Quantitative Spill Risk Assessment

Stochastic spill modelling of the worst case credible loss of well containment spill scenarios was undertaken by RPS APASA, on behalf of Woodside, over a 77-day simulation length to determine the fate of hydrocarbons released in based on the assumptions in **Section 5.4**. Stochastic modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volumes for all loss of well containment scenarios.

Hydrocarbon Characteristics

Pluto condensate contains a low proportion (1% by mass) of residual hydrocarbon compounds that will not evaporate at atmospheric temperatures.

Evaporation rates will increase with temperature, but in general about 73% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); a further 16% should evaporate within the first 24 hours (180 °C < BP < 265 °C); and a further 10% should evaporate over several days (265 °C < BP < 380 °C).

The unweathered hydrocarbon mixture has low density (0.738 g/cm^3) relative to seawater, and very low dynamic viscosity (0.617 cP).

Pluto Condensate will tend to evaporate rapidly, with around 89% of the spilled volume predicted to evaporate after 24 hours for the variable-wind case. Biological and photochemical degradation is predicted to contribute to the decay of the floating slicks and oil droplets in the water column at a very small rate. Adding this to the losses through evaporation indicates that about 6% of the spilled volume is predicted to remain afloat after seven days under light or moderate winds.

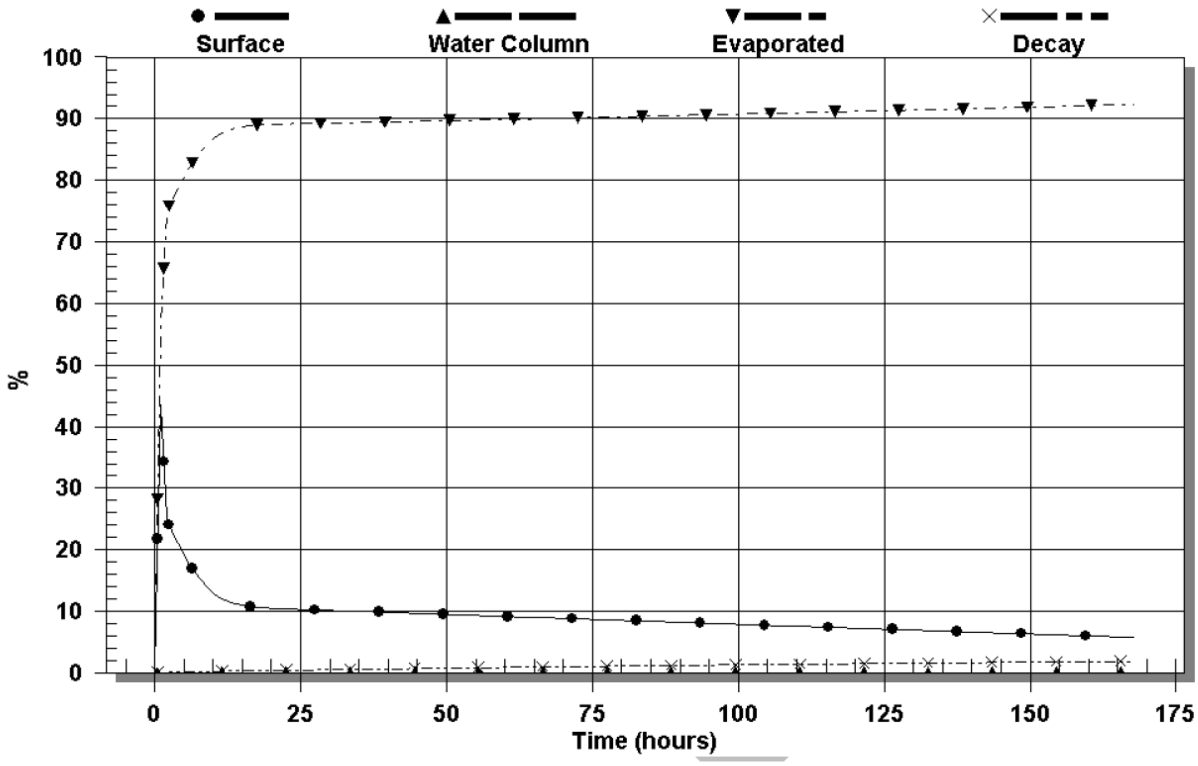

Figure 12-12: Proportional mass balance plot representing the weathering of Pluto condensate spilled onto the water surface as a one-off release (50 m^3 over 1 hour) and subject to constant 5 kn (2.6 m/s) wind at 27 °C water temperature.

Subsea Plume Dynamics

The loss of well containment will result in a buoyant plume of hydrocarbons, which has been modelled using the OILMAP-Deep numerical model.

Table 12-27: Inputs and outputs for OILMAP-Deep model for loss of well containment

	Parameter	Loss of containment (PLA03)
Inputs	Release depth (m below sea level)	830.6
	Oil density (g/cm^3) (at 15°C)	0.738
	Oil viscosity (cP) (at 15°C)	0.617
	Oil temperature (°C)	91
	Gas:oil ratio (bbl/MMscf)	12
	Oil flow rate (m^3/d)	1011
	Hole diameter (m)	0.157
Outputs	Plume diameter (m)	69.9
	Plume height (m above sea bed)	278.4
Predicted oil droplet size distribution	3.5% droplets of size (µm)	3.6
	14.9% droplets of size (µm)	7.2
	24.9% droplets of size (µm)	10.7
	26.5% droplets of size (µm)	14.3
	19.7% droplets of size (µm)	17.9
	10.5% droplets of size (µm)	21.5

Likelihood

In accordance with the Woodside Risk Matrix, a worst-case loss of well containment has been defined as a 'highly unlikely' event as it 'has occurred once or twice in the industry' (experience based likelihood) and aligns with a frequency of a '1 in 10,000 to 1 in 100,000 years' event. Information to support this likelihood determination is outlined below.

Review of industry statistics indicates that the probability of a loss of well containment for production wells is low (10.6% of blowouts) relative to other activities in other hydrocarbon provinces (Gulf of Mexico and the North Sea), such as exploration drilling (31.5% of blowouts), development drilling (23.6% of blowouts) and well workovers (20.5% of blowouts) (SINTEF 2017). When considering likelihood from an 'Experience' perspective, the review also concluded:

- When considering likelihood of the environmental consequence of the blowout event, historic blowouts that have had major, long-term impact to the environment ('B' consequence rating) have not occurred many times in the industry. This also further supports the likelihood ranking of 'Highly Unlikely'.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case loss of well containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Environmental Value/s Potentially Impacted

Zone of Consequence

Surface Hydrocarbons

Quantitative hydrocarbon spill modelling results for surface hydrocarbons indicated no potential for expression above environmental impact threshold concentrations (10 g/m^2). Due to volatile, non-persistent nature of the condensate, modelling indicates that surface hydrocarbons are expected to readily evaporate, resulting in no ZoC.

Entrained Hydrocarbons

Modelling results indicated a number of environmental sensitivities could potentially be contacted by entrained hydrocarbons above impact thresholds, with time to contact ranging from just over two days (Rankin Bank) to 14 days (Ningaloo Coast). In the event of a worst-case loss of well containment scenario occurring, entrained hydrocarbons at or above 500 ppb are forecast to potentially extend up ~450 km from the release site. The most likely direction of drift is south-westerly around the Ningaloo Coast and then southwards, reflecting the prevailing current patterns. Results also indicate that entrained oil may also be likely to drift towards the northeast and in the offshore directions.

Dissolved Hydrocarbons

In the event of a loss of well containment scenario occurring, dissolved hydrocarbons at or above 500 ppb (environmental impact threshold) will be localised and are only forecast to potentially occur up to 10 km away.

Accumulated Hydrocarbons

Quantitative hydrocarbon spill modelling results for maximum local accumulated hydrocarbon concentrations indicated no potential shoreline accumulation above environmental impact threshold concentrations (100 g/m^2).

Table 12-28: Key receptor locations and sensitivities potentially contacted above impact thresholds by the loss of well containment scenario with summary hydrocarbon spill contact

Environmental setting	Location/name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Hydrocarbon Contact and Fate (Condensate/ Crude/Marine Diesel)			
		Physical		Biological																						Socio-economic and Cultural								
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities/Habitats								Protected Species									Other Species										
		Open water – (pristine)	Marine Sediment – (pristine)	Coral reef	Seagrass beds/macroalgae	Mangroves	Spawning/nursery areas	Open water – productivity/upwelling	Non-biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Seasnakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident/demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and recreation	Protected Areas/Heritage – European and Indigenous/Shipwrecks	Offshore oil and gas infrastructure (topside and subsea)	Surface hydrocarbon (≥ 10 g/m²)	Entrained hydrocarbon (≥ 500 ppb)	Dissolved aromatic hydrocarbon (≥ 500 ppb)	Accumulated hydrocarbons (> 100 g/m²)
Offshore[5]	Commonwealth waters	✓	✓					✓		✓					✓	✓				✓	✓	✓	✓	✓		✓		✓		✓		X	X	
	Montebello Marine Park	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X		
	Ningaloo Marine Park	✓	✓					✓		✓					✓	✓			✓		✓	✓	✓	✓	✓	✓		✓	✓			X		
	Gascoyne Marine Park	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		X		
Submerged Shoals and Banks	Rankin Bank	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓				X		
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X		
	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		X		

[5] Note: hydrocarbons cannot accumulate on open ocean, submerged receptors, or receptors not fully emergent.

Environmental setting	Location/name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Hydrocarbon Contact and Fate (Condensate/ Crude/Marine Diesel)			
		Physical		Biological																						Socio-economic and Cultural								
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities/Habitats								Protected Species									Other Species										
		Open water – (pristine)	Marine Sediment – (pristine)	Coral reef	Seagrass beds/macroalgae	Mangroves	Spawning/nursery areas	Open water – productivity/upwelling	Non-biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Seasnakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident/demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and recreation	Protected Areas/Heritage – European and Indigenous/Shipwrecks	Offshore oil and gas infrastructure (topside and subsea)	Surface hydrocarbon (≥ 10 g/m²)	Entrained hydrocarbon (≥ 500 ppb)	Dissolved aromatic hydrocarbon (≥ 500 ppb)	Accumulated hydrocarbons (> 100 g/m²)
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X		
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X		

Summary of Potential Impacts to Environmental Values(s)	
Summary of Potential Impacts to protected species	
Setting	**Receptor Group**
Offshore, Oceanic Reefs and Islands	**Cetaceans** A range of cetaceans were identified as potentially occurring with the Operational Area and wider ZoC. In the event of a well loss of containment entrained and dissolved hydrocarbons exceeding environmental impact threshold concentrations may drift across habitat for oceanic cetacean species and the migratory routes and BIAs of cetaceans considered to be MNES, including humpback whales and pygmy blue whales (north- and southbound migrations). Cetaceans that have direct physical contact with entrained or dissolved aromatic hydrocarbons may suffer ingestion of hydrocarbons (from prey, water and sediments), aspiration of oily water or droplets and inhalation of toxic vapours (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system, neurological damage (Helm *et al.* 2015), reproductive failure, adverse health effects (e.g. lung disease, poor body condition) and potentially mortality (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Given the non-persistent nature of the hydrocarbons and that floating hydrocarbons are not expected above impact thresholds, the area where potential impacts from inhalation may occur is localised around the release location. A review of cetacean observations in relation to large scale hydrocarbon spills was undertaken for the Deepwater Horizon spill. It is worth noting that the Deepwater Horizon and Exxon Valdez spills, two well-studied large-scale hydrocarbon releases, were both crude oil spills. Crude oil is much more persistent in the environment than the condensate that may be released during the Petroleum Activities Program, and also more amenable to the formation of surface slicks, which cetaceans may be exposed to when breathing. The review concluded that exposure to oil from the Deepwater Horizon resulted in increased mortality to cetaceans in the Gulf of Mexico (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Cetacean populations that are resident within the ZoC may be susceptible to impacts from spilled hydrocarbons if they interact with an area affected by a spill. Such species are more likely to occupy coastal waters (refer to the mainland and islands section below for additional information). Suitable habitat for oceanic toothed whales (e.g. sperm whales) and dolphins (e.g. spinner dolphin) is broadly distributed throughout the region and as such, impacts are unlikely to affect an entire population. Other species identified in may also have possible transient interactions with the ZoC (**Table 12-28** for the list of receptor locations important for cetaceans). Physical contact with hydrocarbons to these species is likely to have biological consequences however it is unlikely to affect an entire population and not predicted to impact on the overall population viability. Given the nature of the hydrocarbon, it is expected to weather rapidly and remain entrained in the water column; cetaceans that may interact with spilled hydrocarbons are most likely to be subject to physical impacts. Given cetaceans maintain thick skin and blubber, external exposure to hydrocarbons may result in irritation to skin and eyes. Entrained hydrocarbons may also be ingested, particularly by baleen whales which feed by filtering large volumes of water. Fresh hydrocarbons (i.e. typically in the vicinity of the release location) may have a higher potential to cause toxic effects when ingested, while weathered hydrocarbons are considered to be less likely to result in toxic effects. Pygmy blue whales and humpback whales are known to migrate seasonally through the wider ZoC. A major spill in May to November would coincide with humpback whale migration through the waters off the Pilbara, North West Cape and Shark Bay. A major spill in April to August or October to January would coincide with pygmy blue whale migration. Double *et al.* (2014) suggest that pygmy blue whales migrate in offshore waters west of the Operational Area in approximately 200–1000 m of water. Both pygmy blue and humpback whales are baleen whales, and hence, are most likely to be significantly impacted by toxic effects when feeding. However, feeding during migrations is low level and opportunistic, with most feeding for both species in the Southern Ocean. As such, the risk of ingestion of hydrocarbons is low. Migrations of both pygmy blue whales and humpback whales are protracted through time and space (i.e. the whole population will not be within the ZoC), and as such, a spill from the well loss of containment is unlikely to affect an entire population. The humpback whale resting area in Exmouth Gulf and the calving area in Camden Sound are not predicted to be contacted by surface, entrained or dissolved hydrocarbons above threshold concentrations.
Offshore, Oceanic Reefs and Islands	A loss of well containment resulting in a well blowout, during the migration periods, could result in a disruption to a large portion of the humpback or pygmy blue whale populations. Such disruption could include behavioural impacts (e.g. avoidance of impacted areas), sub-lethal biological effects (e.g. skin irritation, irritation from ingestion or inhalation, reproductive failure) and, in rare circumstances, death. However, such disruptions or impacts are not predicted to impact on the overall population viability of

	cetaceans given the global distribution of these species. **Marine Turtles** Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon spills (National Oceanic and Atmospheric Administration 2010). Contact with entrained hydrocarbon, can therefore, result in hydrocarbon adherence to body surfaces (Gagnon and Rawson 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (National Oceanic and Atmospheric Administration 2010). Given the hydrocarbon is expected to weather rapidly when released to the environment, relatively fresh entrained hydrocarbons (which are typically relatively close to the release location) are considered to have the greatest potential for impact. Hydrocarbons in surface waters may also impact turtles when they surface to breathe and inhale toxic vapours. Their breathing pattern, involving large 'tidal' volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours which are the most toxic component of the hydrocarbon spill (Milton and Lutz 2003). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (National Oceanic and Atmospheric Administration 2010). Given the non-persistent nature of the hydrocarbons and that floating hydrocarbons are not expected above thresholds, the area where potential impacts from inhalation may occur is localised around the release location. Due to the offshore location and therefore the absence of potential nesting habitat, the Operational Area is unlikely to represent important habitat for marine turtles. It is, however, acknowledged that marine turtles may be present foraging within the ZoC, and the ZoC would overlap with the BIAs, in particular, the internesting BIAs for flatback turtles which extend for ~80 km from known nesting locations. The Petroleum Activities Program will coincide with nesting season for marine turtles in the region. In the event of a loss of well containment, there is potential that entrained and dissolved hydrocarbons exceeding environmental impact threshold concentrations will be present in offshore waters. Therefore, a hydrocarbon spill may disrupt a portion of the population; however, there is no threat to overall population viability given the non-persistent nature of predicted hydrocarbons. Potential impacts to nesting and internesting marine turtles are discussed in the *Mainland and Islands (nearshore)* impacts discussion.
	Seasnakes Impacts to seasnakes from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles and may include potential damage to the dermis and irritation to mucus membranes of the eyes, nose and throat (International Tanker Owners Pollution Federation 2011a). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system. In general, seasnakes frequent the waters of the continental shelf area around offshore islands and potentially submerged shoals (water depths < 100 m; see Submerged Shoals below). It is acknowledged that seasnakes will be present in the Operational Area and wider ZoC (refer to **Table 12-28**); however, their abundance is not expected to be high in the deep water and offshore environment. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population but there is not considered to be a threat to overall population viability given the non-persistent nature of hydrocarbons predicted.
	Sharks and Rays Hydrocarbon contact may affect whale sharks through ingestion (entrained/dissolved hydrocarbons), particularly if feeding. Whale sharks may transit offshore open waters when migrating to and from Ningaloo Reef, where they aggregate for feeding from March to July. A whale shark foraging BIA overlaps the Offshore Facility Operational Area, and a foraging (high prey density) BIA lies approximately 276 km south-west of the Operational Area (off the Ningaloo Coast and within the wider ZoC). Therefore, individual whale sharks that have direct contact with hydrocarbons within the spill affected area may be impacted. Impacts to sharks and rays may occur through direct contact with hydrocarbons and contaminate the tissues and internal organs either through direct contact or via the food chain (consumption of prey). As gill breathing organisms, sharks and rays may be vulnerable to toxic effects of dissolved hydrocarbons (entering the body via the gills) and entrained hydrocarbons (coating of the gills inhibiting gas exchange). In the offshore environment, it is probable that pelagic shark species are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Therefore, any impact on sharks and rays is predicted to be minor and localised.
	Seabirds and Migratory Shorebirds The credible loss of well containment scenario results in no floating hydrocarbon above the threshold; hence, the potential for seabird exposure to floating hydrocarbons is considered to be low. Migratory

	shorebirds are unlikely to interact with spilled hydrocarbons; refer to the sections on Islands and Mainland Coast below for a discussion on the potential impacts to migratory shorebirds. Offshore waters are potential foraging grounds for seabirds associated with the coastal roosting and nesting habitat, which includes the numerous islands along the Pilbara coast. There are a number of BIAs for seabirds and migratory shorebirds that overlap with the wider ZoC. Given the relatively low likelihood of encounters between seabirds and floating hydrocarbons, impacts to seabirds in offshore waters are expected to only consist of ecosystem effects, such as reduced prey abundance. Impacts from a loss of well containment to prey such as small pelagic fish (prey for the birds) are not expected to be significant, hence, subsequent impacts to a significant portion of seabirds are not expected.
Submerged Shoals and Banks[6]	**Marine Turtles** There is the potential for marine turtles to be present at submerged shoals such as Rankin Bank. This bank may at times, be foraging habitat for marine turtles, given the coral and filter feeding biota associated with this area. However, is it not a known foraging location. Tagging studies did not indicate any overlap of the tracked post-nesting migratory routes and the Operational Area. It is, however, acknowledged that individual marine turtles may be present at Rankin Bank and the surrounding areas. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population (see offshore description above); however, there is no threat to overall population viability.
	Seasnakes There is the potential for seasnakes to be present at submerged shoals such as Rankin Bank. The potential impacts of exposure are as discussed previously in Offshore – Seasnakes. A hydrocarbon spill may have a minor disruption to a portion of the population but there is no threat to overall population viability. Seasnake species in Australia generally show strong habitat preferences (Heatwole and Cogger 1993); species that have preferred habitats associated with submerged shoals and oceanic atolls may be disproportionately affected by a hydrocarbon spill affecting such habitat.
	Sharks and Rays There is the potential for resident shark and ray populations to be impacted directly from hydrocarbon contact or indirectly through contaminated prey or loss of habitat. Spill model results indicate potential impacts to the benthic communities of Rankin Bank, approximately 24 km from the Operational Area, which may host shark and ray populations. Pelagic sharks and rays are expected to move away from areas affected by spilled hydrocarbons. Impacts to such species are expected to be limited to behavioural responses/displacement. Shark and ray species that have associations with submerged shoals and oceanic atolls may not move in response to such habitat being contacted by spilled hydrocarbons. Such species may be more susceptible to a reduction in habitat quality resulting from a hydrocarbon spill. Impacts to sharks and rays at Rankin Bank are likely to be localised as they are comparable to other Australian reefs and the NWMR submerged shoals and banks. It is expected that there will be no impacts at the population level.
Islands and Mainland (nearshore waters)	**All Species** The information provided on protected species in this section is in addition to that provided in the preceding Offshore and Oceanic Reefs and Submerged Banks and Shoals sections. Refer to these preceding sections for additional discussion of protected species.
	Cetaceans and Dugongs In addition to a number of whale species that may occur in nearshore waters (such as spotted bottlenose dolphins and Indo-Pacific humpback dolphins), coastal populations of small cetaceans and dugongs are known to reside or frequent nearshore waters, including the Ningaloo Coast, Montebello/Barrow/Lowendal Islands Group, Pilbara Southern Island Group, and a number of other nearshore and coastal locations (see **Table 12-28**) which may be potentially impacted by entrained hydrocarbons exceeding threshold concentrations in the event of a loss of well containment. The potential impacts of exposure are as discussed previously in Offshore – Cetaceans. However, nearshore populations of cetaceans and dugongs are known to exhibit site fidelity and are often resident populations. Therefore, avoidance behaviour may have greater impacts to population functioning. Nearshore dolphin species (e.g. spotted bottlenose dolphins) may exhibit higher site fidelity than oceanic species although Geraci (1988) observed relatively little impacts beyond behavioural disturbance. Additional potential environment impacts may also include the potential for dugongs to ingest hydrocarbons when feeding on oiled seagrass stands or indirect impacts to dugongs due to loss of this

[6] The preceding discussion of protected species in the offshore environment is considered to be relevant to protected species associated with submerged shoals and banks. The text in this section is intended to provide additional context and impact assessment for protected species in relation to submerged banks and shoals.

	food source due to dieback in worse affected areas. Therefore, a hydrocarbon spill may have an impact on feeding habitats and result in a disruption to a significant portion of the local population but due to the non-persistent nature of the hydrocarbon, it is not predicted to result in impacts on overall population viability of either dugongs or coastal cetaceans.
	Marine Turtles Several marine turtle species utilise nearshore waters and shorelines for foraging and breeding (including internesting), with significant nesting beaches along the mainland coast and islands in potentially impacted locations such as the Ningaloo Coast, Montebello/Barrow/Lowendal Islands group and Pilbara Islands (Southern Island Group). Many of these locations have been identified as BIA and/or critical habitats. There are distinct breeding seasons. The nearshore waters of these turtle habitat areas may be exposed to entrained hydrocarbons exceeding threshold concentrations. The potential impacts of exposure are as discussed previously in Offshore – Marine Turtles. In the nearshore environment, turtles can ingest hydrocarbons when feeding or can be indirectly affected by loss of food source (e.g. seagrass due to dieback from hydrocarbon exposure) (Gagnon and Rawson 2010). In addition, hydrocarbon exposure can impact on turtles during the breeding season at nesting beaches. Contact with gravid adult females or hatchlings may occur in nearshore waters (entrained hydrocarbons). If entrained hydrocarbons reach the shoreline or internesting coastal waters (refer to **Table 12-28** for receptor locations), there is the potential for impacts to turtles utilising the affected area. During the breeding season, turtle aggregations near nesting beaches within the wider ZoC are most vulnerable due to greater turtle densities and potential impacts may occur at the population level and may impact on overall population viability of some marine turtle species. However, given the volatile nature of the hydrocarbons and low levels of shoreline accumulation predicted, population level impacts will not occur.
	Sharks and Rays Whale sharks and manta rays are known to frequent the Ningaloo Reef system and the Muiron Islands (forming feeding aggregations in late summer/autumn). Whale sharks and manta rays generally transit along the nearshore coastline and are vulnerable to surface, entrained and dissolved aromatic hydrocarbon spill impacts, with both taxa having similar modes of feeding. Whale sharks are versatile feeders, filtering large amounts of water over their gills, catching planktonic and nektonic organisms (Jarman and Wilson 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies, including passive sub-surface ram-feeding and active surface feeding (Taylor 2007). Passive feeding consists of swimming slowly at the surface with the mouth wide open. During active feeding, sharks swim high in the water with the upper part of the body above the surface with the mouth partially open (Taylor 2007). These feeding methods would result in the potential for individuals that are present in worse affected spill areas to ingest potentially toxic amounts of entrained aromatic hydrocarbons into their body. Large amounts of ingested hydrocarbons may affect their endocrine and immune system in the longer term. The presence of hydrocarbons may cause displacement of whale sharks from the area where they normally feed and rest, and potentially disrupt migration and aggregations to these areas in subsequent seasons. Whale sharks may also be affected indirectly by entrained aromatic hydrocarbons through the contamination of their prey. The preferred food of whale sharks are planktonic organisms which are abundant in the coastal waters of Ningaloo Reef in late summer/autumn, driving the annual arrival and aggregation of whale sharks in this area. If the spill event were to occur during the spawning season, this important food supply (in worse spill affected areas of the reef) may be diminished or contaminated. The contamination of their food supply and the subsequent ingestion of this prey by the whale shark may also result in long term impacts as a result of bioaccumulation. There is the potential for other resident shark and ray (e.g. sawfish species) populations to be impacted directly from hydrocarbon contact or indirectly through contaminated prey or loss of habitat. However, it is probable that shark species will move away from the affected areas, although sawfish may exhibit high habitat fidelity. **Table 12-28** indicates the receptor locations predicted to be impacted from entrained aromatic hydrocarbons to the benthic communities of nearshore, subtidal communities, and it is considered that there is the potential for habitat loss to occur. Shark populations displaced or no longer supported due to habitat loss would be expected to redistribute to other locations. Therefore, the consequences to resident shark and ray populations (if present) from loss of habitat, may result in a disruption to a significant portion of the population; however, it is not expected to impact on the overall viability of the population.
	Seabirds and/or Migratory Shorebirds In the event of a loss of well containment, there is the potential for seabirds, and resident/non-breeding overwintering shorebirds that use the nearshore waters for foraging and resting, to be exposed to entrained hydrocarbons. This could result in lethal or sub-lethal effects. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to

	forage in nearshore waters near their breeding colony, resulting in intensive feeding by higher seabird densities in these areas during the breeding season and making these areas particularly sensitive in the event of a spill. Pathways of biological exposure that can result in impact may occur through ingestion of contaminated fish (nearshore waters) or invertebrates (intertidal foraging grounds such as beaches, mudflats and reefs). Ingestion can also lead to internal injury to sensitive membranes and organs (International Petroleum Industry Environmental Conservation Association 2004). Whether the toxicity of ingested hydrocarbons is lethal or sub-lethal will depend on the weathering stage and its inherent toxicity (note the shortest entrained hydrocarbon time to contact with a shoreline is seven days (Southern Island group)). Exposure to hydrocarbons may have longer term effects, with impacts to population numbers due to decline in reproductive performance and malformed eggs and chicks, affecting survivorship and loss of adult birds. Migratory shorebirds may also be exposed to indirect impacts, such as reduced prey availability (Henkel *et al.* 2012). Important areas for foraging seabirds and migratory shorebirds are identified within the ZoC**.** Refer to **Table 12-28** for locations within the predicted extent of the ZoC that are identified as habitat for seabirds/migratory shorebirds. Suitable habitat or seabirds and shorebirds are broadly distributed along the mainland and nearshore island coasts within the ZoC. Of note are important nesting areas (including BIAs within the wider ZoC) including: • Ningaloo Coast • Montebello/Barrow/Lowendal Islands group (including known nesting habitats on Boodie, Double and Middle Islands) • Pilbara Islands North and South Island Group. Therefore, a hydrocarbon spill may result in impacts on key feeding habitat and a disruption to a significant portion of the habitat; however, this is not expected to result in a threat to the overall population viability of seabirds or shorebirds.
Summary of potential impacts to other species	
Setting	**Receptor Group**
All Settings	**Pelagic and Demersal Fish** Fish mortalities are rarely observed to occur as a result of hydrocarbon spills (International Tanker Owners Pollution Federation 2011b). This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Fish that have been exposed to dissolved aromatic hydrocarbons are capable of eliminating the toxicants once placed in clean water, hence individuals exposed to a spill are likely to recover (King *et al.* 1996). Where fish mortalities have been recorded, the spills (resulting from the groundings of the tankers Amoco Cadiz in 1978 and the Florida in 1969) have occurred in sheltered bays. Laboratory studies have shown that adult fish are able to detect hydrocarbons in water at very low concentrations, and large numbers of dead fish have rarely been reported after hydrocarbon spills (Hjermann *et al.* 2007). This suggests that juvenile and adult fish are capable of avoiding water contaminated with high concentrations of hydrocarbons. However, sub-lethal impacts to adult and juvenile fish may be possible, given long-term exposure (days to weeks) to PAH concentrations (Hjermann *et al.* 2007). While modelling of the loss of well containment indicates the potential ZoC for dissolved hydrocarbons is extensive, no time-integrated exposure metrics were modelled; given the oceanographic environment within the wider ZoC, PAH exposures in the order of weeks for pelagic fish are not considered credible. The effects of exposure to oil on the metabolism of fish appears to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Oil reduces the aerobic capacity of fish exposed to aromatics in the water and to a lesser extent affects fish consuming contaminated food (Cohen *et al.* 2005). The liver, a major detoxification organ, appears to be the organ where anaerobic activity is most impacted, probably increasing anaerobic activity to facilitate the elimination of ingested oil from the fish (Cohen *et al.* 2005). Fish are perhaps most susceptible to the effects of spilled oil in their early life stages, particularly during egg and planktonic larval stages, which can become entrained in spilled oil. Contact with oil droplets can mechanically damage feeding and breathing apparatus of embryos and larvae (Fodrie and Heck 2011). The toxic hydrocarbons in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie and Heck 2011). More subtle, chronic effects on the life history of fish as a result of exposure of early life stages to hydrocarbons include disruption to complex behaviours such as predator avoidance, reproductive and social behaviour (Hjermann *et al.* 2007). Prolonged

	exposure of eggs and larvae to weathered concentrations of hydrocarbons in water has also been shown to cause immunosuppression and allows expression of viral diseases (Hjermann *et al.* 2007). PAHs have also been linked to increased mortality and stunted growth rates of early life history (pre-settlement) of reef fishes, as well as behavioural impacts that may increase predation of post-settlement larvae (Johansen *et al.* 2017). However, the effect of a hydrocarbon spill on a population of fish in an area with fish larvae and/or eggs, and the extent to which any of the adverse impacts may occur, depends greatly on prevailing oceanographic and ecological conditions at the time of the spill and its contact with fish eggs or larvae. The continental slope demersal fish communities KEF in the region has been identified as a key ecological feature and overlaps the Operational Area. Additionally, demersal species are associated with the Ancient Coastline KEF (overlaps the Operational Area) and Rankin Bank (approximately 24 km west of the Operational Area). These KEFs and bank may host relatively diverse or abundant fish assemblages compared to relatively featureless continental shelf habitats. Mortality and sub lethal effects may impact populations located close to the well blow out and within the ZoC for entrained/dissolved aromatic hydrocarbons (≥ 500 ppb). Additionally, if prey (infauna and epifauna) surrounding the well location and within the ZoC is contaminated, this can result in the absorption of toxic components of the hydrocarbons (PAHs) potentially impacting fish populations that feed on these. These impacts may result in localised medium/long term impacts on demersal fish habitat (e.g. seafloor).
Summary of potential impacts to marine primary producers	
Setting	**Receptor Group**
Oceanic Reef and Offshore Islands **Submerged Shoals**	The waters overlying the submerged Rankin Bank have the potential to be exposed to hydrocarbons above threshold concentrations (> 500 ppb). This permanently submerged habitat represents sensitive oceanic reef benthic community receptors, extending from deep depths to relatively shallow water. Given the depth of Rankin Bank, it is likely the potential for biological impact is significantly reduced when compared to the upper water column layers. However, potential biological impacts could include sub-lethal stress and in some instances total or partial mortality of sensitive benthic organisms such as corals and the early life stages of resident fish and invertebrate species.
Mainland and Islands (nearshore waters)	**Coral Reef** The quantitative spill risk assessment and ZoC indicate there would be potential for coral reef habitat to be exposed to dissolved and entrained hydrocarbons. There would be potential for entrained and dissolved hydrocarbons above threshold concentrations to reach reef habitat along the Ningaloo Coast and at identified offshore islands and coastline (see **Table 12-28**) such as the Montebello/Barrow/Lowendal Islands Group and Pilbara Southern Islands Group. The shallow coral habitats are most vulnerable to hydrocarbon coating by direct contact with surface slicks during periods when corals are tidally-exposed at spring low tides; such slicks are not expected to form in the event of a loss of well containment for the Petroleum Activities Program due to the nature of the hydrocarbon. Water soluble hydrocarbon fractions associated with surface slicks are also known to cause high coral mortality (Shigenaka 2001) via direct physical contact of hydrocarbon droplets to sensitive coral species (such as the branching coral species). There is significant potential for lethal impacts due to the physical hydrocarbon coating of sessile benthos (e.g. by entrained hydrocarbons), with likely significant mortality of corals (adults, juveniles and established recruits) at the small spill affected areas. This particularly applies to branching corals which are reported to be more sensitive than massive corals (Shigenaka 2001). Exposure to entrained hydrocarbons (≥ 500 ppb) has the potential to result in lethal or sub-lethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals), reef flat (intertidal corals) and lagoonal (back reef) coral communities (with reference to Ningaloo Coast). Mortality in a number of coral species is possible and this would result in the reduction of coral cover and change in the composition of coral communities. Sub-lethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri and Heyward 2000). This could result in impacts to the shallow water fringing coral communities/reefs of the offshore islands (e.g. Barrow/Montebello/Lowendal Islands and Pilbara Southern Islands) and also the mainland coast (e.g. Ningaloo Coast). With reference to Ningaloo Reef, wave-induced water circulation flushes the lagoon and may promote removal of entrained and dissolved hydrocarbons from this particular reef habitat. Under typical conditions, breaking waves on the reef crest induce a rise in water level in the lagoon creating a pressure gradient that drives water in a strong outward flow through channels. In the unlikely event of a spill occurring at the time of coral spawning at potentially affected coral locations or in the general peak period of biological productivity, there is the potential for a significant reduction in successful fertilization and coral larval survival due to the sensitivity of coral early life stages to hydrocarbons (Negri and Heyward 2000). Such impacts are likely to result in the failure of recruitment

	and settlement of new population cohorts. In addition, some non-coral species may be affected via direct contact with entrained and dissolved aromatic hydrocarbons, resulting in sub-lethal impacts and in some cases mortality. This is with particular reference to the early life-stages of coral reef animals (reef attached fishes and reef invertebrates), which can be relatively sensitive to hydrocarbon exposure. Coral reef fish are site attached, have small home ranges and as reef residents they are at higher risk from hydrocarbon exposure than non-resident, more wide-ranging fish species. The exact impact on resident coral communities (which may include fringing reefs of the offshore islands and/or the Ningaloo Reef system) will be entirely dependent on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. Over the worst affected sections of reef habitat, coral community live cover, structure and composition is predicted to reduce, manifested by loss of corals and associated sessile biota. Recovery of these impacted reef areas typically relies on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted. For example, there is evidence that Ningaloo Reef corals and fish are partly self-seeding (Underwood 2009) with the supply of larvae from locations within Ningaloo Reef of critical importance to the healthy maintenance of the coral communities. Recovery at other coral reef areas, may not be aided by a large supply of larvae from other reefs, with levels of recruits after a disturbance event only returning to previous levels after the numbers of reproductive corals had also recovered (Gilmour *et al.* 2013). Therefore, a hydrocarbon spill may result in large-scale impacts to coral reefs, particularly Ningaloo Reef, with long-term effects (recovery > 10 years) likely.
	Seagrass Beds/Macroalgae and Mangroves Spill modelling has predicted entrained hydrocarbons above threshold concentrations have the potential to contact a number of shoreline sensitive receptors such as those supporting biologically diverse, shallow subtidal and intertidal communities. The variety of habitat and community types, from the upper subtidal to the intertidal zones support a high diversity of marine life and are utilised as important foraging and nursery grounds by a range of invertebrate and vertebrate species. Depending on the trajectory of the entrained and dissolved hydrocarbon plume, macroalgal/seagrass communities including the Ningaloo Coast (patchy and low cover associated with the shallow limestone lagoonal platforms), the Barrow/Montebello/Lowendal Islands and the Pilbara Southern Island Group (documented as low and patchy cover) have the potential to be exposed (see **Table 12-28** for a full list of receptors within the ZoC). Seagrass in the subtidal and intertidal zones have different degrees of exposure to hydrocarbon spills. Subtidal seagrass is generally considered much less vulnerable to hydrocarbon spills than intertidal seagrass, primarily because freshly spilled hydrocarbons, including crude oil, float under most circumstances. Dean *et al.* (1998) found that oil mainly affects flowering, therefore, species that are able to spread through apical meristem growth are not as affected (such as *Zostera*, *Halodule* and *Halophila* species). Seagrass and macroalgal beds occurring in the intertidal and subtidal zone may be susceptible to impacts from entrained hydrocarbons. Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie *et al.* 2010). The potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs. Minimum time to contact with receptors that may host seagrasses are 17.5 days (Barrow Island). As such, hydrocarbons released in the event of a loss of well containment are expected to be weathered prior to any credible contact with seagrasses. Exposure to entrained aromatic hydrocarbons may result in mortality, depending on actual entrained aromatic hydrocarbon concentration received and duration of exposure. Physical contact with entrained hydrocarbon droplets could cause sub-lethal stress, causing reduced growth rates and a reduction in tolerance to other stress factors (Zieman *et al.* 1984). Impacts on seagrass and macroalgal communities are likely to occur in areas where hydrocarbon threshold concentrations are exceeded. Mangroves and associated mud flats and salt marsh at Ningaloo Coast (small habitat areas) and the Montebello Islands have the potential to be exposed to entrained hydrocarbons (see **Table 12-28** for the full list of receptors). Hydrocarbons coating prop roots of mangroves can occur from entrained hydrocarbons when hydrocarbons are deposited on the aerial roots. Hydrocarbons deposited on the aerial roots can block the pores used to breathe or interfere with the trees' salt balance resulting in sub-lethal and potential lethal effects. Mangroves can also be impacted by entrained hydrocarbons that may adhere to the sediment particles. In low energy environments, such as in mangroves, deposited sediment-bound hydrocarbons are unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (National Oceanic and Atmospheric Administration 2014). Given the non-persistent nature of the hydrocarbons, no significant effects to mangroves are expected to occur. Entrained hydrocarbon impacts may include sub-lethal stress and mortality to certain sensitive biota in these habitats, including infauna and epifauna. Larval and juvenile fish, and invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be directly impacted due to the loss

	of habitats and/or lethal and sub-lethal in-water toxic effects. This may result in mortality or impairment of growth, survival and reproduction (Heintz *et al.* 2000). In addition, there is the potential for secondary impacts on shorebirds, fish, sea turtles, rays, and crustaceans that utilise these intertidal habitat areas for breeding, feeding and nursery habitat purposes.
Summary of potential impacts to other habitats and communities	
Setting	**Receptor Group**
Offshore	**Benthic Fauna Communities** In the event of a loss of well containment at the seabed, the stochastic spill model predicted hydrocarbons droplets would be entrained in a gas plume, transporting them to the water column and sea surface. As a result, the low sensitivity benthic communities associated with the unconsolidated, soft sediment habitat and any epifauna (filter feeders) within and outside the Operational Area are not expected to be exposed to released hydrocarbons. A localised area relating to the hydrocarbon plume at the point of release is predicted, which would result in a small area of seabed and associated epifauna and infauna exposed to hydrocarbons.
	Open Water – Productivity/Upwelling Primary production by plankton (supported by sporadic upwelling events in the offshore waters of the NWS) is an important component of the primary marine food web. Planktonic communities are generally mixed including phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton, such as crustaceans (e.g. copepods), and the eggs and larvae of fish and invertebrates (meroplankton). Exposure to hydrocarbons in the water column can result in changes in species composition with declines or increases in one or more species or taxonomic groups (Batten *et al.* 1998). Phytoplankton may also experience decreased rates of photosynthesis (Tomajka 1985). For zooplankton, direct effects of contamination may include toxicity, suffocation, changes in behaviour, or environmental changes that make them more susceptible to predation. Impacts on plankton communities are likely to occur in areas where entrained or dissolved aromatic hydrocarbon threshold concentrations are exceeded, but communities are expected to recover relatively quickly (within weeks or months). This is due to high population turnover with copious production within short generation times that also buffers the potential for long-term (i.e. years) population declines (International Tanker Owners Pollution Federation 2011a). Therefore, any impacts are likely to be on exposed planktonic communities present in the ZoC are short-term.
Islands and Mainland (Nearshore Waters)	**Open Water – Productivity/Upwelling** Nearshore waters and adjacent offshore waters surrounding the offshore islands (e.g. Barrow and Montebello Islands) and to the west of the Ningaloo Reef system are known locations of seasonal upwelling events and productivity. The seasonal productivity events are critical to krill production, which supports megafauna aggregations such as whale sharks and manta rays in the region. This has the potential to result in lethal and sub-lethal impacts to a certain portion of plankton in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. However, recovery would occur (see offshore description above). Therefore, any impacts are likely to be on exposed planktonic communities present in the ZoC and temporary in nature.
	Spawning/Nursery Areas Fish (and other commercially targeted taxa) in their early life stages (eggs, larvae and juveniles) are at their most vulnerable to lethal and sub-lethal impacts from exposure to hydrocarbons, particularly if a spill coincides with spawning seasons or if a spill reaches nursery areas close to the shore (e.g. seagrass and mangroves) (International Tanker Owners Pollution Federation 2011b). Fish spawning (including for commercially targeted species) occurs in nearshore waters at certain times of the year and nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters. Modelling indicated that in the unlikely event of a major spill there is potential for entrained hydrocarbons to occur in the surface water layers above threshold concentrations in nearshore waters including, but not limited to the Ningaloo Coast. This, and the potential for possible lower concentration exposure for dissolved aromatic hydrocarbons, have the potential to result in lethal and sub-lethal impacts to a certain portion of fish larvae in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. Although there is the potential for spawning/nursery habitat to be impacted (e.g. mangroves and seagrass beds, discussed above), losses of fish larvae in worst affected areas are unlikely to be of major consequence to fish stocks compared with significantly larger losses through natural predation, and the likelihood that most nearshore areas would be exposed is low (i.e. not all areas in the region would be affected). This is consistent with a recent study in the Gulf of Mexico which used juvenile abundance data, from shallow-water seagrass meadows, as indices of the acute, population-level responses of young fishes to the Deepwater Horizon spill (Fodrie and Heck 2011). Results indicated that there was no change to the juvenile cohorts following the Deepwater Horizon spill. Additionally, there were no significant post-spill shifts in community composition and structure, nor were

	there changes in biodiversity measures (Fodrie and Heck 2011). Any impacts to spawning and nursery areas are expected to be minor and short term, as would flow on effects to adult fish stocks into which larvae are recruited.
	Reefs The reef communities fringing the offshore Ningaloo Coast may be exposed to entrained hydrocarbons (> 500 ppb) and consequently exhibit lethal or sub-lethal impacts resulting in partial or total mortality of keystone sessile benthos, particularly, hard corals and thus potential community structural changes to these shallow, nearshore benthic communities may occur. If these reefs are exposed to entrained hydrocarbons, impacts are expected to result in localised long-term effects.
	Filter Feeders Hydrocarbon exposure to offshore, filter-feeding communities (e.g. deepwater communities of Ningaloo Coast in 20–200 m) may occur depending on the depth of the entrained and dissolved aromatic hydrocarbons. See discussion above on potential impacts.
	Sandy Shores/Estuaries/Tributaries/Creeks (Including Mudflats)/Rocky Shores Potential impacts may occur due to hydrocarbon contact with intertidal areas, including sandy shores, mudflats and rocky shores, listed in **Table 12-28.** Hydrocarbon at sandy shores is incorporated into fine sediments through mixing in the surface layers from wave energy, penetration down worm burrows and root pores. Hydrocarbon in the intertidal zone can adhere to sand particles however high tide may remove some or most of the hydrocarbon back off the sediments. Typically, hydrocarbon is only incorporated into the surface layers to a maximum of 10 cm. Given the hydrocarbons are non-persistent, long-term impacts to shores are not expected. The impact of hydrocarbon on rocky shores will be largely dependent on the incline and energy environment. On steep/vertical rock faces on wave exposed coasts there is likely to be no impact from a spill event. However, a gradually sloping boulder shore in calm water can potentially trap large amounts of hydrocarbon (International Petroleum Industry Environmental Conservation Association 2000). The impact of the spill on marine organisms along the rocky coast will be dependent on the toxicity and weathering of the hydrocarbon however no shoreline accumulation is predicted. The location of rocky shores where impacts are predicted are at Barrow/Montebello/Lowendal Islands group. Intertidal mudflats are susceptible to potential impacts from hydrocarbons as they are typically low energy environments and therefore trap hydrocarbons. The extent of oiling is influenced by the neap and spring tidal cycle and seasonal highs and lows affecting mean sea level. Potential impacts to tidal flats include heavy accumulations covering the flat at low tide; however, it is unlikely that hydrocarbon will penetrate the water-saturated sediments. However, hydrocarbon can penetrate sediments through animal burrows and root pores. It has been demonstrated that infaunal burrows allow hydrocarbons to subsurface sediments where it can be retained for months. Again, no floating or accumulated hydrocarbons are predicted, therefore impacts are expected to be limited. Potential impacts may occur due to entrained contact with shallow, subtidal and intertidal zones of the Ningaloo Coast, Barrow Island, Montebello Islands and the Pilbara Southern Islands. In-water toxicity of the dissolved and entrained hydrocarbons reaching these shores will determine impacts to the marine biota such as sessile barnacle species and/or mobile gastropods and crustaceans such as amphipods. Lethal and sub-lethal impacts may be expected where the entrained hydrocarbon concentration threshold is > 500 ppb. Impacts may result in localised changes to the community structure of these shoreline habitats which would be expected to recover in the medium term (two to five years).
Key Ecological Features	**Key Ecological Features** The KEFs potentially impacted by the hydrocarbon spill from a loss of well containment event are: • Ancient Coastline at 125 m Depth Contour • Continental Slope Demersal Fish Communities • Exmouth Plateau • Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula • Commonwealth waters adjacent to Ningaloo Reef. Although these KEFs are primarily defined by seabed geomorphological features, they are described to identify the potential for increased biological productivity and, therefore, ecological significance. The consequences of a hydrocarbon spill from a loss of well containment may impact the values of the KEFs affected. Potential impacts include the contamination of sediments, impacts to benthic fauna/habitats and associated impacts to demersal fish populations and reduced biodiversity as described above and below. Most of the KEFs within the ZoC have relatively broad-scale distributions and are unlikely to be significantly impacted.

Summary of potential impacts to water quality	
Setting	***Aspect***
Offshore and Mainland and Islands (Nearshore waters)	**Open Water – Water Quality** Water quality would be affected due to hydrocarbon contamination which is described in terms of the biological effect concentrations. These are defined by the ZoC descriptions for each of the entrained and dissolved hydrocarbon fates and their predicted extent. Furthermore, water quality is predicted to have minor long term and/or significant short term hydrocarbon contamination above background compared to background water quality.
Summary of potential impacts to marine sediment quality	
Setting	**Receptor Group**
Offshore	**Marine Sediment Quality** Studies of hydrocarbon concentrations in deep sea sediments in the vicinity of a catastrophic well blowout indicated hydrocarbon from the blowouts can be incorporated into sediments (Romero *et al.* 2015). Proposed mechanisms for hydrocarbon contamination of sediments include sedimentation of hydrocarbons and direct contact between submerged plumes and the seabed (Romero *et al.* 2015). In the event of a major hydrocarbon release at the seabed, modelling indicates that a pressurised release of condensate would atomise into droplets that would be transported into the water column to the surface. As a result, the extent of potential impacts to the seabed area at and surrounding the release site would be confined to a localised footprint. Marine sediment quality would be reduced as a consequence of hydrocarbon contamination for a small area within the immediate release site for a long to medium term.
Mainland and Islands (Nearshore waters)	**Marine Sediment Quality** Entrained and dissolved hydrocarbons (at or above the defined thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coastlines and hydrocarbons may accumulate (at or above the ecological threshold) at a range of nearshore receptors (refer to **Table 12-28**). Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, such as adherence to sediment and deposition shores or seabed habitat.
Summary of potential impacts to air quality	
A hydrocarbon release during a loss of well containment has the potential to result in localised, temporary reduction in air quality and contribution of greenhouse gases to the global concentration of these gases in the atmosphere. The ambient concentrations of methane and VOCs released from diffuse sources is difficult to accurately quantify, although the behaviour and fate is predictable in open offshore environments as it is dispersed rapidly by meteorological factors such as wind and temperature. Methane and VOC emissions from a hydrocarbon release in such environments are rapidly degraded in the atmosphere by reaction with photo chemically-produced hydroxyl radicals. Due to the unlikely occurrence of a loss of well containment; the temporary nature of any methane or VOC emissions (from either gas surfacing or weathering of liquid hydrocarbons from a loss of well containment); the predicted behaviour and fate of methane and VOCs in open offshore environments; and the significant distance from the Operational Area to the nearest sensitive air shed (town of Dampier approximately 130 km away), the potential impacts are expected to be minor and short-term.	
Summary of potential impacts to protected areas	
The quantitative spill risk assessment results indicate that the open water environment protected within the Commonwealth marine parks listed in refer to **Table 12-28** may be affected by the released hydrocarbons. In the unlikely event of a major spill, entrained hydrocarbons and/or dissolved hydrocarbons may contact the identified key receptor locations of islands and mainland coastlines, resulting in the actual or perceived contamination of protected areas as identified for the ZoC (refer to **Table 12-28**). Objectives in the Ningaloo Marine Park (Commonwealth Waters) Management Plan and the Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area require considerations to a number of physical, ecological and social values identified in these areas. Impact on the values of this protected area is discussed in the relevant sections above for ecological and physical (water quality) values and below for social (socio-economic) values. Impact on the protected areas is discussed in the sections above for ecological values and sensitivities and below for socio-economic values. Additionally, such hydrocarbon contact may alter stakeholder understanding and/or perception of the protected marine environment, given these represent areas largely unaffected by anthropogenic influences and contain biological diverse environments.	
Summary of potential impacts to socio-economic values	

Setting	Receptor Group
Offshore	**Fisheries – Commercial** Spill scenarios modelled are unlikely to cause significant direct impacts on the target species of Commonwealth and offshore State fisheries within the defined ZoC. Further details are provided below (impact assessment relating to spawning is discusses above under 'Summary of potential impacts to other habitats and communities'). Fish exposure to hydrocarbon can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Tainting is reversible through the process of depuration which removes hydrocarbons from tissues by metabolic processes, although it is dependent upon the magnitude of the hydrocarbon contamination. Fish have a high capacity to metabolise these hydrocarbons while crustaceans (such as prawns) have a reduced ability (Yender *et al.* 2002). Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender *et al.* 2002). A major spill would result in the establishment of an exclusion zone around the spill affected area. There would be a temporary prohibition on fishing activities for a period of time and subsequent potential for economic impacts to affected commercial fishing operators. Additionally, hydrocarbon can foul fishing equipment such as traps and trawl nets, requiring cleaning or replacement.
	Tourism including Recreational Activities Recreational fishers predominantly target tropical species, such as emperor, snapper, grouper, mackerel, trevally and other game fish. Recreational angling activities include shore-based fishing, private boat and charter boat fishing, with the peak in activity between April and October (Smallwood *et al.* 2011). Limited recreational fishing takes place in the offshore waters of the Operational Area due to the distance from shore; however, fishing may take place at Rankin Bank. Impacts on species that are recreationally fished are described above and under 'Summary of potential impacts to other species' above. A major loss of hydrocarbon from the Petroleum Activities Program may lead to exclusion of marine nature-based tourist activities, resulting in a loss of revenue for operators.
	Offshore Oil and Gas Infrastructure In the unlikely event of a major spill, surface hydrocarbons may affect production from existing petroleum facilities (platforms and FPSOs). For example, facility water intakes for cooling and fire hydrants could be shut off which could in turn lead to the temporary cessation of production activities. Spill exclusion zones established to manage the spill could also prohibit activity support vessel access as well as tankers approaching facilities on the NWS. The impact on ongoing operations of regional production facilities would be determined by the nature and scale of the spill and metocean conditions. Furthermore, decisions on the operation of production facilities in the event of a spill would be based primarily on health and safety considerations. The closest oil and gas operation is the Wheatstone platform (operated by Chevron). Other nearby facilities include the Jadstone-operated Stag platform (**Section 4.3**). Operation of these facilities is likely to be affected in the event of a worst-case loss of well containment.
Mainland and Islands (Nearshore Waters)	**Fisheries – Commercial** *Nearshore Fisheries and Aquaculture:* In the unlikely event of a loss of well containment, there is the possibility that target species in some areas utilised by a number of state fisheries in nearshore waters of the Ningaloo Coast, and aquarium fisheries and aquaculture activities (**Section 4.3**) in the nearshore waters that are within the ZoC could be affected. Targeted fish resources could experience sub-lethal stress, or in some instances, mortality depending on the concentration and duration of hydrocarbon exposure and its inherent toxicity. *Prawn Managed Fisheries:* In the event of a major spill, the modelling indicated the entrained ZoC may extend to nearshore waters closest to the mainland coasts, including the actively fished areas of the designated Onslow prawn fishery. Prawn habitat utilisation differs between species in the post-larval, juvenile and adult stages (Dall *et al.* 1990) and direct impacts to benthic habitat due to a major spill has the potential to impact prawn stocks. For example, juvenile banana prawns are found almost exclusively in mangrove-lined creeks, whereas juvenile tiger prawns are most abundant in areas of seagrass (Masel and Smallwood 2000). Adult prawns also inhabit coastline areas but tend to move to deeper waters to spawn. In the event of a major spill, the model predicted shallow subtidal and intertidal habitats at the Ningaloo Coast, and mangrove and seagrass habitats of the Ningaloo Coast are located within the ZoC and could be exposed to hydrocarbon concentrations above threshold concentrations, depending on the trajectory of the plume. Localised loss of juvenile prawns in worse spill affected areas is possible. Whether lethal or sub-lethal effects occur will depend on duration of exposure, hydrocarbon concentration and weathering stage of the hydrocarbon and its inherent toxicity. Furthermore, seafood consumption safety concerns and a

	temporary prohibition on fishing activities may lead to subsequent potential for economic impacts to affected commercial fishing operators.
	Fisheries – Traditional Although no designated traditional fisheries have been identified it is recognised that Indigenous communities fish in the shallow coastal and nearshore waters of Ningaloo Reef, and therefore, may be potentially impacted if a hydrocarbon spill from a loss of well containment were to occur. Impacts would be similar to those identified for commercial fishing in the form of a potential exclusion zone and contamination/tainting of fish stocks.
	Tourism and Recreation In the unlikely event of a major spill, the nearshore waters of the Ningaloo Coast could be reached by entrained hydrocarbon, depending on prevailing wind and current conditions. This location offers a number of amenities such as fishing, swimming and utilisation of beaches and surrounds have a recreational value for local residents and visitors (regional, national and international). If a major spill resulted in hydrocarbon contact, there could be restricted access to beaches for a period of days to weeks, until natural weathering or tides and currents remove the hydrocarbons. In the event of a major spill, tourists and recreational users may also avoid areas due to perceived impacts, including after the hydrocarbon spill has dispersed. There is potential for stakeholder perception that this remote environment will be contaminated over a large area and for the longer term resulting in a prolonged period of tourism decline. Oxford Economics (2010) assessed the duration of hydrocarbon spill related tourism impacts and found that on average, it took 12 to 28 months to return to baseline visitor spending. There is likely to be, resulting in moderate, medium term impacts to the tourism industry, wider service industry (hotels, restaurants and their supply chain) and local communities in terms of economic loss as a result of spill impacts to tourism. Recovery and return of tourism to pre-spill levels will depend on the size of the spill, effectiveness of the spill clean-up and change in any public misconceptions regarding the spill (Oxford Economics 2010).
	Cultural Heritage There are a number of historic shipwrecks identified in the vicinity of the Operational Area. Shipwrecks occurring in the subtidal zone will be exposed to entrained and dissolved hydrocarbons and marine life that shelter and take refuge in and around these wrecks may be affected by in-water toxicity of dispersed hydrocarbons, The consequences of such hydrocarbon exposure may include all or some of the following: large fish species moving away and/or resident fish species and sessile benthos such as hard corals exhibiting sub-lethal and lethal impacts (which may range from physiological issues to mortality). Entrained hydrocarbons above threshold concentrations (> 500 g/m^2) are predicted at Ningaloo Coast. It is acknowledged that the area contains numerous Indigenous sites such as burial grounds, middens and fish traps that provide a historical account of the early habitation of the area and a tangible part of the culture of local Indigenous groups. Additionally, artefacts, scatter and rock shelter are contained on Barrow and Montebello islands (no contact by surface hydrocarbons or accumulated hydrocarbons predicted for these areas). Within the wider ZoC a number of places are designated World, National and Commonwealth heritage places (**Section 4.3**) These places are also covered by other designations such as WHA, marine parks, and listed shipwrecks. Potential impacts have, therefore been discussed in the sections above.

Summary of Control Measures

- Maintaining well mechanical integrity to contain reservoir fluids within the well envelope to avoid an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standards to prevent environment risk related damage to SCEs for:
  - P10 – Wells;
  - P28 – Sand Management System
- Maintaining availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standards to prevent environment risk related damage to SCEs for:
  - E04 – Safety Critical Communication Systems
- Maintaining emergency shutdown (ESD) system and valves to detect and respond to pre-defined initiating conditions and/or initiate response that put the process plant, equipment and the wells in a safe condition to prevent or mitigate the effects of an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standards to prevent environment risk related damage to SCEs for:
  - F06 – Safety Instrumented System
  - F05 – ESD valves

  - P10 - Wells
- OPGGS (Resource Management and Administration) Regulations 2011: Accepted WOMP
- OPGGS (Safety) Regulations 2009: Accepted Safety Case for the facility.
- Incident reports are raised for unplanned releases within event reporting system
- Mitigation – hydrocarbon spill response

Unplanned Hydrocarbon Release: Subsea Equipment Loss of Containment (MEE-02)

Impacts and Risks Evaluation Summary													
Source of Risk	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Release of hydrocarbons resulting from loss of containment of export pipeline, riser and infrastructure.		X	X	X	X	X	X	B	B	1	M	LCS GP PJ RBA CV SV	Acceptable if ALARP
Release of hydrocarbons resulting from loss of containment of flowlines riser and infrastructure..		X	X	X	X	X	X	B	C	1	M		

Description of Source of Risk

The Pluto subsea systems comprise one subsea production manifold tied in to a total of eight subsea production trees. Production from the Pluto wells is routed approximately 27 km through dual flowlines to the riser platform. Xena (and future Pyxis) wells connect to the Pluto production flowlines through via a flexible production jumper and a midline connector system to the flowline tees. Once on the riser platform, gas, condensate and other fluids are transported to the onshore LNG Plant via a 36-inch carbon steel subsea export pipeline.

A subsea equipment loss of containment of these components may result in the release of large volumes of hydrocarbon inventory. Due to the potential consequence of a worst-case subsea equipment loss of containment, this risk is considered to be an MEE (MEE-02). The potential hazard sources that could instigate an MEE loss of containment from the flowlines, riser and export pipeline are:

- internal corrosion
- external corrosion
- erosion
- overpressure
- equipment fatigue
- anchoring impact/dragging
- pipeline stability and freespans
- loss of control of suspended load from visiting vessel.

Escalation from other MEEs can cause subsea equipment loss of containment:

- Loss of Structural Integrity (**MEE-03**)
- Loss of Marine Vessel Separation (**MEE-04)**
- Loss of Control of Suspended Load from the platform (**MEE-05**)

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure bowties

Subsea Equipment Loss of Containment – Credible Scenarios

Two credible worst-case subsea equipment loss of containment scenarios were identified:

- surface release, within 500 m of the riser platform, during a full bore rupture of the export riser
- subsea release during a full bore rupture of the export pipeline, at the midpoint.

Each worst-case scenario assumes the loss of the hydrocarbon inventory of the export pipeline, with no additional supply of hydrocarbons to the compromised infrastructure assumed (i.e. assumed that the ESD system has functioned correctly). The release location for the subsea release from the export pipeline was selected at the midpoint as this was the closest point to sensitive receptors (Montebello Islands, Barrow Island) based on prevailing currents.

The subsea equipment loss of containment scenario parameters are summarised in **Table 12-29.**

Table 12-29: Summary of worst-case subsea equipment loss of containment release scenario

Scenario	Hydrocarbon	Duration (hrs)	Depth (m)	Latitude (D°M'S'' S)	Longitude (D°M'S'' E)	Total Release Volume (m^3)
Full bore rupture of export pipeline discharging at the seabed	Pluto condensate	4 hrs	78	20° 3' 55.1	115° 36' 1.1	1800
Full bore rupture of the export riser discharging at the water surface	Pluto condensate	4 hrs	Surface	19° 59' 46.5	115° 22'5.6	1800

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in subsea system design and construction. In the company's recent history, it has not experienced any subsea integrity events that have resulted in significant environmental impacts. The Pluto offshore facility has not experienced a worst-case subsea equipment loss of containment in its operational history.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the Bowtie methodology and hydrocarbon spill trajectory modelling. Company were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons as a result of subsea equipment loss of containment is considered a Major Environment Event (MEE-02). The hazard associated with this MEE is hydrocarbons in subsea infrastructure (pipeline, flowlines, manifolds, etc.) tied to or originating from the riser platform.

Quantitative Spill Risk Assessment

Spill modelling of each of the subsea equipment loss of containment credible spill scenarios was undertaken by RPS APASA, on behalf of Woodside, to determine the fate of hydrocarbon released in each scenario based on the assumptions in **Table 12-29.** Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volumes for all subsea equipment loss containment scenarios.

Subsea Plume Dynamics

The subsea equipment loss of containment scenario (pipeline rupture outside of the PLA PSZ) will result in a buoyant plume of hydrocarbons, which has been modelled using the OILMAP-Deep numerical model (summarised in **Table 12-30**).

Table 12-30: Inputs and outputs for OILMAP-Deep model for subsea export pipeline loss of containment

	Parameter	Subsea Release
Inputs	Release depth (m below sea level)	78.0
	Oil density (g/cm^3) (at 15°C)	0.745
	Oil viscosity (cP) (at 15°C)	0.622
	Oil temperature (°C)	70
	Gas:oil ratio (m^3/m^3)	5,833
	Oil flow rate (m^3/ 4 hrs)	1800
	Hole diameter (m)	0.914
Outputs	Plume diameter (m)	8.7
	Plume height (m above sea bed)	surface
Predicted oil droplet size distribution	3.5% droplets of size (µm)	4.6
	14.9% droplets of size (µm)	9.2
	24.9% droplets of size (µm)	13.9

	26.5% droplets of size (µm)	18.5
	19.7% droplets of size (µm)	23.1
	10.5% droplets of size (µm)	27.7

Likelihood

Subsea loss of containment full bore rupture in the export pipeline

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance, pipeline marked on marine charts), the likelihood has been taken as 1 (Highly Unlikely).

Surface release loss of containment full bore rupture in riser

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance, pipeline marked on marine charts), the likelihood has been taken as 1 (Highly Unlikely).

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case subsea or riser loss of containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Potential Impacts to Marine Sediment, Water Quality, Air Quality, Ecosystems/Habitats, Species and Socio-Economic Environment

Zone of Consequence

Surface Hydrocarbons

Quantitative spill modelling for the subsea release did not indicate any surface hydrocarbons at concentrations > 10 g/m^2. While quantitative spill modelling for the surface release indicated a slick extending 30 km from the release location. Therefore, only offshore receptors are predicted to be contacted by floating hydrocarbons for these scenarios.

Entrained Hydrocarbons

Modelling results for the subsea rupture of the export pipeline indicated a number of environmental sensitivities may be contacted by entrained hydrocarbons above impact thresholds, with time to contact ranging from about two days (Rankin Bank) to 19 days (Ningaloo Coast Middle). In the event of a worst-case subsea equipment loss of containment scenario occurring, entrained hydrocarbons at or above 500 ppb are forecast to potentially extend up to 475 km from the release site. The most likely direction of drift is south-westerly around the Ningaloo Coast, reflecting the prevailing current patterns. Results also indicate that entrained oil may also be likely to drift towards the northeast contacting the Dampier Archipelago and in the offshore directions at lower probabilities.

Modelling results for the surface rupture of the export pipeline indicated the entrained ZoC remained offshore and did not contact any sensitive receptors.

Dissolved Hydrocarbons

Dissolved hydrocarbons above 500 ppb were not forecast within the model.

Accumulated Hydrocarbons

No accumulated hydrocarbons above impact thresholds were predicted by modelling for the release scenarios considered in MEE-02.

Table 12-31: Zone of Consequence – key receptor locations and sensitivities with the summary hydrocarbon spill contact for a subsea equipment loss of containment

Environmental setting	Location/name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Hydrocarbon Contact and Fate (Condensate/ Crude/Marine Diesel)			
		Physical		Biological																						Socio-economic and Cultural								
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities/Habitats								Protected Species									Other Species										
		Open water – (pristine)	Marine sediment – (pristine)	Coral reef	Seagrass beds/macroalgae	Mangroves	Spawning/nursery areas	Open water – productivity/upwelling	Non-biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Seasnakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident/demersal fish	Fisheries – commercial	Fisheries – traditional	Tourism and recreation	Protected Areas/Heritage – European and Indigenous/Shipwrecks	Offshore oil and gas infrastructure (topside and subsea)	Surface hydrocarbon (≥ 10 g/m²)	Entrained hydrocarbon (≥ 500 ppb)	Dissolved aromatic hydrocarbon (≥ 500 ppb)	Accumulated hydrocarbons (> 100 g/m²)
Offshore[7]	Commonwealth waters	✓	✓					✓		✓					✓	✓				✓	✓	✓	✓	✓		✓		✓		✓		X*		
Offshore[7]	Montebello Marine Park	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X*		
Offshore[7]	Ningaloo Marine Park	✓	✓					✓		✓					✓	✓			✓		✓	✓	✓	✓	✓	✓		✓	✓			X		
Offshore[7]	Gascoyne Marine Park	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		X		
Submerged Shoals and banks	Rankin Bank	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓				X		
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X		
Islands	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		X		

[7] Note: hydrocarbons cannot accumulate on open ocean, submerged receptors, or receptors not fully emergent

Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))

Environmental setting	Location/name	Physical – Water Quality – Open water – (pristine)	Physical – Sediment Quality – Marine sediment – (pristine)	Biological – Marine Primary Producers – Coral reef	Biological – Marine Primary Producers – Seagrass beds/macroalgae	Biological – Marine Primary Producers – Mangroves	Biological – Other Communities/Habitats – Spawning/nursery areas	Biological – Other Communities/Habitats – Open water – productivity/upwelling	Biological – Other Communities/Habitats – Non-biogenic reefs	Biological – Other Communities/Habitats – Offshore filter feeders and/or deepwater benthic communities	Biological – Other Communities/Habitats – Nearshore filter feeders	Biological – Other Communities/Habitats – Sandy shores	Biological – Other Communities/Habitats – Estuaries/tributaries/creeks/lagoons (including mudflats)	Biological – Other Communities/Habitats – Rocky shores	Biological – Protected Species – Cetaceans – migratory whales	Biological – Protected Species – Cetaceans – dolphins and porpoises	Biological – Protected Species – Dugongs	Biological – Protected Species – Pinnipeds (sea lions and fur seals)	Biological – Protected Species – Marine turtles (including foraging and internesting areas and significant nesting beaches)	Biological – Protected Species – Seasnakes	Biological – Protected Species – Whale sharks	Biological – Protected Species – Sharks and rays	Biological – Protected Species – Sea birds and/or migratory shorebirds	Biological – Other Species – Pelagic fish populations	Biological – Other Species – Resident/demersal fish	Socio-economic and Cultural – Fisheries – commercial	Socio-economic and Cultural – Fisheries – traditional	Socio-economic and Cultural – Tourism and recreation	Socio-economic and Cultural – Protected Areas/Heritage – European and Indigenous/Shipwrecks	Socio-economic and Cultural – Offshore oil and gas infrastructure (topside and subsea)	Hydrocarbon Contact and Fate (Condensate/ Crude/Marine Diesel) – Surface hydrocarbon (≥ 10 g/m²)	Hydrocarbon Contact and Fate – Entrained hydrocarbon (≥ 500 ppb)	Hydrocarbon Contact and Fate – Dissolved aromatic hydrocarbon (≥ 500 ppb)	Hydrocarbon Contact and Fate – Accumulated hydrocarbons (> 100 g/m²)
	Lowendal Islands (including State Nature Reserve)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X		
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X		
	Muiron Islands (WHA, State Marine Park)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X		
	Dampier Archipelago	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X		
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X		

Consequence Assessment
Consequence Assessment Summary The credible worst-case hydrocarbon spill scenarios that may arise from MEE-02 may impact upon a range of environmental receptors; refer to **Table 12-31** for a summary of receptors identified by the stochastic spill modelling studies. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01; refer to **MEE-01** for a description of potential impacts. A number of additional receptor locations, from MEE-01, may be impacted by the subsea hydrocarbon release from a rupture of the export pipeline, including: • Dampier Archipelago (specifically Rosemary Island) • Lowendal Islands • Muiron Islands. The sensitive receptors in these locations (e.g. coral reefs, turtle nesting, seagrass, filter feeders, shore and seabirds) are the same as those described in **MEE-01** and there are no unique features. As such, the impacts predicted for those sensitive receptors will be the same, where they are present.
Summary of Control Measures
• Maintain pipeline, riser and hydrocarbon-containing infrastructure integrity to avoid a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: o E04 - Critical Communications o F06 - ESD System o F05 - ESD Valves o P09 - Pipeline Systems o P21 - Substructures o P28 - Sand Management Systems • Maintaining Fire and Gas Detection and Alarm Systems on PLA facility to facilitate prevention and response to fire or gas hazards. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: o F01 - Fire and Gas Detection and Alarm Systems, • Maintaining availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: o E04 – Safety Critical Communication Systems` • Maintaining ESD system and valves to detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant, equipment and the wells in a safe condition to prevent or mitigate the effects of an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: o F06 – ESD System o F05 – ESD Valves o P09 – Pipeline Systems o P10 – Wells • OPGGS (Resource Management and Administration) Regulations 2011: Accepted WOMP • OPGGS (Safety) Regulations 2009: Accepted Safety Case for the facility. • OPGGS (Safety) Regulations 2009: Accepted Safety Case for Pluto export pipeline. • Raising incident reports within event reporting system for unplanned releases. • Mitigation – hydrocarbon spill response

Unplanned Hydrocarbon Release: Loss of Structural Integrity (MEE-03)

Impacts and Risks Evaluation Summary													
	Environmental Value Potentially Impacted							Evaluation					
Source of Risk	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon release from pipeline, flowline(s) and riser(s) to the marine environment and atmosphere.			X	X		X		A	C	1	M	LCS GP PJ RBA CV SV	Acceptable if ALARP
Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse riser platform.		X	X		X	X	X	B	C	1	M		

Description of Source of Risk

Extreme environmental conditions or other causes which result in an exceedance of the design criteria and a catastrophic failure of the facility and individual equipment (e.g. cranes, flare tower, etc.) have been identified as a potential MEE (MEE-03). Catastrophic structural failure of the facility could lead to the release of hydrocarbons from topsides process and non-process hydrocarbon inventories, and pipeline/flowline/riser inventories.

The following causes of structural failure of the facility were identified:

- internal corrosion
- external corrosion
- equipment failure
- extreme weather
- seismic events/seabed instability
- fire/explosion event (escalation of loss of containment event).

Escalation from other MEEs that can cause loss of structural integrity:

- Loss of marine vessel separation (MEE-04)
- Loss of control of suspended load (MEE-05)

There is a possibility of platform collapse ('slow' or 'rapid') caused by the extreme loads induced by strong winds and extreme waves. Extreme weather may induce fracture of pipework due to vibration/fatigue and loosen/dislodge objects/projectiles causing impact to equipment/pipework and subsequently, result in a loss of containment.

Structural damage to the platform resulting from the causes listed above could be minor or could in the most extreme situation result in total loss of the platform. The type of structural failure considered is restricted to major structural damage (e.g. catastrophic collapse of the jacket or release of hydrocarbons on or adjacent to the platform). Such events are beyond the design basis for the platform.

Loss of Structural Integrity – Credible Hydrocarbon Spill Scenario

A loss of structural integrity could result in a significant release of hydrocarbons. Hydrocarbon releases may result in a spill to the marine environment, as described for **MEE-02 – Subsea Equipment Loss of Containment**. In addition, vessel cargo, including diesel inventory could be spilled if the cause of the loss of platform integrity was a collision from a support vessel as per **MEE-04 – Loss of Marine Vessel Separation**.

Worst case hydrocarbon release scenarios for subsea equipment loss of containment that could result from loss of structural integrity of the riser platform are discussed in the relevant sections referenced above. Relevant trajectory modelling as applicable to these scenarios is also discussed in the above-mentioned sections.

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in structural design and construction. The facility has not experienced a worst-case loss of containment due to structural failure in its operational history.

<u>Decision Type</u>

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the Bowtie Methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The loss of structural integrity is considered a Major Environment Event (MEE-03). The hazards associated with this MEE is hydrocarbons in pipelines, process and non-process inventories and potentially vessels and the riser platform structure itself.

<u>Quantitative Spill Risk Assessment</u>

Credible worst-case hydrocarbon release form subsea equipment, MEE-02, is considered to apply to a loss of structural integrity (MEE-03). Refer to the **MEE-02** for a discussion of these credible worst-case spill scenarios.

<u>Likelihood</u>

In accordance with the Woodside Risk Matrix, the following likelihoods have been assigned to the sources of risk:

- Hydrocarbon release from subsea equipment to the marine environment and atmosphere: 'Highly Unlikely' event as it 'has occurred once or twice in the industry' (experience based likelihood) and aligns with a frequency of a '1 in 10,000 to 1 in 100,000 years' event.
- Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of riser platform: 'Highly Unlikely' event as it 'has occurred once or twice in the industry' (experience based likelihood) and aligns with a frequency of a '1 in 10,000 to 1 in 100,000 years' event.

<u>Consequence</u>

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon and the potential seabed disturbance footprint from the riser platform were considered during the impact assessment for a worst-case loss of structural integrity. These considerations were informed primarily by the outputs from the numerical spill modelling studies undertaken by RPS/APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Potential Impacts Overview

Zone of Consequence – Hydrocarbon Spill

As discussed under Description of Source of Risk, the potential impacts from hydrocarbon release caused by a loss of structural integrity are those which would result from:

- Subsea Equipment Loss of Containment, (MEE-02).

The potential impacts are therefore discussed in the above-mentioned sections.

Seabed Disturbance

In the event of a loss of structural integrity, there is the potential for collapse of the platform leading to an incremental increase of the facility's footprint on the seabed. The potential area that would be affected can conservatively be defined as the existing facility footprint plus 100 m in all directions, that is approximately 300 m by 350 m (0.105 km^2). The benthic habitats surrounding the facility have been subject to historical disturbance (e.g. construction) and are considered to be of low ecological value (although it is acknowledged that the facility provides artificial hard substrate, which has formed the basis of relatively high biodiversity communities when compared to the surrounding seabed). The physical disturbance to the seabed resulting from the collapse of the riser platform would be localised but result in long-term disturbance to benthic communities.

The riser platform could act as a source of environmental contaminants due to material onboard the platform (e.g. chemical/hydrocarbon inventories, corrosion of structural materials, debris, etc.). The potential for contamination would diminish over time as the structure degrades. Depending on the nature of the loss of structural integrity, complete or partial salvage of the riser platform may not be feasible. Any structures not able to be recovered would be left on the seabed indefinitely. These structures are expected to be colonized by marine organisms, and a reef habitat would develop over time on the structures

Summary of Control Measures

- Maintaining structural integrity to ensure availability of critical systems during a major accident or environment event, and prevent structural failures from contributing to escalation of an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - P07 – Topside / surface structures
  - P21 - Substructures

- Maintaining control of ignition sources and passive fire protection to prevent loss of structural integrity. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - F27 – Control of Ignition Sources
    - F20 – Passive Fire and Explosion Protection,
- Maintaining topsides hydrocarbon-containing infrastructure integrity. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P01 – Pressure Vessels
    - P02 – Heat Exchangers
    - P03 – Rotating Equipment
    - P04 – Tanks
    - P08 – Piping Systems
- Maintaining emergency shutdown (ESD) system and valves to detect and respond to pre-defined initiating conditions and/or initiate response that put the process plant, equipment and the wells in a safe condition to prevent or mitigate the effects of an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - F06 – ESD System
    - F05 – ESD Valves
    - P10 – Wells,
- OPGGS (Safety) Regulations 2009. Pluto A Safety Case for Operations.
- Raising incident reports within event reporting system for unplanned releases.
- Mitigation – hydrocarbon spill response

Unplanned Hydrocarbon Release: Loss of Marine Vessel Separation (MEE-04)

Impacts and Risks Evaluation Summary													
Source of Risk	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon release from pipeline, flowline(s) and riser(s) to the marine environment and atmosphere.		X	X	X	X	X	X	B	C	1	M	LCS GP PJ RBA CV SV	Acceptable if ALARP
Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of riser platform.		X	X	X	X	X	X	B	C	1	M		

Description of Source of Risk

A loss of marine vessel separation between a vessel and the facility may result in a loss of hydrocarbon containment from the facility and/or the release of fuel from the vessel. A vessel collision with the riser platform has been identified as a potential MEE (MEE-04). Vessel collisions can arise from:

- visiting vessel collisions associated with platform support vessels, accommodation vessels and/or HLV – ships which are visiting the platform can accidentally collide with the platform during approach to, or manoeuvring alongside, the platform
- errant passing vessel collision – ships which are not visiting the platform (i.e. passing vessels) can, for one reason or another, move off-course and collide with the platform
- vessel operations during adverse weather.

The different collision hazards involve significantly different sized vessels and collision speeds, hence, differing impact energies and consequences, and have been assessed.

Visiting Vessels

Visiting vessels are defined as those which are used to service the facility. Operating procedures will dictate how vessels are operated, loaded and unloaded, but it will generally occur so that the prevailing winds move the vessel away from the facility. The primary causes of visiting vessel collisions are failure to follow safe procedures and communication errors between the marine vessels and platform operations. These errors could be worsened by the following:

- vessel station keeping failures, or
- vessel operations in adverse weather conditions.

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure bowties.

Errant Passing Vessels

Errant passing vessels are defined as third-party vessels that enter the riser platform's 500 m PSZ, but do not call at the riser platform or other installations (i.e. not platform or subsea support vessels). The collision can be powered or drifting. Either has the potential to cause significant damage to the riser platform.

The causes of errant passing vessel collisions include:

- failure of propulsion or steering systems
- adverse weather conditions resulting in poor visibility
- rough seas
- human error.

Woodside implements a range of control measures to mitigate the risk of errant vessel collision.

In addition to the potential for large hydrocarbon releases following impact by a vessel with the riser platform, powered collisions from large passing vessels or tankers could have sufficient impact energy to breach both skins of the vessel to the extent that there is a loss of containment of cargo or fuel oil with the potential for significant loss of inventory and consequent environmental impact. This is not within the control of Woodside so is not assessed further.

Loss of Vessel Separation – Credible Hydrocarbon Spill Scenario

The loss of marine vessel separation is considered a Major Environment Event (MEE-04). The hazards associated with this MEE is loss of containment of hydrocarbons in subsea equipment, process and non-process inventories and potentially vessels, and fuel onboard platform support vessels. A loss of marine vessel separation could result in a significant release of hydrocarbons. Hydrocarbon releases will result in a spill to the marine environment as described in **MEE-02 – Subsea Equipment Loss of Containment**, surface scenario. In addition, vessel cargo, including diesel inventory, could be spilled if the cause of the loss of platform integrity was a collision from a support vessel.

Worst case hydrocarbon release scenarios for a subsea equipment loss of containment (MEE-02) that could result from loss of marine vessel separation is discussed in the relevant section referenced above. Relevant trajectory modelling as applicable to these scenarios is also discussed above.

A loss of vessel separation may lead to the accidental release of marine diesel from the fuel tanks on the vessel(s) involved. For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmental receptor, several factors must align as follows:

- vessel interaction must result in a collision
- the collision must have enough force to penetrate the vessel hull
- the collision must be in the exact location of the fuel tank
- the fuel tank must be full, or at least of volume which is higher than the point of penetration.

The probability of the chain of events described above aligning, to result in a breach of fuel tanks resulting in a spill that could potentially affect the marine environment is considered highly unlikely. Given the offshore location of the Operational Area, vessel grounding in relation to the Petroleum Activities Program is not considered a credible risk.

A collision between a platform, subsea support vessel or HLV with a third party vessel (i.e. commercial shipping, other petroleum related vessels and commercial fishing vessels) was considered the only credible event that could release a significant quantity of marine diesel to the environment. This was assessed as being credible but highly unlikely given the platform support vessels typically operate in the Operational Area, the presence of vessels in the Operational Area is typically temporary (e.g. while undertaking IMR activities), vessels undertaking the Petroleum Activities Program typically operate of low speeds or are stationary, the standard vessel operations and equipment in place to prevent collision at sea, and the construction and placement of storage tanks. The largest tank of a platform support or subsea support vessel is unlikely to exceed 105 m^3. However, the heavy lift vessel required for the installation of the water treatment module may have in the order of 1000 m^3 in an individual tank. Currently a number of Heavy Lift Vessel candidates meet the technical requirements for the installation of the water treatment module onto the riser platform, with individual tank inventories of such vessels varying in the order of 1000 m^3. This quantity is dependent on the final HLV selected as part of the project, and actual tank inventory may differ. For the purposes of understanding the characteristics of a marine diesel release from a HLV, an instantaneous loss of 1000 m^3 has been selected as being representative of a worst-case spill scenario.

Decision Type, Risk Analysis and ALARP Tools

Woodside has not experienced any loss of marine vessel separation events that have resulted in significant environmental impacts. The facility has not experienced a worst-case loss of containment due to loss of vessel separation in its operational history.

<u>Decision Type</u>

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the Bowtie Methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

<u>Quantitative Spill Risk Assessment</u>

Credible worst-case hydrocarbon spill scenarios subsea equipment loss of containment (MEE-02) is to apply to a loss of vessel separation (MEE-04). Refer to the **MEE-02** for a discussion of this credible worst-case spill scenario.

Spill modelling of the worst case credible loss of marine diesel from a vessel spill scenario was undertaken by RPS APASA, on behalf of Woodside. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volumes for all loss of well containment scenarios.

<u>Hydrocarbon Characteristics</u>

See **Unplanned Hydrocarbon Release: Topside Loss of Containment** for a description of marine diesel.

Likelihood

In accordance with the Woodside Risk Matrix, a likelihood of ‘highly unlikely’ event as it ‘has occurred once or twice in the industry’ (experience based likelihood) and aligns with a frequency of ‘1 in 10,000 to 1 in 100,000 years’ has been assigned to each of the following events:

- hydrocarbon release from subsea equipment to the marine environment and atmosphere
- marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of riser platform.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon from the riser platform and platform support vessels were considered during the impact assessment for a worst-case loss of marine vessel separation. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Potential Impacts Overview

Subsea Equipment Release

As discussed under Description of Source of Risk, the potential impacts from a hydrocarbon release caused by a loss of marine separation are those which would result from:

- Subsea Equipment Loss of Containment, MEE-02;

The potential impacts are therefore discussed in the above-mentioned sections.

Zone of Consequence

Surface Hydrocarbons

The surface hydrocarbon spill is forecast to drift in all directions, reflecting the competing influence of both surface currents and winds across the wide area in which a large and persistent slick could travel over the long duration of the release. At the surface threshold of 10 g/m^2, floating oil is forecast to potentially occur up to 110 km from the release site. No contact with sensitive receptors, other than open water sensitivities and marine fauna, are predicted.

Entrained Hydrocarbons

Modelling results indicated the only environmental sensitivities that may be contacted by entrained hydrocarbons above impact thresholds is Rankin Bank. In the event of a worst-case loss of well containment scenario occurring, entrained hydrocarbons at or above 500 ppb are forecast to potentially extend up to 500 km from the release site

Dissolved Hydrocarbons

In the event of a loss of well containment scenario occurring, dissolved hydrocarbons at or above 500 ppb (environmental impact threshold) are not predicted within the model

Summary of Potential Impacts to Environmental Values(s)

Diesel Spill from Vessel

Rankin Bank, open ocean and the Montebello Marine Park are the only sensitive receptor locations expected to be contacted by hydrocarbons above impact thresholds. The credible worst-case hydrocarbon volumes that can credibly be released by MEE-04 are significantly smaller than the credible worst-case loss of well containment volumes considered in MEE-01 and MEE-02. Additionally, the credible release durations are significantly shorter. These considerations are reflected in the significantly smaller ZoC than MEE-01 and MEE-02.

See Subsea Equipment Loss of Containment (MEE-02) for potential impacts.

Summary of Control Measures

- Maintaining collision warning systems and navigational aids to alert the facility of a potential collision with marine vessels, and to alert marine vessels of facility location so they may take timely action to avoid the facility and hence reduce likelihood of collision. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard to prevent environment risk related Damage to SCEs for
  - P34 – Ship Intrusion Detection System
- Maintaining availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard to prevent environment risk related Damage to SCEs for:
  - E04 – Safety Critical Communication Systems
- Maintaining structural integrity to ensure availability of critical systems during a major accident or environment event, and prevent structural failures from contributing to escalation of an MEE. Integrity will be managed in

accordance with SCE Management Procedure and SCE technical Performance Standard to prevent environment risk related Damage to SCEs for:
  - P07 – Substructures
  - P21 – Topsides/Surface Structures
  - F22 – Open Hazardous Drains
- OPGGS (Safety) Regulations 2009. Pluto A Safety Case for Operations.
- Raising incident reports within event reporting system for unplanned releases.
- Mitigation – hydrocarbon spill response

Unplanned Hydrocarbon Release: Loss of Control of Suspended Load from Platform (MEE-05)

Impacts and Risks Evaluation Summary														
Source of Risk	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release from subsea equipment to the marine environment and atmosphere.		X	X	X	X	X	X	B	C	1	M	LCS GP PJ RBA CV	Acceptable if ALARP	**EPO 17**

Description of Source of Risk

Lifting activities on the riser platform can take place from the platform crane between supply vessels and laydown areas, or between laydown areas. Lifting operations performed using the platform or visiting vessel cranes (e.g. HLV) could potentially lead to dropped objects, including the water treatment module, impacting assets (topsides equipment, subsea infrastructure) inside the riser platform 500 m PSZ, potentially leading to a hydrocarbon loss of containment from topsides and/or subsea infrastructure. Loss of suspended load has been identified as an MEE (MEE-05). A loss of suspended load may arise from:

- lifting equipment failure
- facility lifting operations.

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure bowties.

Loss of Suspended Load – Credible Hydrocarbon Spill Scenario

The identified outcome of this MEE is a loss of containment of hydrocarbons due to impact of a dropped object on topsides equipment or subsea pipelines resulting in a release of the hydrocarbon inventory to the atmosphere or the marine environment; refer to **MEE-02 – Subsea Equipment Loss of Containment** and **Unplanned Hydrocarbon Release: Topside Loss of Containment** for a description of these credible loss of containment scenarios.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the Bowtie methodology and hydrocarbon spill trajectory modelling. Company values were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons as a result of subsea equipment loss of containment is considered a Major Environment Event (MEE-02 as a surrogate). The hazard associated with this MEE is hydrocarbons in subsea infrastructure (flowlines, manifolds, etc.) tied to, or originating from, the riser facility.

Quantitative Spill Risk Assessment

Credible worst-case hydrocarbon release from subsea equipment (MEE-02) is considered to apply to the potential loss of containment that may occur in the event of a loss of a suspended load. Refer to **MEE-02** for a discussion of these credible worst-case spill scenarios.

Likelihood

In accordance with the Woodside Risk Matrix, a likelihood of 'highly unlikely' event as it 'has occurred once or twice in the industry' (experience based likelihood) and aligns with a frequency of '1 in 10,000 to 1 in 100,000 years' has been assigned to each of the following events:

- hydrocarbon release from subsea equipment to the marine environment and atmosphere
- hydrocarbon release from topsides equipment to the marine environment and atmosphere.

Consequence The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case loss of suspended load. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.
Consequence Assessment
Zone of Consequence As discussed under Description of Source of Risk, the potential impacts from hydrocarbon release caused by a loss of structural integrity are those which would result from: • Subsea Equipment Loss of Containment, MEE-02. The potential impacts are therefore discussed in the above-mentioned sections.
Summary of Control Measures

• Maintaining platform lifting equipment to prevent platform lifting equipment failure or dropped/swinging loads that could result in an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  o P20 – Lifting Equipment
  o P15 – Cranes
• Maintaining structural integrity to ensure availability of critical systems during a major accident or environment event, and prevent structural failures from contributing to escalation of an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  o P07 – Substructures
  o P21 – Topsides/Surface Structures
• OPGGS (Safety) Regulations 2009: Accepted Safety Case for the facility.
• Raising incident reports within event reporting system for unplanned releases
• Mitigation – hydrocarbon spill response.

MEE Common Cause Event failure mechanisms: SCE Failure CCE-01 and Human Error CCE-02

This section presents common mode failure causes and controls applicable across MEEs, which are also observed within the bowties of the MEEs discussed within sections above. Controls, EPSs and MCs presented within this section are also considered relevant to MEE 01 to MEE-05.

Pluto: Major Environmental Event Datasheet	
MEE Number	ALL
Hazard Description	Generic Safety Critical Equipment failure (CCE-01)

HAZARD DESCRIPTION

Hazard Overview and Scope

There are a number of causes which contribute to failures of SCEs and other systems which might protect against an MEE. These include:

- maintenance errors;
- defects;
- electrical supply failure;
- hydraulic supply failure; and
- adverse environmental conditions.

The generic SCE failure bowties illustrates the causes, outcomes and the controls in place to manage these failure mechanisms.

Summary of Control Measures

- Maintaining hydraulic supplies (e.g. to support Emergency Shutdown Systems and actuation of SCE valves/isolations). Integrity will be managed in accordance with SCE Management Procedure and SCE Technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - F06 – ESD System
    - P09 – Pipeline Systems
    - P10 – Wells
- Maintaining protection from environmental conditions. Integrity will be managed in accordance with SCE Management Procedure and SCE Technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P01 – Pressure Vessels
    - P02 – Heat Exchanger
    - P03 – Rotating Equipment
    - P04 – Tanks
    - P07 – Topsides/Surface Structures
    - P08 – Piping Systems
    - P09 – Pipeline Systems
    - P10 – Wells
    - P21 – Substructures
- Maintaining UPS/emergency power system to supply essential safety systems. Integrity will be managed in accordance with SCE Management Procedure and SCE Technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - F25 – UPS/Emergency Power

OPGGS (Safety) Regulations 2009: Accepted Safety Case for the facility

Pluto: Major Environmental Event Datasheet	
MEE Number	ALL
Hazard Description	Generic Safety Critical Equipment failure (CCE-01)

There are a number of causes of human errors which contribute to MEEs, or which can result in failure or degradation of the barriers in place to protect against MEEs. These are presented in the following bowtie pages and include:

- task issues (e.g. poor task design; time pressures, task complexity)
- poor physical interfaces/working environment
- provision of inappropriate tools for the task
- communication errors (i.e. poor quality information, lack of clarity in instructions)
- operator failings (e.g. competence, fitness, impairment or fatigue)
- organisational issues (e.g. peer pressure, poor safety culture, inadequate supervision, lack of clarity on roles and expectations).

The Generic Human Errors bowtie illustrates the causes, outcomes and the barriers in place for these failure mechanisms.

Human Errors are managed solely via the WMS (no SCEs) and the bowtie is included in this section for completeness.

APPENDIX B: CONTROL MITIGATION MEASURES FOR POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH SPILL RESPONSE ACTIVITIES

Response activities can introduce new impacts and risks. Therefore, it is necessary to complete an environmental risk assessment process to ensure impacts and risks from response activities have been considered, practical control measures are in place to minimise impacts and risks to ALARP. A simplified assessment process has been used to complete this task which covers the identification, analysis, evaluation and treatment of impacts and risks introduced by responding to the event.

Identification of impacts and risks from implementing response strategies

Each of the control measures can modify the impacts and risks identified in the EP. These impacts and risks have been previously assessed within the scope of the EP. Refer to the EP for details regarding how these risks are being managed. They are not discussed further in this document.

- *atmospheric emissions*
- *routine and non-routine discharges*
- *physical presence, proximity to other vessels (shipping and fisheries)*
- *routine acoustic emissions vessels*
- *lighting for night work/navigational safety*
- *invasive marine species*
- *collision with marine fauna*
- *disturbance to seabed.*

Additional impacts and risks associated with the control measures not included within the scope of the EP but discussed below include:

- *additional stress or injury caused to wildlife*
- *additional drilling impacts from relief well drilling*

Analysis of impacts and risks from implementing response strategies

The table below compares the adopted control measures for this oil spill response activity against the environmental values that can be affected when they are implemented.

Table 12-32: Analysis of risks and impacts

	Environmental Value						
	Soil & Groundwater	***Marine Sediment Quality***	***Water Quality***	***Air Quality***	***Ecosystems/ Habitat***	***Species***	***Socio-Economic***
Monitor and evaluate		X	X		X	X	
Source control		X	X		X	X	X
Oiled Wildlife					X	X	
Scientific Monitoring	X	X	X	X	X	X	X
Waste Management	X			X	X	X	X

- **Evaluation of impacts and risks from implementing response strategies**

Additional stress or injury to wildlife could be caused through the following phases of a response:

- Capturing wildlife
- Transporting wildlife
- Stabilisation of wildlife
- Cleaning and rinsing of oiled wildlife
- Rehabilitation (e.g. diet, cage size, housing density)
- Release of treated wildlife

Inefficient capture techniques have the potential to cause undue stress, exhaustion or injury to wildlife, additionally pre-emptive capture could cause undue stress and impacts to wildlife when there are uncertainties in the forecast trajectory of the spill. During the transportation and stabilisation phases there is the potential for additional thermoregulation stress on captured wildlife. Additionally, during the cleaning process, it is important personnel undertaking the tasks are familiar with the relevant techniques to ensure that further injury and the removal of water proofing feathers are managed and mitigated. Finally, during the release phase it's important that wildlife are not released back into a contaminated environment.

Vessel operations

Typical booms used in containment and recovery operations are designed to sit on the water surface, meaning that fauna capable of diving, such as cetaceans, marine turtles and sea snakes can readily avoid contact with the boom. Impacts to species that inhabit the water column such as sharks, rays and fish are not expected. Additionally, many fauna, such as cetaceans, are likely to detect and avoid the spill area, and are not expected to be present in the proximity of containment and recovery operations.

Drill cuttings and Drilling Fluids Environmental Impact Assessment for Relief Well Drilling

The identified potential impacts associated with the discharge of drill cuttings and fluids during a relief well drilling activity include a localised reduction in water and seabed sediment quality, and potential localised changes to benthic biota (habitats and communities).

A number of direct and indirect ecological impact pathways are identified for drill cuttings and drilling fluids as follows:

- Temporary increase in Total Suspended Solids (TSS) in the water column;
- Attenuation of light penetration as an indirect consequence of the elevation of TSS and the rate of sedimentation;
- Sediment deposition to the seabed leading to the alteration of the physico-chemical composition of sediments, and burial and potential smothering effects to sessile benthic biota; and
- Potential contamination and toxicity effects to benthic and in-water biota from drilling fluids.

Potential impacts from the discharge of cuttings range from the complete burial of benthic biota in the immediate vicinity of the well site due to sediment deposition, smothering effects from raised sedimentation concentrations as a result of elevated TSS, changes to the physico-chemical properties of the seabed sediments (particle size distribution and potential for reduction in oxygen levels within the surface sediments due to organic matter degradation by aerobic bacteria) and subsequent changes to the composition of infauna communities to minor sediment loading above background and no associated ecological effects. Predicted impacts are generally confined to within a few hundred metres of the discharge point (International Association of Oil and Gas Producers 2016) (ie within the ZoC for a hydrocarbon spill event).

The discharge of drill cuttings and unrecoverable fluids from relief well drilling is expected to increase turbidity and TSS levels in the water column, leading to an increased sedimentation rate above ambient levels associated with the settlement of suspended sediment particles in close proximity to the seabed or below sea surface, depending on location of discharge. Cuttings with retained (unrecoverable) drilling fluids are discharged below the water line at the MODU location, resulting in drill cuttings and drilling fluids rapidly diluting, as they disperse and settle through the water column. The dispersion and fate of the cuttings is determined by particle size and density of the retained (unrecoverable) drilling fluids, therefore, the sediment particles will primarily settle in proximity to the well locations with potential for localised spread downstream (depending on the speed of currents throughout the water column and seabed) (IOGP 2016). The finer particles will remain in suspension and will be transported further before settling on the seabed.

The low sensitivity of the deepwater benthic communities/habitats within and in the vicinity of relief well locations, combined with the relatively low toxicity of WBM and NWBMs, no bulk discharges of NWBM and the highly localised nature and scale of predicted physical impacts to seabed biota indicate that any localised impact would likely be of a slight magnitude (especially when considering the broader consequence of the LOC event a relief well drilling activity would be responding too).

Treatment of impacts and risks from implementing response strategies

The following control measures and monitoring have been adopted for the identified impacts and risks. The treatment measures identified in this assessment will be captured in Operational Plans, Tactical Response Plans, and/or First Strike Response Plans, to ensure an ALARP level is achieved.

<u>Additional stress or injury caused to wildlife</u>

Operations conducted with advice from the DBCA Oiled Wildlife Advisor and in accordance with the processes and methodologies described in the WA Oiled Wildlife Response Plan OWRP and the relevant regional plan.

<u>Vessel operations</u>

The boom will be monitored and maintained to ensure trapped fauna are released as early as possible, with CAR activities occurring in daylight hours only (PS 15.1).

<u>Drill Cuttings and Drilling Fluids</u>

The low sensitivity of the deepwater benthic communities/habitats within and in the vicinity of relief well locations, combined with the relatively low toxicity of WBM and NWBMs, no bulk discharges of NWBM and the highly localised nature and scale of predicted physical impacts to seabed biota indicate that any localised impact would likely be of a slight magnitude (especially when considering the broader consequence of the LOC event a relief well drilling activity would be responding too).

Monitoring of Environmental Impacts from a Response

Potential impacts from an oiled wildlife operation would be monitored by the DBCA Oiled Wildlife Advisor who would advise the Incident Management Team in an OWR response. Part of the role of the OWR Advisor is to ensure that the minimum standards for OWR are being monitored and adhered to, whilst providing expert advice for critical decision making.

The risk of secondary contamination from waste management operations will be managed through appropriate zoning. This will be monitored through the submission of daily reports, detailing operations and reporting on any potential environmental impacts associated with shoreline operations.

APPENDIX C: SUMMARY OF STAKEHOLDER FEEDBACK AND WOODSIDE'S RESPONSE

Relevant Stakeholder feedback for the Petroleum Activities Program

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
Department of Industry, Innovation and Science	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Department of Mines, Industry Regulation and Safety (*formerly Department of Mines and Petroleum*)	Email with fact sheet	**Date:** 13 April 2018 **Feedback summary:** The Department acknowledged that Woodside will revise and submit an EP for the Pluto Offshore Facility Operations. The Department advised that no further information is required at this stage, however recommends Woodside review the *Pluto Pipeline (State Waters) EP* once the Pyxis gas field subsea tieback is complete to evaluate whether or not there are any increases or changes in environmental risk rankings in the EP (e.g. in relation to maximum credible spill scenarios).	The stakeholder raised no claims or objections.	**Response/Action:** Woodside to review the *Pluto Pipeline (State Waters) EP* once the Pyxis gas field subsea tieback is complete with regard to any increase or change in environmental risk rankings.
Director of National Parks (DNP)	Email with fact sheet	**Date:** 21 August 2018 **Feedback summary:** No response at the time of submission.	Woodside will continue to accept and assess feedback.	**Response/Action:** Woodside to follow up with the stakeholder as to whether further information is required.
	Email	**Date:** 25 September 2018 **Feedback summary:** The DNP provided general advice around the Montebello Marine Park and the authorisation of a class approval through the *North-west Marine Parks Network Management Plan 2018* (Management Plan), and advised that the EP	No prohibitions, restrictions or determinations have been raised by the DNP. Woodside confirmed with the DNP that all	**Response/Action:** Woodside to ensure that the EP identifies and manages the impacts and risks on marine park values to an acceptable level, and demonstrates that the activity will not be inconsistent with the

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		should include management of impacts and risks on marine park values in the context of the Management Plan.	relevant points are covered in the EP.	Management Plan. Woodside to notify the DNP if the EP is approved by NOPSEMA.
	Email	**Date:** 22 February 2019 **Feedback summary:** Woodside provided additional information to the DNP on specific activities that may occur in the Montebello Marine Park, or have the potential to impact the values thereof, namely IMR activities and produced water discharges. An assessment of potential impact from both activities was provided against each of the Marine Park Values. A figure outlining the location of the export pipeline and the produced water potential mixing zone in relation to the values of the Montebello AMP was also provided.	No prohibitions, restrictions or determinations have been raised by the DNP.	**Response/Action:** Woodside to include discussion on potential impacts to Montebello Marine Park Values at upcoming meeting with Parks Australia on 15 March 2019.
	Meeting with Parks Australia	**Date:** 15 March 2019 **Feedback summary:** Woodside provided an overview of produced water (PW) from Pluto Platform in relation to Montebello Marine Park. Parks Australia queried how far away the platform was from Montebello Marine Park, to which Woodside responded that it was 416 m away from the boundary of the Multiple Use Zone. Parks Australia also asked if Woodside takes PW samples from the Pluto reservoir, to which Woodside responded that it will be using the worst case from other facilities in the worst possible conditions). Woodside then provided an overview of annual chemical characterisation, and the other three-yearly surveys. Woodside asked Parks Australia if the type of fact sheet provided during consultation is	No prohibitions, restrictions or determinations have been raised by the DNP.	**Response/Action:** Woodside to email DNP with information requested on baseline monitoring and relevant permits required.

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		useful. Parks Australia advised that it is quite general and they are more interested in the activities and impacts within the park, also that they would like notification of what is is going on in the park and when, and/or how far away from the park. Parks Australia advised that the level of detail in the PW presentation was more than they require. Woodside asked if Parks Australia would like to contribute/comment on the baseline monitoring. Parks Australia requested that Woodside send through an email including baseline monitoring relevant permits (whether Woodside needs to apply for a monitoring permit in the AMP if its under an EP).		
	Email (with presentation on Produced Water attached)	**Date:** 25 March 2019 **Feedback summary:** Woodside emailed DNP on 21 March 2019 with the information requested on baseline monitoring and any permits required. The DNP responded on 25 March 2019 thanking Woodside for providing the information, and also requested Woodside to note additional notifications to the DNP required, namely: - on approval of the EP; - 10 days prior to IMR activities occurring within Montebello Marine Park (and on conclusion); and - should any oil/gas pollution incidences occur within a marine park or are likely to impact on a marine park as soon as possible.	Woodside confirmed that notification will be provided to the DNP at least 10 days prior to all inspection, monitoring, maintenance or repair activities occurring within the Montebello Marine Park (excluding transiting) and on conclusion of those activities. Woodside also advised that in cases where inspections are required for emergent issues or following a cyclone, notifications will be provided as soon as	**Response/Action:** Notification to DNP will be undertaken as requested (**Section 6.7.6 and 6.9**).

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
			practicable. Woodside also confirmed that the DNP will be notified of any oil/gas pollution incidences which occur within a marine park or are likely to impact on a marine park in line with the guidance provided.	
AMSA (maritime safety)	Email with fact sheet and shipping density map	**Date:** 16 April 2018 **Feedback summary:** The Authority advised that they have no comments to provide at this time.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
	Email with updated fact sheet	**Date:** 30 August 2018 **Feedback summary:** AMSA advised that they have reviewed the information and have no comments to provide at this time.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
Australian Hydrographic Service	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** The Service acknowledged receipt of Woodside's email.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
Department of Primary Industries and Regional Development (*formerly Department of Fisheries (Western Australia*))	Email with fact sheet and state fisheries map	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
Western Australian Fisheries: • Pilbara Fish	Letter with fact sheet and state fisheries map	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post	**Response/Action:** No further action required.

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
Trawl • Pilbara Trap • Marine Aquarium Fish • Specimen Shell • Onslow Prawn • West Australian Mackerel Fishery.			EP submission to NOPSEMA.	
Department of Defence	Email with fact sheet and map of defence zones	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Department of Transport	Email with fact sheet and map of shipping density	**Date:** 26 April 2018 **Feedback summary:** The Department asked Woodside to ensure that if there are any changes to the relevant Oil Spill Contingency Plan (OSCP)/OPEP that DoT are consulted in accordance with the requirements as detailed in the DoT Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements (December 2017).	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
	Emailed draft First Strike Plan	**Date:** 14 May 2018 **Feedback summary:** The Department acknowledged receipt of email and advised that they would review the First Strike Plan as soon as they could.	Woodside will accept and assess feedback from stakeholder	**Response/Action:** No further action required.
		Date: 14 June 2018 **Feedback summary:** The Department advised that the Pluto Oil Pollution First Strike Plan	Woodside updated Pluto Oil Pollution First Strike Plan.	**Response/Action:** No further action required.

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		contained a reference to the old Industry Guidance Notes (January 2017 version) and requested an updated First Strike Plan.		
AFMA	Email with fact sheet and Commonwealth fisheries map	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
	Phone conversation	**Date:** 11 December 2018 **Feedback summary:** Woodside called to advise AFMA of the updated consultation material which now includes IMR activities, and queried if AFMA would see any additional concerns from a Commonwealth fisheries perspective. AFMA did not see any concerns but agreed to read the updates via email and respond.	The stakeholder raised no claims or objections verbally.	**Response/Action:** Woodside to send updated consultation material via email to AFMA.
	Email requesting advice on additional IMR activities with updated fact sheet	**Date:** 11 December 2018 **Feedback summary:** AFMA advised that they do not believe the additions and amendments provided regarding IMR activities warrant additional consultation with Commonwealth fishers and that they are unlikely to pose an increased risk.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
Commonwealth Fisheries Association	Email with fact sheet and fishery map	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Western Australian Fishing Industry Council	Email with fact sheet and fishery map	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to	**Response/Action:** No further action required.

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
			NOPSEMA.	
	Email requesting advice on additional IMR activities	**Date:** 17 August 2018 **Feedback summary:** WAFIC advised that as the IMR activities added to the consultation information sheet will not generate any additional exclusion zones or add any significant additional burden to resource sharing, there should be no need to re-consult fishers as it is a typical activity with which commercial fishers engage throughout the region.	The stakeholder raised no claims or objections. Woodside will not re-send updated consultation material to commercial fishers.	**Response/Action:** No further action required.
Other operators: • Chevron • Quadrant • Jadestone	Email with fact sheet and infrastructure map	**Date:** 21 August 2018 **Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.

Feedback from Interested Stakeholders on the Petroleum Activities Program

Organisation	Method	Feedback	Woodside assessment	Woodside's Response
AMSA (marine pollution)	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Australian Conservation Foundation	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
AMOSC	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
APPEA	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Pearl Producers Association	Email with fact sheet and fishery map	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
RecfishWest	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
World Wildlife Foundation	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of	Woodside will accept and assess feedback from stakeholder post EP	**Response/Action:** No further action required.

Organisation	Method	Feedback	Woodside assessment	Woodside's Response
		submission.	submission to NOPSEMA.	
Wilderness Society	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Australian Customs Service – Border Protection Command	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Department of Biodiversity, Conservation and Attractions (formerly Department of Parks and Wildlife	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
International Fund for Animal Welfare	Email with fact sheet	**Date:** 12 April 2018 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.