Scarborough Project Nearshore Component

Referral Supplementary Report

December 2018

Revision 1 – For Submission

TABLE OF CONTENTS

1 Introduction

The Scarborough gas field is located 380 km west-north-west of the Burrup Peninsula in the north-west of Australia. Woodside Energy Ltd (Woodside) will be the development operator, with BHP Billiton Petroleum (North West Shelf) Pty Ltd (BHP) as joint venture participant. The Scarborough gas field development (Scarborough Project) includes drilling of a number of subsea gas wells (which includes wells in the Scarborough, Thebe and Jupiter reservoirs) but may also include additional future tiebacks. Wells will be tied-back to a semi-submersible Floating Production Unit (FPU) moored in approximately 900 m of water, over the Scarborough field. The FPU topsides has processing facilities for gas dehydration and compression to transport the gas through an approximately 430 km trunkline to the Woodside-operated Pluto Liquified Natural Gas (LNG) facility on the Burrup Peninsula. Woodside is proposing the brownfield expansion of Pluto LNG to process third-party gas. Which will require brownfield expansion to process the Scarborough gas (Figure 1-1).

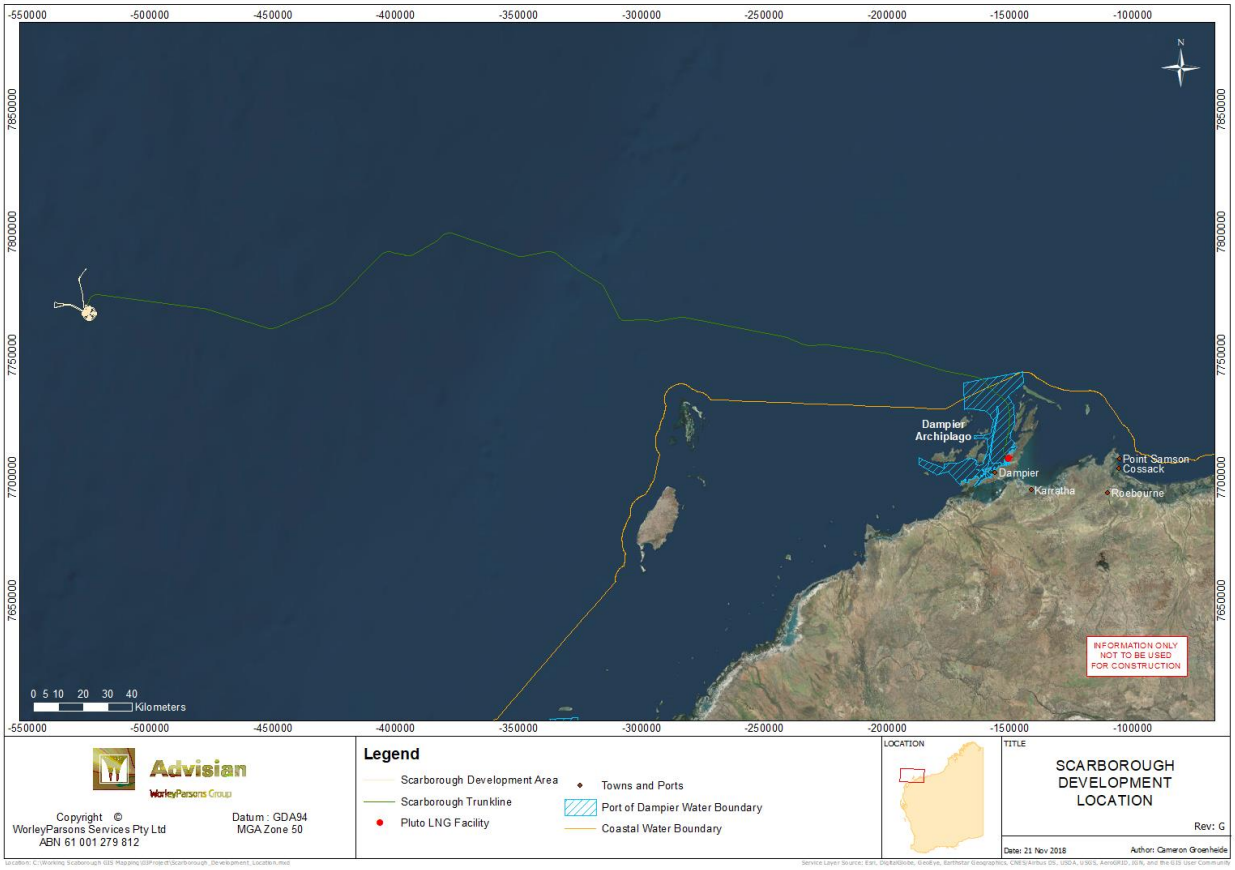


Figure 1-1: Proposed Scarborough Project

1.1 Purpose and scope

1.1.1 Purpose

The Proposal, subject of this referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *WA Environmental Protection Act 1986* (EP Act), is defined as the State waters components of the Scarborough Project. A detailed scope of the Proposal is presented in Section 2. The purpose of this document is to present an initial environmental impact assessment (EIA) of the Proposal and other information as relevant under the EPBC and EP Acts; to assist the Commonwealth Minister for the Environment and the WA Environmental Protection Authority (EPA) in determining whether the Proposal requires assessment and approval under the relevant Acts and if required the level of assessment that will be applied.

This document should be read in conjunction with the EPBC Referral Form and EP Act Referral Form prepared for the Proposal.

1.1.2 Scope

This report presents an environmental review of the Proposal, including all components of the Proposal within State waters and the onshore crossing as described in Table 1-1 and shown in Figure 2-1.

Table 1-1: Approvals scope and activities

Project Phase	Activities
Construction	Trenching, pipelay and backfill activities for the installation of the trunkline. This includes the installation of the pipe up to Kilometre Point (KP) 0, 1.5m above Highest Astronomical Tide (HAT), the exact location may vary slightly but will remain within the referred proposal development envelope (Figure 2-2).
	The use of existing spoil grounds within State Waters for disposal of dredged sediments.
	The potential use of an existing borrow ground within State Waters, to obtain sediment for trunkline stabilisation activities.
	The installation of temporary facilities along the shoreline at the Pluto LNG Facility to facilitate the installation of the trunkline in shallower depth and the connection to the Facility (Figure 2-3).
Operations	The operation of the trunkline in State waters up to point KP0.

This document includes:

- a description of the Proposal, including key characteristics of the Proposal which have the potential to cause an impact on the environment (Section 2) as per the scope described above
- the approach to stakeholder consultation undertaken and proposed to support the Proposal (Section 3)
- an assessment of the potential significant environmental impacts of the Proposal for each of the EPA's relevant Key Environmental Factors and proposed mitigation measures to avoid and/or mitigate those impacts (Section 4)
- an assessment of the potential environmental impacts of the Proposal on Matters of National Environmental Significance (MNES) (Section 5).

All activities in Commonwealth Waters will be assessed separately as part of an Offshore Project Proposal (OPP) to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). This includes the following components of the proposed Scarborough Project:

- drilling of the gas wells and installation of the FPU
- the trunkline section and all related activities within Commonwealth Waters
- the dredging of material from borrow grounds within Commonwealth Waters
- the hydrotesting of the trunkline and release of hydrotest water in Commonwealth Waters.

The use of spoil grounds will be the subject of a separate Sea Dumping Permit application to the Department of Environment and Energy (DoEE).

1.2 Proponent

The proponent for the Proposal is Woodside as operator for and on behalf of the Scarborough Joint Venture. The proponent details are provided in Table 1-2.

Table 1-2: Proponent details

Name of the proponent/s	Woodside Energy Ltd (Woodside) for and on behalf of the Scarborough Joint Venture (SJV) consisting of Woodside and BHP Billiton Petroleum (North West Shelf) Pty Ltd (BHP NWS)
ABN	Woodside ACN - 005 482 986 BHP NWS ACN - 004 514 489
Address	Mia Yellagonga 11 Mounts Bay Road, Perth, 6000
Contact for the Proposal	Tegan Box Scarborough Development 11 Mount street, Perth, WA, 6000 feedback@woodside.com.au 1800 442 977

1.3 Environmental impact assessment process

1.3.1 Environmental Protection Act 1986 (Part IV)

The Proposal is being referred to the EPA in accordance with Part IV (Section 38) of the EP Act. The EP Act is WA's primary environmental legislation. The Act sets out to prevent, control, and abate pollution and environmental harm, for the conservation, preservation, protection, enhancement, and management of the environment. The EPA has statutory obligations under the EP Act to conduct EIAs, initiate measures to protect the environment from environmental harm and pollution and to provide advice to the WA Minister for Environment on environmental matters.

A screening of the Proposal against the EPA's Key Environmental Factors and associated Environmental Objectives has been completed (Section 4.1). The Proposal has the potential to pose a risk of compromising the Environmental Objectives for the following environmental factors which are described in detail in Section 4 of this document:

- Benthic Communities and Habitat
- Marine Environmental Quality
- Marine Fauna
- Social Surroundings.

'Other Environmental Factors' were also considered to be potentially impacted, though impacts were considered to be minor, specifically:

- Coastal Processes
- Terrestrial Environmental Quality
- Air Quality.

The factors considered irrelevant to the Proposal are:

- Flora and vegetation
- Landforms
- Subterranean Fauna
- Terrestrial Fauna
- Inland Waters

- Human Health.

1.3.2 Environment Protection and Biodiversity Conservation Act 1999

Based on the outcomes of environmental investigations detailed in Section 4 and 5, Woodside does not consider that the elements of the Proposal assessed in this report (Section 1.1.2), involves an action that is likely to have a significant impact upon MNES or other protected matters. Therefore, the Proposal is not expected to require assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). However, a referral to the Commonwealth Department of Environment and Energy (DoEE) will be undertaken concurrently with the EPA referral to confirm this position.

The potential for impacts upon MNES are considered and discussed in Section 5 and this referral report will be submitted to DoEE to inform the EPBC referral process.

1.4 Other approvals and regulation

1.4.1 Applicable Commonwealth legislation and policies

The key Commonwealth legislation applicable to the Proposal is the EPBC Act (Section 1.3.2).

Other Commonwealth legislative requirements for the Proposal may include:

- Australian Heritage Council Act 2003
- Biosecurity Act 2015
- Biosecurity (Ballast Water & Sediment) Determination 2017
- Environmental Protection (Sea Dumping) Act 1981
- Hazardous Waste (Regulation of Exports and Imports) Act 1989
- Historic Shipwrecks Act 1976
- Underwater Cultural Heritage Act 2018
- National Greenhouse and Energy Reporting Act 2007 (NGER Act)
- Navigation Act 2012
- Protection of the Sea (Prevention of Pollution from Ships) Act 1983
- Protection of the Sea (Harmful Anti-fouling Substances) Act 2006
- Submarine Cables and Trunklines Protection Act 1963
- Native Title Act 1993.

The Commonwealth Government policies relevant for the Proposal referral may include:

- Australian Offshore Petroleum Development Policy
- Australia's Oceans Policy
- Marine Bioregional Plans
- Conservation Advice
- Species Management Plans
- Recovery Plans
- Australian Ballast Water Management Requirements 2017
- National Biofouling Management Guidance for the Petroleum Production and Exploration Industry 2009

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000.

1.4.2 Applicable State legislation

Key State legislation applicable to this referral are the EP Act (Section 1.3.1) and the *Petroleum (Submerged Lands) Act 1982* (PSL Act).

The PSL Act provides the regulatory framework for the exploration and production of petroleum resources located within State marine waters, including related trunklines.

Other State legislative requirements potentially relevant to the referral may include:

- Biosecurity and Agriculture Management Act 2007
- Biodiversity Conservation Regulations 2018
- Conservation and Land Management Act 1984
- Fish Resources Management Act 1994
- Land Administration Act 1997
- Maritime Archaeology Act 1973
- Petroleum and Geothermal Energy Resources Act 1967
- Petroleum (Submerged Lands) Act 1982
- Pollution of Waters by Oil and Noxious Substances Act 1987
- Waste Avoidance and Resource Recovery Act 2007
- Wildlife Conservation Act 1950 (WA) (WC Act).

2 The Proposal

2.1 Background

In 2018, Woodside acquired an additional 50% interest in WA-1-R containing the majority of the Scarborough gas field, taking the Company's interest to 75% in WA-1-R and a 50% interest in WA-61-R, WA-62R and WA-63-R. Prior to this acquisition, the previous operator had evaluated the development of the Scarborough field via Floating Liquefied Natural Gas (FLNG) technology. This Proposal was referred under the EPBC Act (reference no. 2013/6811) by ExxonMobil to the Commonwealth in 2013, and was set a level of assessment as "assessed by preliminary documentation". The Proposal was approved the same year with conditions and varied in 2015 to allow for changes resulting from the streamlining arrangements set in place for the assessment of petroleum activities under the OPGGS Act and EPBC Act. Woodside is proposing to bring the gas onshore to existing LNG facilities through an approximately 430 km trunkline.

2.2 Justification

2.2.1 Proposal need and alternatives considered

The Scarborough field was discovered in 1979 with the drilling of the Scarborough-1 well. The field was previously held by ExxonMobil (50%) and BHP (50%). Woodside now holds a 75% share along with BHP who retained 25%. Since discovery various development options have been considered.

The previous operator evaluated two concept themes, a tieback to a shore-based LNG site and Floating LNG (FLNG). Given high costs for developing a greenfield LNG site and the limited commercial solutions for expanding existing LNG facilities at the time, the previous operator selected FLNG as the preferred development concept. The FLNG concept included proprietary technologies of the previous operator. Woodside's view of the concept was that it would take several years to fully mature the technology prior to being ready for deployment.

Woodside has further considered development options and undertaken a comparative assessment (including a 'no development' option) to identify the benefits, risks and impacts of each. A summary of the evaluation outcome is presented in (Table 2-1).

Table 2-1: Woodside Assessment of Alternative Concepts for the Scarborough Project

Concept	Summary of Woodside Evaluation
1. Semisubmersible to Pluto LNG *Semisubmersible platform with trunkline to Pluto LNG. Includes infield processing and compression at ready for start-up (RFSU).*	***Preferred approach*** - Pre-investment made during construction of Pluto LNG (including the trunkline corridor, tanks and jetty infrastructure) for future expansion, and existing primary environmental approvals for a second LNG train, has provided cost benefits and reduced risk. Processing Scarborough gas through Pluto LNG will maximise use of existing infrastructure, extend the life of the facility and supply domestic and export markets from mid 2020s for decades. Lower environmental impact as area has previously been developed and no additional onshore clearing or significant dredging required.
2. Subsea Tieback to Shore *Various subsea focussed development options with initial free flow and later installation of floating or subsea compression facilities.*	There is negligible difference in environmental impacts/risks between this option and the preferred option (ie both have an infrastructure footprint and both require an export pipeline from the field site to the onshore location). Weakness in the concept are complexity in delivering design rate, technology development risk and complex liquids management in the Scarborough trunkline.
3. Subsea Tieback via Pluto upstream *Subsea development tieback to existing offshore Pluto Platform.*	Carries similar weaknesses to the above subsea tieback to Shore option, and presents higher technical risks and value impacts associated with the offshore brownfield integration (i.e. integration of new platform with existing riser platform, complex liquids management in the Scarborough trunkline, shutdown implications during offshore installation and integration).

Concept	Summary of Woodside Evaluation
4. FLNG *Concept as proposed by previous operator, includes immature proprietary gas processing, storage and cryogenic offloading technology.*	Higher technical risk including unproven technology in Scarborough conditions. Higher cost, longer schedule and risks to predictable delivery. Does not support use of existing onshore LNG infrastructure.
5. No Development	Titleholder is required to undertake certain petroleum exploration and production related activities towards commercialising the Scarborough resources.

Concept 1 is Woodside's (as operator) preferred development option, where Scarborough gas would be processed through a brownfield expansion of Pluto LNG, where additional LNG processing capacity and domestic gas infrastructure will be installed. The composition of Scarborough gas is well suited to Pluto LNG facilities, which is designed for lean gas and nitrogen removal.

2.2.2 Design/Activity Alternatives

As part of Woodside's (as operator) preferred concept, namely a brownfield expansion of the existing Woodside-operated Pluto LNG Facility to process Scarborough resources, Woodside is considering and assessing a range of options for facilities, activities, installation and construction methods as listed below:

- Mooring of construction vessels
- Manning of FPU
- Drilling fluids
- Piling techniques
- Compression facilities
- Trunkline route
- Pre-lay survey vessel/technique
- Trunkline construction technique
- Pre-lay seabed preparation and Post-lay stabilisation/protection

The process for considering options for each of these will include evaluation against set criteria, including environment and safety and be documented in the key decision logs (KDL) where appropriate.

2.3 Proposal description

The Proposal as defined in Section 1.1.2 would include the following activities:

- shore crossing site preparation including installation of temporary facilities along the shoreline at the Pluto LNG Facility to facilitate the installation of the trunkline in shallower depths
- preparation works associated with the installation of the trunkline including dredging and associated spoil disposal at existing spoil grounds
- trunkline installation (about 32.7 kilometres long within State waters)
- shore crossing site reinstatement
- rock supply and dumping/sand supply and backfilling of the trench with sand and/or rock to protect the trunkline
- pre-commissioning testing

- commissioning and operation
- decommissioning.

The development envelope and indicative footprints are illustrated in Figure 2-1 and Figure 2-2, and defined as:

- development envelope – the maximum area within which the proposal footprint would be located (Section 1.1.2)
- indicative footprint – the location where the physical proposal elements occur.

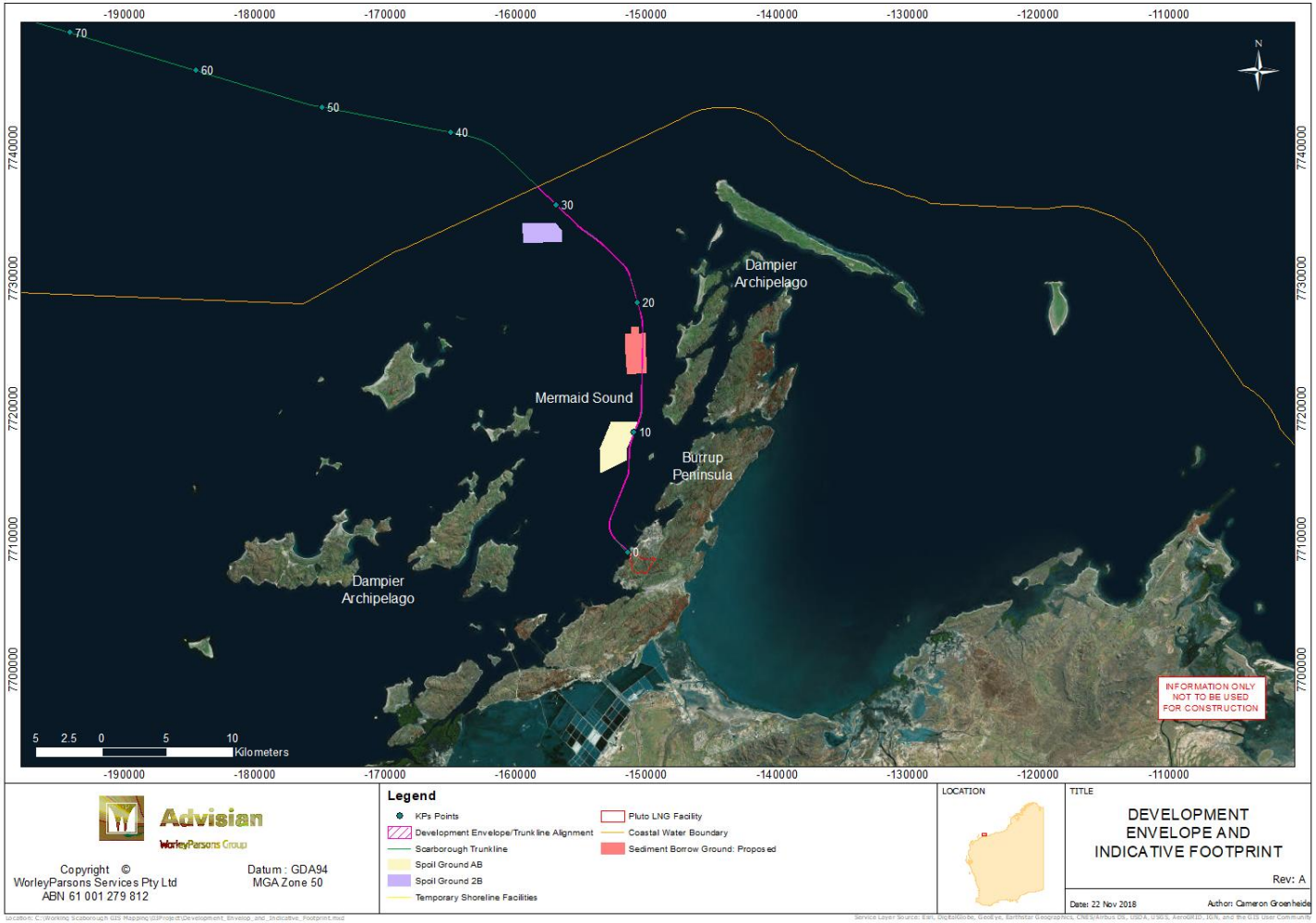


Figure 2-1: Development envelope and indicative footprint of the Proposal

Figure 2-2: Development envelope and indicative footprint of the shore crossing site

2.3.1 Key proposal characteristics

Table 2-2 includes a short description of the Proposal. Table 2-3 describes the location and extent of the physical and operational elements of the Proposal.

Table 2-2: Summary of the Proposal

Proposal title	Scarborough gas field development – nearshore component
Proponent name	Woodside Energy Ltd
Short description	Woodside is proposing to develop the Scarborough gas field, with a target of achieving first gas production between 2023 and 2025. The Scarborough Project concept comprises subsea wells, a semi-submersible gas processing and compression floating production unit in offshore Commonwealth waters and export trunkline 434 kilometres long running to the Pluto LNG Facility on the Burrup Peninsula. The nearshore component subject of this referral includes the installation of the section of the trunkline running from the State waters boundary up to KP0 (approximately 1.5m above HAT) (~32.7 kilometres long) and associated activities.

Table 2-3: Location and proposed extent of physical and operational elements

Element	Location	Proposed extent
Physical elements		
Trunkline and trench	Figure 2-1 and Figure 2-2	A 32 inch carbon steel trunkline 32.7 kilometre long installed in a trench around 2–4.3 metres deep and up to 30 m wide. The trench would be backfilled with sand and/or rock material for stabilisation purposes along the trunkline as required. Concrete blocks backfilled with trenching material may also be required to provide reaction forces. These would be laid within the trench footprint and retained in place to maintain the reaction forces once the pipe is laid. The trench backfilling operations will cover these blocks on completion of the construction works.
Temporary infrastructure and laydown areas for the shore crossing	Figure 2-1 and Figure 2-2	A temporary groyne around 100 metres long would be constructed on the shoreline between the pre-excavated trench and the Pluto jetty to allow excavating equipment to access and excavate the rock berm currently covering the trench. A suitable storage location will be required for the excavated rock assuming that this rock will be used to reinstate the shore crossing rock berm following trunkline installation. Piles may also be required to anchor the nearshore pipelay barge. Piles are required due to the proximity to the Pluto trunkline which may prevent the use of anchors for the pipelay activities. It's estimated a total of 8 driven piles may be required. Space would be required at the shore crossing location for temporary offices, cranes and other equipment for the shore pull of the trunkline.
Spoil ground for disposal of dredged sediments	Figure 2-1	Spoil from the trunkline dredging operations will be placed in a combination of the spoil grounds listed below. The final spoil ground locations are subject to further engineering design and consultation with relevant stakeholders. Spoil Ground A/B (restricted to backhoe works) and 2B located in State Waters. Spoil Ground 5A located in Commonwealth Waters[1].
Rock/sediment source for backfilling	Figure 2-1	Sand and Rock materials may be required to assist with trunkline stabilisation.

[1] Provided for information only but not assessed as part of this referral (refer to Section 1.1.2)

Element	Location	Proposed extent
		Sand is proposed to be obtained from borrow ground locations located in either State or Commonwealth waters. Rocks would be obtained from domestic or international sources.
Operational elements		
Dredging and disposal of material during the trenching	Figure 2-1	Dredging of maximum 2,781,700 m^3 during the trenching for the trunkline, of which a maximum of 1,612,600 m^3 will be in State Waters[2]. Dredge spoil would be disposed of at Spoil Grounds A/B, 2B and/or 5A. The volumes would be confirmed during detailed engineering design.
Rock/sediment placement	Figure 2-1 and Figure 2-2	Sediment from the borrow ground and rock material would be required. The volumes would be confirmed during detailed engineering design.
Pre-commissioning testing of trunkline	No figure	Wet and/or dry pre-commissioning testing would need to be undertaken prior to trunkline operations. Total discharge volume for a wet pre-commissioning would be maximum 225,189, m^3 based on length (434 km) and trunkline internal diameter (32 inch). Bulk discharge of the hydrotesting water is likely to be undertaken in Commonwealth Waters. The nearshore component of the pipeline may be tested separately to provide pipeline stability prior to back fill/rock dumping activities or if a performance test of the nearshore component of the pipeline is required prior to back fill/rock dumping operations.

Further details on the construction methodology are provided in the following sections.

2.3.2 Sequence of construction activities

A number of construction activities would need to be performed under this Proposal. This includes shore crossing site preparation, trunkline installation and seabed intervention in the form of dredging and trench backfill. The requirement for seabed intervention stems from the need to provide mechanical protection and/or provide secondary stabilisation for the trunkline.

The design currently assumes the stabilisation and protection requirements for the Scarborough trunkline would be the same as for the Pluto LNG Facility trunkline.

2.3.2.1 Shore crossing site preparation

The shore crossing site would need to have sufficient area to safely conduct site preparations, the shore pull and post pull operations (including pre-commissioning if required) without adversely impacting the adjacent Pluto LNG Facility operations and other sensitive receptors (e.g. heritage site, North West Shelf Venture (NWSV) boundary).

The shore crossing site preparation would include:

- setting up facilities (offices, utilities, etc)
- constructing a temporary rock groyne around 100 metres in length between the Scarborough trench and the Pluto LNG Facility jetty, to allow excavating equipment to access and excavate the rock currently covering the trench line
- removing the existing rock covering the trench at the trunkline shore crossing site before performing the shore pull; a suitable storage location within the development envelope and/or offsite would need to be identified for the excavated rock, if this rock is used to reinstate the shore crossing rock berm following trunkline installation
- installing a bedding layer in the trench

[2] All trenching volumes are based on 'in-situ' measurement (i.e confirmed by hydrographic survey techniques)

- installing an anchor block or piles and shore pull equipment.

Figure 2-3 illustrates an indicative site layout for the temporary construction plant and facilities that would be required at the shore crossing location.

Construction and operation of the trunkline from the point approximately 1.5m above HAT to the existing Pluto LNG Facility is covered under the existing Ministerial Statement (MS) 757.

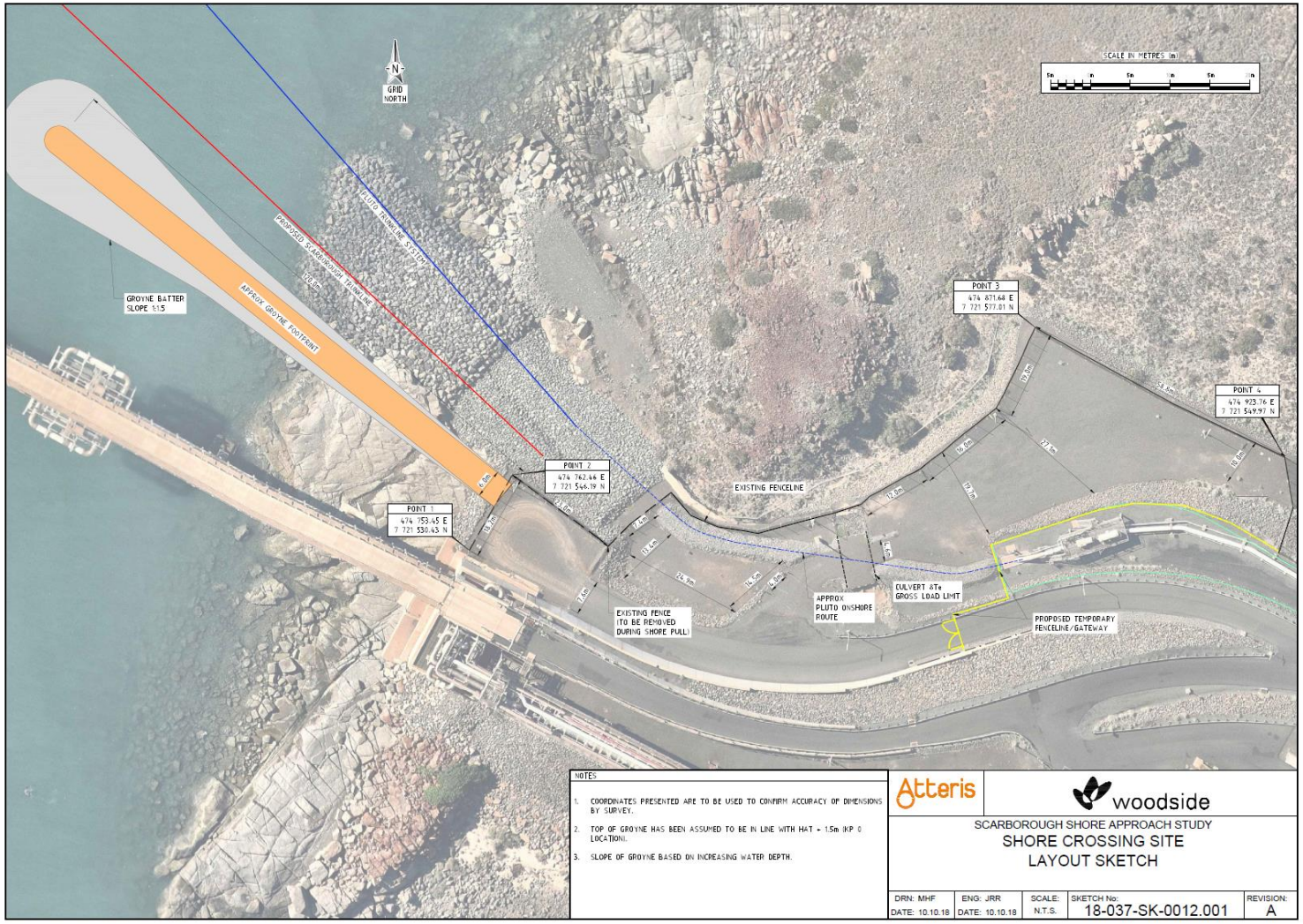


Figure 2-3: Indicative shore crossing site layout

2.3.2.2 Dredging and spoil disposal

Hard rock sections of the proposed trunkline route were previously dredged with a Cutter Suction Dredge as part of the Pluto foundation project. No nearshore blasting or Cutter Suction Dredge works are required as part of this project. During Front End Engineering Design (FEED) the trunkline dredging, protection and stabilisation design will be refined, to provide an optimum solution in terms environmental impact, safety, cost and schedule.

The geotechnical conditions along the Scarborough trunkline route are anticipated to be largely similar to those of the existing Pluto trunkline system (the proposed Scarborough trunkline would be located between 10 metres and 200 metres from the Pluto trunkline). The material encountered while dredging the Pluto trenches during the Pluto LNG Facility foundation project was predominantly calcareous marine sediments and clays. Previous experience on Pluto showed no difficulties with equipment employed for dredging, thus similar equipment is proposed for the Scarborough proposal.

Trailing suction hopper dredgers (TSHD) and backhoe dredgers (BHD) have been proposed. Table 2-4 lists the dredging activities along the trunkline alignment. Final volumes and depths will be confirmed during FEED using data obtained from a geophysical/geotechnical survey campaign scheduled to be performed in 2019 (separately assessed).

Seabed surveys would be completed prior to and following dredging and disposal to confirm depth profiles.

Where the dredged material is not used to backfill the trench, it will be disposed at existing spoil grounds within the region (Figure 2-1). Estimated maximum volumes for trenching and backfill activities are presented in Table 2-5.

Table 2-4: Trunkline dredging activities

Section	Area	Primary design focus	Vessel Types – Pre lay Works	Vessel Types – Post lay Works
KP0-KP0.1	Intertidal Zone	Protection	Excavation: Backhoe dredge; Land based long reach excavator	Land based long reach excavator (rock backfill)
KP0.1-KP3.6	Shore Approach	Protection / Stabilisation	Excavation: Back hoe dredge and barges; Trailer Suction Hopper Dredge	Trailer Suction Hopper Dredge (sand backfill); Rock Dump Vessel
KP3.6-KP4.6	NWS Channel Crossing	Protection	Trailer Suction Hopper Dredge	Rock Dump Vessel
KP4.6-KP32.7	Shore Approach – State waters	Stabilisation	Trailer Suction Hopper Dredge; Backhoe Dredge (possible)	Trailer Suction Hopper Dredge (sand backfill); Rock Dump Vessel
KP32.7-KP50	Shore Approach – Commonwealth Waters[3]	Stabilisation (if required)	Trailer Suction Hopper Dredge	Sand backfill: Trailer Suction Hopper Dredge

[3] All activities in Commonwealth Waters will be assessed separately as part of an Offshore Project Proposal (OPP) to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)

Table 2-5: Estimated Maximum Volumes

Activity	Estimated maximum volumes [4]
State waters trenching	1,612,600 m^3
Commonwealth waters trenching[5]	1,169,100 m^3
Total Trenching	2,781,700 m^3
State waters sand backfill	1,982,100 m^3
Commonwealth waters backfill[5]	1,488,000 m^3
Total Backfill	3,470,000 m^3

Rock dump volume	238,600 m^3
Rock dump tonnage	429,400 T

2.3.2.3 Installation of trunkline

The Scarborough trunkline is expected to be installed by two different pipelay vessels, a shallow water lay barge and a conventional pipelay vessel, similar to the Trunkline System Expansion Project (TSEP) trunkline and Pluto trunkline pipelay campaigns (refer to Figure 2-4 for examples).

A. B.

Figure 2-4: Examples of A. shallow water lay barge and B. a conventional pipelay vessel

[4] All trenching volumes are based on 'in situ' measurement (i.e confirmed by hydrographic survey techniques)

All backfill volumes are based on 'in-hopper' measurements (i.e confirmed by vessel with onboard measurements)

Rock dump tonnage is based on a conversion of 1.8ton/m^3 bulk density

[5] All activities in Commonwealth Waters will be assessed separately as part of an Offshore Project Proposal (OPP) to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)

A shallow water pipelay barge would be required in the nearshore area up to around KP24, given that the water depth is as low as 6 to 7 m (Lowest Astronomical Tide (LAT)) in certain areas of Mermaid Sound. Existing infrastructure (e.g. Pluto trunkline, TSEP trunkline, NWSV shipping channel, Pluto jetty, Pluto shipping channel and turning circle, etc.) would need to be considered when assessing the shallow water lay barge anchor patterns.

NWSV shipping channel crossing

The NWSV shipping channel crossing is expected to be constructed using a similar method to Pluto to avoid impacts to shipping. It is anticipated that the trunkline would be pre-laid at the north side of the channel and pulled across using the shallow water pipelay barge. Once the trunkline section has been pulled across the channel, an Above Water Tie-In (AWTI) would be performed on the south side of the channel. The lay barge would then pick up the trunkline end on the north side of the channel and lay out to around KP24.

***Shore* crossing shore pull**

The proposed construction method for the Scarborough trunkline shore crossing is a shore pull from the lay barge through a pre-dredged trench. This method was successfully used for the adjacent Pluto trunkline shore crossing. A back anchor and winch would be installed at the shore crossing approximately 50 m from KP0. This winch would be used to pull the pipe from the lay barge. Should the final pipelay activities using the shore winch not be linear, reaction blocks would be set in the trench to provide reaction forces for the pipe pull. The blocks would be cast concrete and backfilled with trenched material. On completion they would be buried in the trench below the seabed to maintain the reaction forces.

2.3.2.4 Shore crossing site reinstatement

The shore crossing trench would be backfilled with quarried rock following the shore pull to provide secondary stabilisation and protection to the trunkline. This would be achieved using conventional onshore equipment. Equipment access to the shore crossing would need to be maintained until the rock berm has been constructed. Rock placement would need to be performed with care given the proximity of the neighbouring Pluto trunkline. The anchor block for the pull winch, the rock groyne and any ancillary facilities (e.g. offices) would be removed once construction is complete.

2.3.2.5 Sediment and rock dumping

Rock supply and rock dumping

Rock dumping may be required at the following locations (Table 2-4):

- the shore crossing trench
- the NWSV shipping channel crossing
- areas where pre-trenching is not cost-effective (Table 2-4)
- the nearshore area (up to around KP0.8). The TSHD may not be able to backfill shallower sections using sand backfill material (for Pluto this was inshore of KP0.8). Consequently, rock may need to be used to backfill the trench in this area.

Furthermore, the requirement to hydrotest the Scarborough trunkline is currently under review. Large diameter trunklines are typically flooded during backfill to ensure that trunkline flotation does not occur. Should a decision be made to forgo flooding/hydrotesting (wet pre-commissioning testing, see Section 2.3.3), alternative methods of weighing the trunkline down during trench backfill may be required. Alternative methods could include:

- increased concrete weight coating (CWC) thickness
- placement of a thin layer of rock over the trunkline

- spot dumping of rock at selected locations
- a combination of the above.

A large side dump vessel (SDV) or a combination of SDV and fall pipe vessel (FPV) would most likely be used for the rock dumping.

Rocks could be obtained from a variety of locations, the most likely locations proposed at this stage include:

- a local quarry on the Burrup Peninsula, transported via trucks to the coast via existing roads before being transferred to a supply vessel which would transport the material to the sites
- overseas. One or more of the following may be required:
    - The rock dump vessel would be loaded overseas and place material once on site.
    - The rock would be transported to Mermaid Sound via bulk carrier and would be unloaded from the bulk carrier to the rock dump vessel at sea.
    - The rock would be transported to Mermaid Sound via bulk carrier and offloaded to a (quarantined) wharf area, prior to loading on rock dump vessel from the wharf for the actual placement onto the trunkline.

Sediment supply and sand backfill

The trench sections that do not require rock cover can be backfilled with sand backfill material using a TSHD (Table 2-4), if additional stabilisation is required. A TSHD can reverse pump the sand backfill material into the trench through a suction pipe. This trench backfill method was used successfully on both the Pluto project and the TSEP project.

It is proposed that sand be sourced from one of the pre-identified borrow ground locations (Figure 2-1).

2.3.3 Pre-commissioning testing

Pre-commissioning testing would be undertaken to test the trunkline for integrity. Pre-commissioning testing can be undertaken using one of the following three methods:

1. Dry testing – This does not include any hydro testing but requires stricter weld acceptance criteria. This method would be subject to approval from NOPSEMA, DMIRS and class society (DNVGL). Dry testing would result in no discharge and a reduction in equipment and time.
2. Wet testing – This involves filling the trunkline with treated seawater, dewatering and drying. Total discharge volume for a wet pre-commissioning would be maximum 225,000 m^3. Dewatering would take place in Commonwealth waters. This method would be subject to the relevant approvals.
3. A hybrid method of the above where wet testing would occur in shallow waters near the shore crossing and dry testing in deeper waters.

2.3.4 Commissioning and operation

The trunkline will transport dehydrated export quality gas and will be operational for around 25 years. The gas would contain low concentration of CO2, no H_2S or contaminants. The operating temperature would be close to ambient temperatures under high pressure. The gas would be processed upstream. Trunkline inspection and maintenance activities will be required throughout the life of the trunkline to ensure the structural integrity of the trunkline is retained for the life of the project.

2.3.5 Decommissioning

Following the end of life of the Scarborough Project, subsea infrastructure will either be removed, partly removed or left in place. The preferred option will be assessed prior to the decommissioning and all necessary approvals obtained.

2.3.6 Schedule

Trunkline installation activities are expected to start in March 2021 and are estimated to be completed in 18 months. Table 2-6 provides a breakdown of the estimated duration of the main construction activities. Some construction activities would be undertaken concurrently.

Once commissioned, the trunkline is expected to operate for around 25 years.

Table 2-6: Construction activities estimated timeframe

Activity	Estimated duration	Estimated start of activity
Shore crossing site preparation	7 months	March 2021
Dredging	10 months	May 2021
Trunkline installation	6 months	September 2021
Rock supply and stockpile	6 months	July 2021
Rock dumping/sand backfill	6 months	November 2021 - January 2022
Pre-commissioning testing	2.5 months	November 2021 - September 2022
Commissioning and operation		Mid 2023

2.3.7 Construction plant and vessels

Table 2-7 lists the construction plant and vessels that would be needed to undertake the scope of works.

Table 2-7: Proposed Construction plant and vessels

Activity	Construction plant/vessel/equipment
Shore crossing site preparation and reinstatement	Crane Hold back anchor Horizontal winch Pull cable reel Hydraulic power unit Generator 4WD and trucks Excavators
Dredging	Trailing suction hopper dredger Backhoe dredger and towed/self-propelled hopper barges Support vessels Survey vessel
Trunkline installation	Shallow water pipelay barge Conventional pipelay vessel Support vessels
Sand dredging from borrow ground	Trailing suction hopper dredger Supply vessel Hydrographic survey vessel
Obtain rocks from quarry and transport to site	Trucks Potential bulk carriers if rock soured from overseas

Activity	Construction plant/vessel/equipment
Rock dumping/sand backfill	Large side dump vessel or a combination of large side dump vessel and fall pipe vessel. Supply vessel and Survey vessel

2.4 Local and regional context

2.4.1 Dampier Port and land use

The Proposal is located within the Pilbara region, with the state waters component in the Port of Dampier limits, managed by the Pilbara Port Authority (PPA). Dampier Port is a major industrial port in the northwest of Western Australia. It is currently one of the world's largest bulk export port by tonnage and services petrochemical, salt, iron ore and natural gas export industries. The shore crossing site is located adjacent to the Pluto LNG facility in an industrial zone. The facility is located eight kilometres to the north east of Dampier Port and 15 kilometres north west of Karratha, the closest residential townships. Surrounding land uses include (Figure 2-5):

- North West Shelf Project – one of the world's largest LNG producers supplies oil and gas to the Western Australian and international markets from offshore gas and condensate fields, located 135 km north-west of Karratha in the Carnarvon Basin
- Pluto LNG – a major LNG gas project with onshore facilities that process gas from the Pluto and Xena gas fields, located 190 km north-west of Karratha in the Carnarvon Basin
- Rio Tinto Iron Ore operations – a major iron ore producer that exports iron ore from inland mines from their export facilities at Parker Point and East Intercourse Island
- Rio Tinto Dampier Salt operations – the world's largest exporter of salt
- Yara Pilbara Fertilisers operations – one of the world's largest ammonia producers

Sea access to the Port is via the three major and three minor shipping channels (Table 2-8 and Figure 2-5).

Subsea infrastructure in the area includes oil and gas trunklines including the Pluto, North Rankin and TSEP trunklines (Figure 2-5).

Dampier Port is also the departure point for day cruises to the Dampier Archipelago.

Table 2-8: Shipping channels within Port waters (Dampier Port Authority 2014)

Channel	Declared depth (chart datum)	Provides access to
NWSV Channel	12.2 m	NWSV LNG and LPG jetties
Rio Tinto Iron Ore (RTIO) Channel	15.4–15.5 m	East Intercourse Island, Parker Point and Mistaken Island wharves
Pluto Channel	12.5 m	Pluto LNG Facility jetty
Mermaid Marine Australia Supply Base (MMASB) Channel	5.2 m	MMASB wharves
King Bay Supply Base (KBSB) Channel	6.0 m	KBSB tug pens, Pluto Supply Base berths
Dampier Bulk Liquids Berth (DBLB) Channel	11.0 m	Dampier Cargo Wharf (DCW), DBLB, Heavy Load Out Facility (HLO), Alternate Load Out Facility (ALF), FDTS

2.4.2 Natural environment

The Dampier Archipelago consists of 42 islands covering about 400 kilometres. It contains a wide diversity of marine habitats including coral reefs, mangroves, inter-tidal sands and mudflats, inter-tidal reef platforms, beaches, rocky shores, seagrasses and macro algae. Conservation significant species also occur in the waters surrounding the islands including dugongs, dolphins, whales and

marine turtles. Twenty five of the islands are protected as a Nature Reserve (Dampier Archipelago Nature Reserve) (Figure 2-5).

2.4.3 Heritage

The Dampier Archipelago including the Burrup Peninsula is known as Murujuga (meaning hipbone sticking out) by traditional owners. It is rich in Aboriginal heritage sites of considerable cultural and archaeological significance including quarries, middens, fish traps, rock shelters, artefact scatters, grinding patches, stone arrangements and petroglyphs. Dating back more than 15,000 years, these sites demonstrate the world's oldest living continual culture. Their significance was recognised with the Dampier Archipelago and parts of the Burrup Peninsula being placed on the National Heritage List in 2007 and the creation of the Murujuga National Park in 2013 (Figure 2-5). The area has also been nominated for World Heritage listing

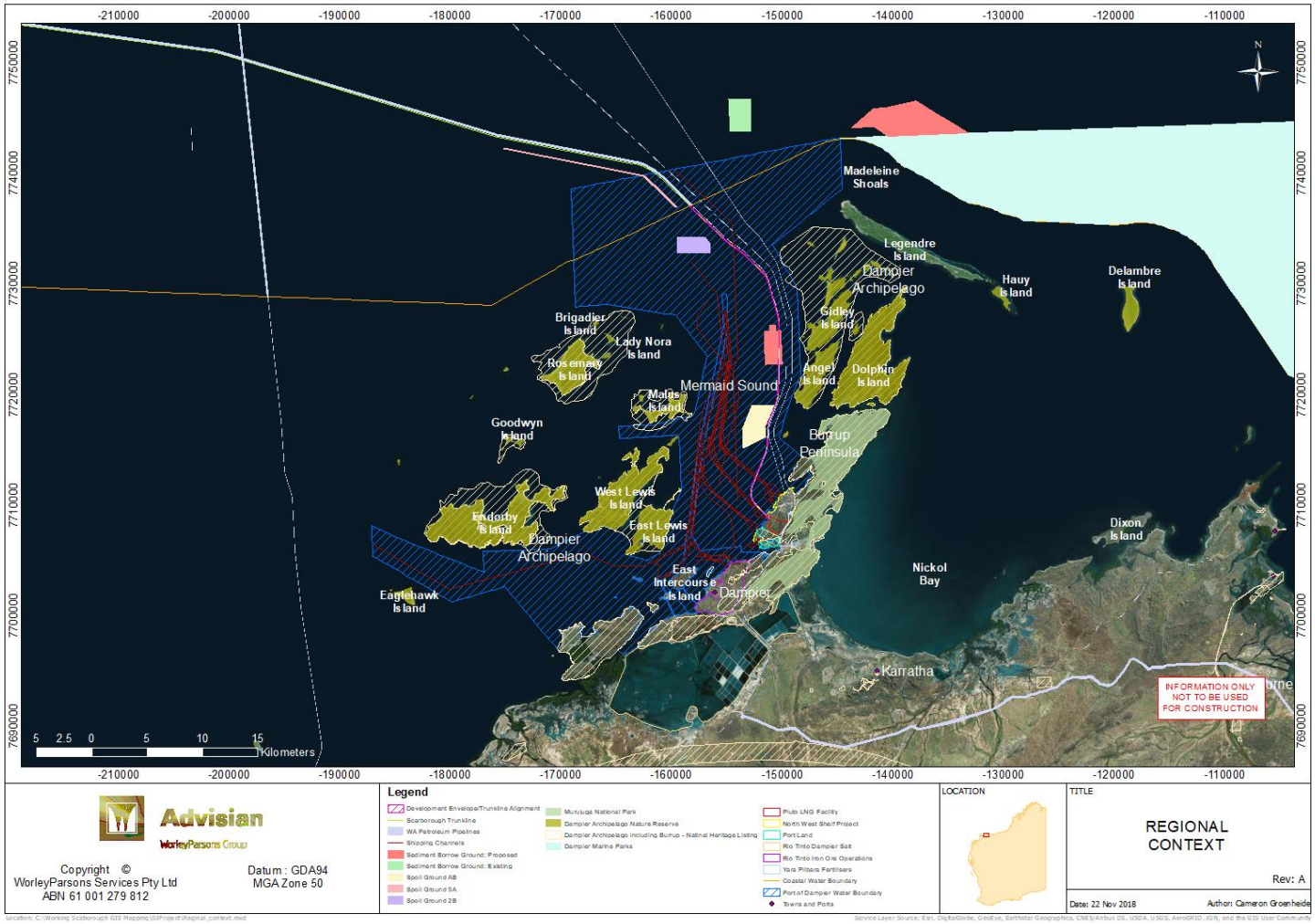


Figure 2-5: Regional context of the Proposal

3 Stakeholder engagement

3.1 Stakeholder Approach

Woodside's objective is to build long-term and meaningful relationships with our host communities. Woodside has been part of the Australian community for over 60 years and has been operating on the Burrup Peninsula for more than 30 years.

Woodside has well established relationships with the Pilbara and surrounding communities, regularly engaging with stakeholders through various forums on a broad range of issues, including potential environmental and social impacts associated with our operations. Key to understanding local issues are mechanisms such as the standing Karratha Community Liaison Group and Heritage Liaison Group, which meet quarterly. Woodside also has an established office in Karratha and presence in Roebourne which provides an avenue for locals to talk to any issues via one-on-one engagement.

Woodside will maintain a program of stakeholder engagement to:

- Ensure all relevant stakeholders are identified and communicated to in a timely and effective manner;
- Provide communications material in response to stakeholder needs; and
- Analyse stakeholder feedback to inform decision-making and planning.

3.2 Stakeholder Engagement Plan

Woodside has a Stakeholder Engagement Plan that will continue to be revised as the project is matured to ensure comprehensive engagement with stakeholders.

As operator of the Scarborough Project, Woodside has commenced a phased stakeholder engagement program for this proposal, which will continue throughout the environmental impact assessment process. The program is based on leveraging existing relationships and forging new connections with parties likely to have an interest in the Scarborough Project proposal from the following groups: Traditional Owner groups, Local, State and Commonwealth Government, community, fishing and tourism groups, local businesses and service providers, non-government and environmental non-government organisations and industry.

Preliminary engagement on the Scarborough Project commenced in February 2018. This engagement has broadly informed Woodside's stakeholder planning and execution for the concept definition, front-end engineering and design (FEED) and execute project phases. Specifically, this engagement has informed the frequency and nature of engagement to support key regulatory approvals and our approach to identifying and managing potential impacts.

Woodside's ongoing stakeholder activities will include:

- Independent social impact assessment;
- Social impact management planning;
- Economic impact assessment;
- One-on-one engagement;
- Broad stakeholder forums;
- Targeted correspondence;
- Hard-copy and electronic communication materials; and
- Media and social media.

3.3 Stakeholder Identification

Identified stakeholder groups are those that affect and/or could be affected by the proposed Project during all Project phases. Stakeholders have been identified by considering:

- Organisations or individuals with a role in regulatory processes;
- Individuals or groups directly or indirectly affected by the proposed Project either physically, socially and/or commercially;
- Organisations or individuals with an interest in the outcome, progress or activities of the proposed Project.

The following stakeholder groups have been identified for the Scarborough Project:

- Commonwealth Government / Agencies;
- State Government / Agencies;
- Local Government;
- Business / Industry;
- Indigenous Groups and Traditional Owners;
- Community Groups;
- Marine Users;
- Social Contribution Partners;
- Non-Government Organisations;
- Science / Academia;
- Media and Regulatory Communications;
- Unions.

3.4 Feedback and Areas of Stakeholder Interest

The following provides a summary of preliminary consultation completed by Woodside with interested and affected stakeholders.

Preliminary stakeholder consultation has focused on Woodside's Burrup Hub opportunities, including the Scarborough Project, from 14 February 2018 to 12 December 2018. Consultation was completed by email, letter, phone call or meeting. Table 3-1 to Table 3-3 outline consultation completed to date.

Table 3-1: Commonwealth Government Consultation

Commonwealth Government	
Australian Customs Service – Border Protection Command	National Offshore Petroleum Titles Administrator
Australian Hydrographic Service	Office of Federal Minister for Resources and Northern Australia
Australian Maritime Safety Authority	Office of Shadow Minister for Environment
Department of Industry, Innovation and Science	Office of Shadow Minister for Resources
National Offshore Petroleum Safety and Environmental Management Authority	Senator Pat Dodson
Department of Environment and Energy	Shadow Minister for Environment; Water
Federal Minister for Environment; Member for Durack	

Table 3-2: State Government Consultation

State Government	
Australian Industry Participation Authority	Member for the Kimberley
Department of Communities, Housing Division Pilbara	Member for the Pilbara
Department of Defence	Office of State Minister for Mines and Petroleum
Department of Education	Office of the Leader of the Opposition, Public Sector Management, State Development, Jobs and Trade and Federal-State Relations
Department of Jobs, Tourism, Science and Innovation	Office of the Minister for Fisheries
Department of Mines, Industry, Regulation and Safety	Office of the Premier & Minister for State Development
Department of Planning, Lands and Heritage	Office of the State Minister for Environment
Department of Primary Industries and Regional Development	Office of the State Minister for Regional Development
Department of Transport	Office of the State Minister for Transport, Planning and Lands
Department of Water and Environmental Regulation	Office of the State Treasurer, Minister for Finance, Energy and Aboriginal Affairs
Environmental Protection Authority	Upper House Member for Mining and Pastoral
Landcorp	

Table 3-3: Traditional Owner Groups, Local Government, Industry Organisations, Community, Educational Institutions and eNGOs Consultation

Traditional Owner Groups, Local Government, Industry Organisations, Community, Educational Institutions and eNGOs	
Australia Maritime and Fisheries Academy	Market Forces
Australian Conservation Foundation	Mawrankarra
Australian Marine Oil Spill Centre Pty Ltd	Murujuga Aboriginal Corporation
Australian Petroleum Production and Exploration Association	Ngarluma Aboriginal Corporation
Broome Chamber of Commerce and Industry	Ngarluma Yindjibarndi Foundation Ltd
Broome Future Alliance	Ngarliyarndu Bindirri Aboriginal Corporation
Broome International Airport	North West Regional TAFE
Broome Visitors Centre	Nyamba Buru Yawuru
Chamber of Minerals and Energy Western Australia	Pearl Producers Association
City of Karratha	Pilbara Development Commission
Conservation Council of WA	Pilbara Port Authority
Dampier Technical Advisory and Consultative Committee (TACC) (includes Pilbara Port Authority, Department of Biodiversity Conservation and Attraction, Department of Transport, Rio Tinto, Department of Environment and Energy, Department of Planning, Lands and Heritage, Department of Primary Industries and Regional Development, Toll, Water Corp, Department of Jobs, Tourism, Science and Innovation, Murujuga Land & Sea Unit).	Shire of Broome
Friends of Australian Rock Art	Toll
GreenPeace	St Mary's Senior High School
International Fund for Animal Welfare	St Luke's College
Karratha and Districts Chamber of Commerce and Industry	Western Australian Marine Science Institution (WAMSI) Dredging Node (includes Australian Institute of Marine Science, WAMSI, Department of Water and Environmental Regulation).
Karratha Community Liaison Group (includes Karratha Districts Chamber of Commerce and Industry, Dampier Community Association, Karratha Community Association, City of Karratha, Regional Development Australia, Pilbara Development	Western Australian Country Health Club

Traditional Owner Groups, Local Government, Industry Organisations, Community, Educational Institutions and eNGOs	
Commission, Pilbara Ports Authority, Ngarluma Yindjibarndi Foundation Ltd and Yara Pilbara)	
Karratha Heritage Group (includes Yindjibarndi Aboriginal Corporation, Yaburara and Coastal Mardudhunera Aboriginal Corporation, Wong-Goo-Tt-Oo, Ngarluma Aboriginal Corporation)	Wilderness Society
Karratha PCYC	Wong-Goo-Tt-Oo
Kimberley Aboriginal Law and Cultural Centre	World Wildlife Fund
Kimberley Aboriginal Medical Services	Yaburara and Coastal Mardudhunera Aboriginal Corporation
Kimberley Ports Authority	Yandina
Kullari Regional Communities Indigenous Corporation	Yindjibarndi Aboriginal Corporation
Kimberley Land Council	Yiraman Project

Table 3-4: Fisheries Consultation

Fisheries
Australian Fisheries Management Authority
Australian Hydrographic Service
Australian Maritime Safety Authority
Charter boat operators and recreational fishers
Commonwealth Fisheries Association
Recfishwest
Western Australian Fisheries (State and Commonwealth commercial fisheries)
Western Australian Fishing Industry Council

Feedback received from relevant stakeholders will be used to inform Woodside's approach to the referral process for the Scarborough Project. Areas of stakeholder interest identified to date, which are of particular relevance to the proposed Project, include:

- Interaction with protected areas under Commonwealth and State legislation;
- Interactions with fisheries;
- Interactions with cultural heritage, including marine;
- Understanding of physical and ecological characteristics of the Project area;
- Aspects of petroleum development with potential for impact on listed species, such as vessel movements, light, GHG and underwater noise emissions;
- Cumulative impacts;
- Decommissioning.

Woodside will continue its stakeholder engagement activities through the duration of the Project which includes ensuring opportunities for consultation, maintaining a stakeholder register, recording stakeholder engagement and feedback and making communications material publicly available.

4 Environmental principles and factors

4.1 Key environmental factors

Relevant environmental factors assessed are based on 'the Statement of Environmental Principles, Factors and Objectives' (EPA, 2016a). Table 4-1 lists the environmental factors, their relevant objectives and if and how they apply to the Proposal.

Table 4-1: Environmental factors and objectives in relation to the Proposal

Environmental Factor	Objective	Comment
Sea		
Benthic Communities and Habitats	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.	Dredging and trunkline installation are likely to impact benthic communities and habitats. **This is considered a key environmental factor** and is assessed in Section 4.3.
Coastal Processes	To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.	The shoreline crossing of the trunkline may require temporary/permanent infrastructure which may impact coastal processes. However, considering the small footprint and temporary nature, substantial impacts to geophysical processes that shape coastal morphology are unlikely, therefore, Coastal Processes are not considered a key environmental factor.
Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected.	Dredging and trunkline installation are likely to impact water quality, sediments and biota. **This is considered a key environmental factor** and is assessed in Section 4.4.
Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.	Dredging and trunkline installation are likely to impact marine fauna. **This is considered a key environmental factor** and is assessed in Section 4.5.
Land		
Flora and Vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.	No terrestrial flora or vegetation would be impacted by the Proposal. This factor is not considered relevant to the Proposal.
Landforms	To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.	Distinctive physical landforms are unlikely to be impacted such that their environmental values would be compromised. This factor is not considered relevant to the Proposal.
Subterranean Fauna	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.	Subterranean fauna (i.e. stygofauna – aquatic and living in groundwater; troglofauna – air-breathing and living in caves and voids) are unlikely to be impacted. This factor is not considered relevant to the Proposal.
Terrestrial Environmental Quality	To maintain the quality of land and soils so that environmental values are protected.	The onshore crossing of the trunkline may impact a small area along the coast. This factor is not considered relevant to the Proposal.
Water		
Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.	Groundwater and surface waters are unlikely to be impacted by the Proposal. This factor is not considered relevant to the Proposal.

Environmental Factor	Objective	Comment
Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water so that environmental values are protected.	Due to the location of the Proposal, there would not be any impacts groundwater and surface water. This factor is not considered relevant to the Proposal.
Air		
Air Quality	To maintain air quality and minimise emissions so that environmental values are protected.	Some temporary and localised impacts to air quality during dredging and installation of the trunkline may occur. This factor is, however, not considered a key environmental factor.
People		
Social Surroundings	To protect social surroundings from significant harm.	The Proposal has the potential to impact recreational water users, users of marine parks, vessel operations, commercial fisheries, Aboriginal heritage as a result of the temporary presence of vessels during trunkline installation and shore crossing activities. **This is considered a key environmental factor** and is assessed in Section 4.6.
Human Health	To protect human health from significant harm.	This factor deals with potential radiation impacts and is therefore not relevant to the Proposal. Other issues that have a potential to impact health are dealt with in other sections. This factor is not considered relevant to the Proposal.

4.2 Impact assessment methodology

For each of the key environmental factors assessed in Sections 4.3 to 4.6, the receiving environment is described and the potential impacts of the Proposal are assessed.

The assessment has been undertaken in accordance with Woodside's Environment Impact Assessment Guideline. This guideline and associated Environment Impact Assessment Guidance Tool and Environment Risk Assessment Guidance Tool support the implementation of impact assessments, and set out the broad principles and high level steps for assessing environmental impacts across the lifecycle of Woodside's activities.

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

- **Environmental Impact:** An expected change to the environment, whether adverse or beneficial, wholly or partially resulting from the planned and routine project activities including mitigation measures (i.e. routine liquid discharges).
- **Environmental Risk:** A change to the environment resulting from an unplanned event or incident (i.e. oil spill resulting from vessel collision).

The impact assessment approach undertaken included the following steps:

1. Identify project **aspects** (i.e. results of planned or unplanned project activities that have the potential to impact on the environment).
2. Identify the **receptors** (i.e. physical, biological, cultural or human elements of the environment that may be impacted by project aspects).
3. Assess the **receptor sensitivity** (i.e. the sensitivity/vulnerability/importance of the receptor) as either high, medium or low value.
4. Assess the **magnitude** (i.e. no lasting effect, slight, minor, moderate, major or catastrophic) of the credible environmental impacts from each aspect based on the extent, duration, frequency and scale.
5. Assign an **impact significance level** to each environmental impact based on the receptor sensitivity and the magnitude of the impact (Figure 4-1).

6. Assign an **environment risk consequence** to each environmental risk based on the receptor sensitivity and magnitude of the impact; and the likelihood of occurrence (Figure 4-2).
7. Use the impact significance level to assess the Proposal against the EPBC Act Significant Impacts Criteria and the Western Australian EPA Objectives.

The following impact significant levels may be assigned for the environmental impacts (Figure 4-1):

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

	Receptor Sensitivity			
Magnitude	Low	Medium	High	**Significance Level**
Catastrophic	B	A	A	Catastrophic (A)
Major	C	B	A	Major (B)
Moderate	D	C	B	Moderate (C)
Minor	E	D	C	Minor (D)
Slight	F	E	D	Slight (E)
No lasting effect	F	F	E	Negligible (F)

Figure 4-1: Impact significance level

Environment risk consequences are determined slightly differently than impact significant levels due to the requirement to consider the likelihood that the unplanned event or incident occurs. The likelihood of a risk event occurring can be considered remote (0), highly unlikely (1), unlikely (2), possible (3), likely (4) or highly likely (5). The following risk levels may be assigned for the environmental risks:

- Severe
- Very High
- High
- Moderate
- Low.

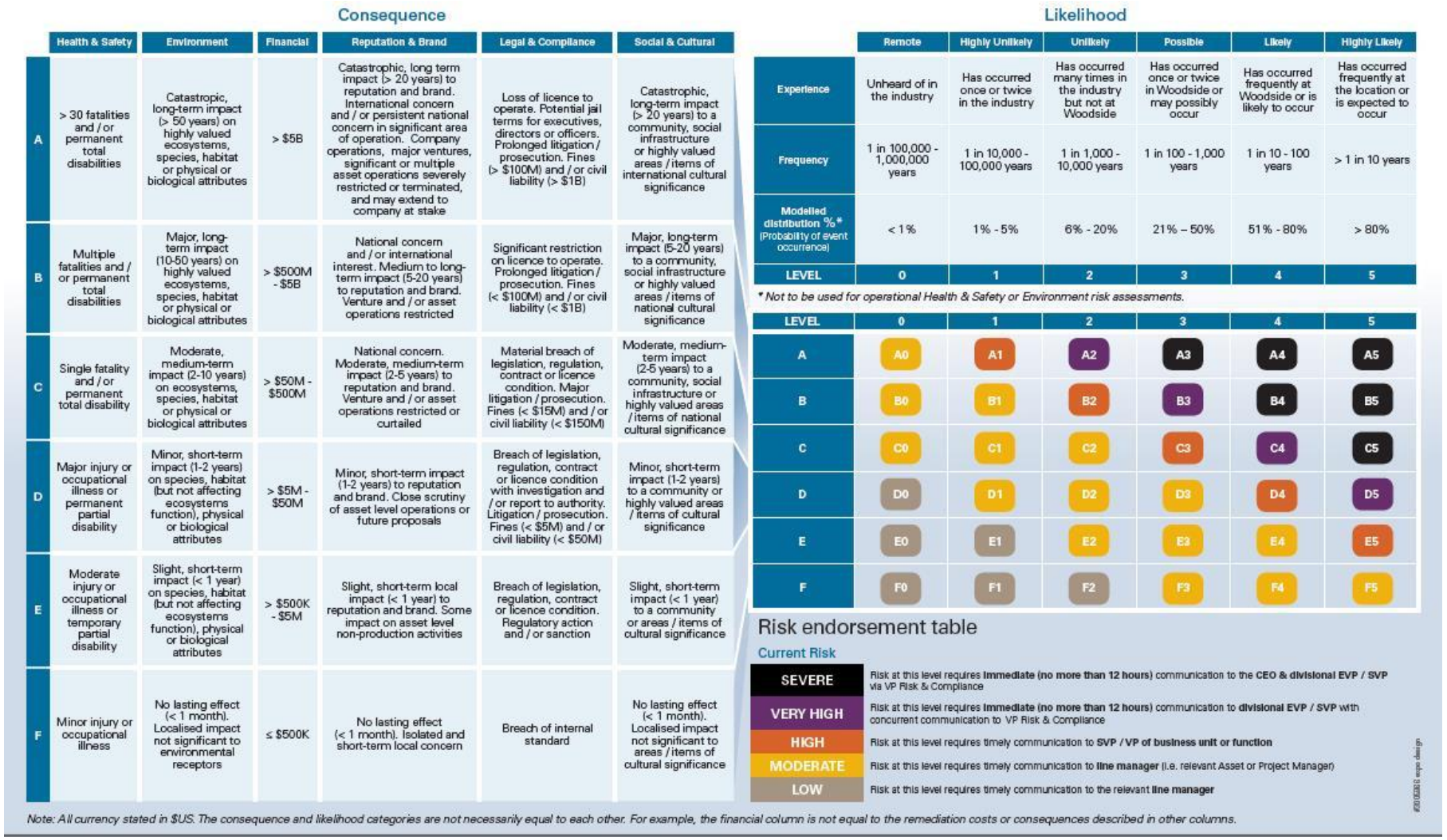


Figure 4-2: Environment risk consequence

4.3 Benthic communities and habitats

4.3.1 EPA objective

The EPA objective in relation to the key environmental factor 'Benthic Communities and Habitats' (BCH) is 'To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.'

4.3.2 Policy and guidance

The following EPA guidance has been considered in evaluating potential impacts on this factor:

- EPA (2016b). Environmental Factor Guideline: Benthic Communities and Habitats, EPA, Western Australia
- EPA (2016c). Technical Guidance – Protection of Benthic Communities and Habitats, EPA, Western Australia
- EPA (2016d). Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals, EPA, Western Australia
- EPA (2001). Guidance for the Assessment of Environmental Factors – Guidance Statement for protection of tropical arid zone mangroves along the Pilbara coastline, EPA, Western Australia.

4.3.3 Studies and information sources

A number of studies and surveys have been completed within the Dampier Archipelago. Table 4-2 lists the relevant studies and publications for BCH. These have informed the description of the existing environment and assessment of impacts for the Proposal.

Table 4-2: Relevant studies/surveys/databases that support the Proposal

Author	Study (Date)
Existing studies/surveys/databases used	
Advisian	Chemical and Ecological Monitoring of Mermaid Sound: 2017 Compliance Report (2017)
	DOT307215 Provision of Western Australian Marine Oil Pollution Risk Assessment – Protection Priorities (2017)
The Department of Conservation and Land Management (CALM)	The major marine habitats of proposed Dampier Archipelago/Cape Preston marine conservation reserve. Report MRI/PI/DAR-49/2000. August 2000.
MScience	Pluto LNG Development: Final Report on Coral and Water Monitoring (2010)
	Marine Habitat Mapping: Dampier and Cape Lambert 2017. Unpublished report MSA264R01 to Rio Tinto, Perth Western Australia, pp13 (2018)
	Dampier Port Authority Marine Environment: Distribution of Benthic Primary Producer Habitats within Port Waters (2014)
SKM	Pluto LNG Project: Baseline Marine Habitat Survey Report (2007)
	Pluto LNG Development: Post-Dredging Benthic Habitat Survey (2011)
Western Australian Museum	Marine Biodiversity of the Dampier Archipelago, Western Australia 1998–2002 – Supplement No. 66 (2004)
Woodside Energy Limited	Pluto LNG Development: Draft Public Environment Report/Public Environment Review (2006), and associated studies
WorleyParsons	Dampier Marine Services Facility *Assessment on Proponent Information* (2011)

Author	Study (Date)
Existing studies/surveys/databases used	
Planned studies/surveys	
Advisian	Trunkline dredging plume modelling study (2018)
TBC	Hydrocarbon spill modelling study
Advisian	Dampier Archipelago benthic habitat and assessment surveys (2018)

4.3.4 Receiving environment

A review of publicly available reports and papers on the Dampier Archipelago including the Port of Dampier (MScience, 2014) identified five key BCHs likely to be present, including; hard corals, macroalgae, mangroves, seagrass and mixed BPPHs. The key BCH of the Dampier Archipelago, including the Port of Dampier where the development envelope would be located, are discussed in detail below in this section and are summarised in Table 4-3 and shown in Figure 4-3.

Table 4-3: Relevant Benthic Communities and Habitats

Communities	Assessment
Marine invertebrates	Direct and indirect impacts to marine invertebrates, such as infauna, may result from dredging activities. Refer to Section 4.3.4.2 for description of the community.
Coral	Direct and indirect impacts to corals may result from dredging activities. Refer to Section 4.3.4.5 for description of the community.
Seagrass	Indirect and indirect impacts to seagrass may result from dredging activities. Refer to Section 4.3.4.6 for description of the community.
Macroalgae	Indirect and indirect impacts to macroalgae may result from dredging activities. Refer to Section 4.3.4.7 for description of the community.
Mangroves	Indirect impacts to mangroves may result from dredging activities. Refer to Section 4.3.4.8 for description of the community.
Microphytobenthos and algal mats	Indirect and indirect impacts to microphytobenthos and algal mats may result from dredging activities. Refer to Section 4.3.4.9.
Saltmarsh	These would be present in the Dampier Archipelago behind mangroves and/or areas occasionally flooded during high tides. They have not been recorded at the shore crossing site. Saltmarsh are therefore unlikely to be impacted and are therefore not discussed.

Figure 4-3: Significant benthic communities and their distribution in the Dampier Archipelago

4.3.4.1 Benthic habitats

The Dampier Archipelago contains a high number of various subtidal and intertidal habitats and these are briefly described below.

Soft sediments and sandy beaches

Soft sediment composed of sand and silt is the dominant subtidal habitat within Mermaid Sound (Bancroft and Sheridan, 2000). While the sand habitat may overlay reef platforms or contain patches of another habitat. In the Dampier Archipelago, sand habitats are typically bare though may contain seasonal vegetation or permanent patches of seagrass, macroalgae and invertebrate infauna. The silty subtidal habitats of the Dampier Archipelago are in more sheltered areas, such as embayments, and are usually unvegetated. These habitats typically support a rich variety of infauna species such as polychaete worms, molluscs and crustaceans. The intertidal mudflats of the inner Archipelago occur predominantly on the eastern side of the Burrup Peninsula and support significant arid-zone mangrove communities, foraging shorebirds and wading birds and can also host bacteria important to carbon cycling (Heyward et al., 2000).

Rocky shores

Rocky shores are the dominant shoreline habitat associated within the Dampier region (Semeniuk et al., 1982). Wells and Walker (2003) described the fauna of the littoral zone as sparse, comprised predominately of littorinid snails and grapsid crabs while the intertidal zones are dominated by a diverse range of species including sponges, oysters, limpets, chitons, crabs, and barnacles. The biota becomes increasingly diverse in the lower intertidal, with a variety of sessile and motile invertebrates and benthic algae. Corals reach into the lowest portions of the intertidal zone (Jackson et al., 2006).

Reefs

Reef habitat is considered as anywhere that hard bottom exists in the subtidal environment. Hard bottom substrates have the potential to support a variety of communities and may have a foundation of biota, such as biogenic reefs composed of skeletal remains of hard corals (i.e. coral reefs). The coral communities of the Dampier Archipelago have been described below. These communities are mostly present as individual colonies that settle and grow on existing hard substrate (Jones, 2004; WorleyParsons, 2009; MScience, 2014), predominantly located close to shore to a depth of 10 m lower low water (MScience, 2014).

Reef habitat also supports macroalgal and mixed biota communities within the Dampier Archipelago, the majority of which occur in the lower intertidal areas of the Archipelago. Algal habitats have been previously determined to be essentially all hard substrates within the photic zone (MScience, 2014). As a result, large macroalgal reef habitats occur in the southwest region of the inner harbour around West Intercourse Island. Furthermore, there are a number of shallow reef flats on the western and eastern margins of Mermaid Sound that may support seasonal macroalgal assemblages (MScience, 2014).

A description of the benthic communities using the habitats described above is provided in the following sections.

4.3.4.2 Marine invertebrates

Nearshore areas of the Dampier Archipelago support an abundant and diverse group of tropical invertebrate species due to the wide variety of suitable habitats. Over 2226 species of marine invertebrates have been recorded in the Archipelago, including 1227 molluscs, 438 crustaceans, 275 sponges and 286 echinoderms (CALM, 2005). Sponges and soft corals (filter feeders) are considered primarily within this section, mobile invertebrates, such as crabs and molluscs, and sessile invertebrates, like bivalves, are considered in the section for Rocky Shores, as they are more prevalent there.

4.3.4.3 Filter feeder communities

The Pilbara region has a very high diversity of marine sponges (Fromont et al., 2016), within which, the Dampier Archipelago 275 sponge species have been recorded. About 20% of these species are presently known to be limited to Western Australia and are likely to be endemic (Fromont, 2003). While extensive surveys of the Western Australian coastline are limited, there is data to suggest that some sponge species have limited distributions and Fromont (2003) suggests that the high level of endemism may be the result of a short larval phase and limited dispersal.

Surveys conducted by Fromont (2004) found that the highest diversity of sponges in the Dampier Archipelago occurred in sponge communities that were either low relief or pavement habitats often with a sediment layer with strong tidal currents. High diversity sponge communities have been observed at the eastern end of Flying Foam Passage, at the western end of Mermaid Strait and between Enderby and West Lewis Islands (Fromont, 2004; Jones, 2004). Generally, the high habitat complexity of the Dampier Archipelago corresponds with high sponge species richness, contributing to the high biodiversity value of the nearshore environment of the Pilbara region (Fromont, 2016). MScience (2018a) grouped sponges, soft corals and other such biota occurring together, classifying them as mixed communities. Figure 4-3 shows the distribution of mixed communities as primarily present in confined aggregations around Intercourse Island and between East Mid Intercourse and East Intercourse islands.

4.3.4.4 Epifauna and Infauna

Given the dominance of soft sand and silt habitat within the inner Dampier Archipelago (Bancroft and Sheridan, 2000), sedimentary infauna associated with soft unconsolidated sediments is likely to be widespread and well represented. In the context of the contiguous extent of habitats across the region, it is considered of relatively low environmental sensitivity.

4.3.4.5 Coral

Coral communities of the Dampier Archipelago predominantly occur as narrow linear features fringing the shorelines of islands and the Burrup Peninsula typically between 2 m and 10 m mean lower low water (Blakeway and Radford, 2005; Jones, 2004). The fringing reefs are not true coral reefs in that they establish and grow on existing hard substratum (Jones, 2004; WorleyParsons, 2009).

Both zooxanthellate and azooxanthellate corals are found throughout the Dampier Archipelago, including a total of 229 species from 57 hermatypic coral genera (Woodside, 2006; Griffith, 2004), representing a large proportion of the 318 hermatypic species from 70 genera known to occur in Western Australia (URS, 2004). Distribution of coral communities shows a strong gradient in which nearshore or inner harbour reefs are dominated by sediment tolerant species that shift to wave tolerant clear water species further offshore in the outer port harbour (Wilson, 1994).

It is widely recognised that coral communities provide high ecological value to the marine environment. As such coral communities within the Dampier Archipelago have been researched to identify community ecological structure and manage impacts associated with port development and other anthropogenic impacts. Historically taxonomic surveys and ecological research have concentrated on the outer Archipelago (Griffith, 2004), while studies associated with monitoring potential impacts on coral from industrial development and port expansion have focused on nearshore areas (Blakeway & Radford, 2005).

The coral communities along the mainland Burrup Peninsula coast show little evidence of reef development; rather they grow by encrusting solid substrata such as Precambrian rock (URS, 2004; Jones, 2004). Coral reefs have been recorded in the vicinity of King Bay, between Phillip Point and the Dampier Public Wharf; however, water conditions in this area are extremely turbid and the reef is considered to be patchy (Water Corporation, 2000). URS (2003) recorded various species of coral along the western coast of the Burrup Peninsula, with the most dominant genera being *Favities*, *Favia*, *Platygyra*, *Goniastrea* and *Caulastrea*, as well as *Turbinaria* colonies. Other common corals

recorded include *Porites*, *Pavona*, *Acropora*, *Lobophyllia*, *Symphyllia*, *Goniopora*, *Montipora* and *Pectinia* species (URS, 2003). These communities experience elevated levels of natural turbidity and suspended sediment most of the year and appear to be relatively resilient in terms of the persistent turbidity (Blakeway & Radford, 2005). The *Turbinaria* and mixed coral assemblages found in this area are considered less sensitive to turbidity and sedimentation compared with the *Pavona*, *Porites* and *Acropora*-dominated assemblages found further offshore (Blakeway & Radford, 2005).

Figure 4-3 shows the distribution of hard coral communities within the Dampier Archipelago (MScience, 2018).

Coral recruitment and spawning

The ecology, particularly reproductive ecology, of corals in the Dampier Archipelago has been extensively studied (Simpson, 1985b; Simpson, 1985a; Simpson, 1988; Heyward et al., 2000; Baird et al., 2011). Most of the major coral species are broadcast spawners and have their major peak of reproductive activity between March and April, about seven to ten nights after the full moon. A second, though less pronounced, peak occurs in October and November, coinciding with the major spawning on the Great Barrier Reef in eastern Australia, though it is considered possible that sampling during the spring time event in the Dampier Archipelago has occurred during periods when corals are experiencing environmental stress and is therefore an underestimate of participation of some species (Gilmour et al., 2016). Brooding species tend to spawn more evenly throughout the year. Stoddard & Gilmour (2005) investigated spawning behaviour of corals at the inshore Dampier Harbour finding that coral spawning was not uniform and appeared less synchronised than off-shore coral communities. For environmental management, coral reproduction is often considered at a level that considers the entire community. Assessment of reproductive behaviours should involve ascertaining the cumulative composition of species to determine dominance, while also considering the ecosystem criticality of less abundant species (Gilmour et al., 2016). The spawning of hard corals i.e. the phenomenon of synchronous, multi-specific mass release of gametes by broadcasting spawning species, which occurs over a comparatively short period each year is considered by the EPA as a critical window of environmental sensitivity (CWES) (Jones et al, 2015a).

4.3.4.6 Seagrass

Seagrasses in the Dampier Archipelago are generally sparse, occurring in low abundance on shallow sandy sediments in sheltered areas and interspersed with other BCH (CALM, 2005; Jones, 2004; MScience, 2014) (Figure 4-3). Surveys and studies of the region have identified nine species: *Cymodocea angustata*, *Enhalus acoroides*, *Halophila decipiens*, *Halophila minor*, *Halophila ovalis*, *Halophila spinulosa*, *Halodule uninervis*, *Thalassia hemprichii* and *Syringodium isoetifolium* (McMahon et al., 2017; Woodside, 2006). However, Halophila is the predominant species and is typically restricted to the 6 m (CD) depth contour (MScience, 2014).

Surveys conducted by Bertolino (2006) reported seagrass in Conzinc and Withnell Bays, southern side of East Lewis Island and between the causeways connecting East Intercourse Island and Mistaken/East Mid Intercourse Islands (MScience, 2014). Sparse patches of seagrass have also been recorded throughout Mermaid Strait and in the nearshore environments of the bordering islands (MScience, 2014; Huisman and Borowitzka, 2003; Waycott, 2004).

The most significant areas of seagrass in the Dampier Archipelago are found between Keast and Legendre Islands to the north of the Burrup Peninsula, and between West Intercourse Island and Cape Preston. Recorded occurrences of *Halophila* species in the Dampier Archipelago fluctuate depending on a variety of factors such as salinity, success of seed set and colonisation, temperature and grazing by dugongs (Woodside, 2006). Furthermore, this fluctuation may indicate the presence of transitory communities, which are annual meadows that develop from the seed bank, grow flower, set seed and die back each year (McMahon et al., 2017).

4.3.4.7 Macroalgae

Macroalgal communities of the north west of Western Australia are relatively poorly understood/surveyed in comparison to other regions of Australia (Huisman, 2004; Huisman and Borowitzka, 2003). Macroalgae generally require a hard substrate, sufficient light and water clarity to survive, and so are generally limited to shallow water. Macroalgal assemblages in the Pilbara region display an ephemeral growth pattern and may not be present year-round, despite presence of suitable habitat. Previously, macroalgal habitats were determined to be essentially all hard substrates within the photic zone. As a result, large algal habitats occur around West Intercourse Island and a number of shallow reef flats on the western and eastern margins of Mermaid Sound. In nearshore areas, macroalgae are most commonly found on shallow limestone pavements located on the northern and western portions of West Intercourse, West Lewis and Malus Island (Figure 4-3). More broadly, large expanses of macroalgae are prevalent along the seaward side of West Intercourse Island, extending south-west along the coast to Cape Preston and beyond.

The most abundant group of algae in the region is brown algae; in particular, species from the genus *Sargassum*, *Dictyopteris* and *Padina* are very common (Woodside, 2006). The most common species of green algae in the Dampier Archipelago include *Caulerpa* species and calcareous *Halimeda* species (CALM, 2005; Jones, 2004). A variety of red algae are also found in the Dampier Archipelago including corallines, calcified red algae and algal turf (Jones, 2004).

4.3.4.8 Mangroves

Mangroves are an important part of the coastal ecosystem, contributing to primary productivity and providing habitat for fauna species including fish, sea snakes, turtles and birds (Wells et al., 2003). The significance of tropical arid zone mangroves along the Pilbara coastline is recognised and specific guidance documentation has been established by the EPA (2001) for the protection of these communities, habitats and dependant habitats from development pressures.

Six species of mangrove occur in the Dampier region: *Avicennia marina*, *Aegialitis annulata*, *Aegiceras corniculatum*, *Bruguiera exaristata*, *Ceriops tagal*, and *Rhizophora stylosa*. Most mangrove communities contain a number of species, and a variety of structures of zonation persist, dependent on the underlying sediment type, tidal height, and wave and current action (Semeniuk et al., 1987). *Avicennia marina* is the most abundant species, existing in some monospecific stands that range from forests down to stunted shrubs. Regionally significant areas of mangroves that occur in the Dampier Archipelago include communities at West Intercourse Island, Enderby Island Complex and Searipple Passage/Conzinc Bay (EPA, 2001).

The nearest mangrove community to the Proposal is a stand of *Avicennia* and *Rhizophera* located at the north east pocket of the sandy beach at No Name Bay (Figure 4-3). This stand has been studied as part of a long term Chemical and Ecological Monitoring Program of Mermaid Sound (ChEMMS) program initiated by Woodside in 1985. The most recent survey undertaken by Advisian (2017) recorded very little, to no decline in the health of this stand over time, indicating very little impact to this mangrove community from existing industrial activities. The next closest, and considerably larger, mangrove community exists at King Bay (Figure 4-3). The mangrove community at King Bay was the subject of studies by the WA Department of Conservation and Environment in the early 1980s when the main Burrup access road was constructed through its upper reaches (Semeniuk et al., 1982). A comparison of aerial photography from 1957 and 2001 shows the distribution of individuals and species within the Hamersley Lease has changed little over the intervening 44 years (MScience, 2004).

4.3.4.9 Microphytobenthos and algal mats

Subtidal sandy seabed areas that support benthic algae or microphytobenthos (MPB) are recognised as a major contributor to overall benthic primary productivity of ecosystems as well as providing habitat for short range endemic fauna (Murrell et al., 2009). With the dominance of subtidal sandy habitat and the relatively shallow bathymetry of Mermaid Sound, it is likely that MPB occurs throughout the area, although its abundance and distribution has not been previously described. In

Mermaid Sound the more environmentally significant MPB habitat is likely to occur in shallower areas, where more light is available on the seabed. Regular fluctuations in biomass indicate that MPB respond rapidly to environmental variation. Monitoring in Port Phillip Bay, for example, has shown that MPB biomass is highly dynamic and capable of rapid recovery in shallow waters (Beardall et al., 1997; AME, 2006).

In the Dampier region, many areas of the otherwise bare zone contain intertidal blue-green algal mats (Wells and Walker, 2003). These have been studied by Paling (1986) and Paling and McComb (1994). The distribution of algal mats is controlled by tidal height, tidal current, sediment influx and sediment drainage (Wells and Walker, 2003). The algal mat is a cohesive fabric consisting of cyanophyte filaments, stabilising the substrate to resist erosion. The mats are rich in organic matter, storing carbon, nitrogen and phosphorous. The nutrients from the algal mats provide a significant source of nutrient input to mangrove communities in the region (Paling and McComb, 1994).

4.3.5 Potential Impacts

The proposed Scarborough trunkline is located immediately to the west of the Pluto trunkline and would employ a similar installation methodology as the Pluto trunkline. The impact assessment prepared for the Pluto trunkline (Woodside, 2006), the results of the monitoring undertaken during the installation of the Pluto trunkline and the review of the extent and intensity of the turbid plumes around the Pluto trunkline dredging program by MScience (2018) have been used as part of this impact assessment.

4.3.5.1 Pluto trunkline program impact assessment

MScience (2018b) outlines the studies undertaken in 2009, during trunkline dredging for the Pluto Development, discusses insights from predictive modelling and details the implications for impacts on sensitive receptors adjacent to dredging. The report also considers results of recent research conducted by the Western Australian Marine Science Institute's (WAMSI) Dredging Science Node.

Woodside have reviewed the impacts from the Pluto trunkline dredging program (MScience, 2018b). The construction methodology for the Scarborough trunkline is similar to that of the Pluto trunkline and thus impacts can be expected to be broadly similar.

A comprehensive program of plume and water quality monitoring was implemented during the Pluto trunkline dredging, in the same location where this Proposal will take place. The study integrated boat-based monitoring of turbidity of the waters to the east of dredging between dredging and coral communities, satellite-derived (MODIS) imagery of the location of turbid plumes, and monitoring of turbidity by in situ instruments adjacent to the coral communities. A predictive modelling study that used the on-site results for development and validation was also completed as part of this monitoring program.

During dredging for the Pluto program, boat-based monitoring indicated an increase in turbidity within 500 m east of the dredge with a rapid decrease in turbidity at distances beyond 500 m east. The median turbidity outside 500 m east was below both the median and 80th percentile of turbidity at two reference sites located in an area unaffected by dredging. As the relevant coral sites were all east of dredging, turbidity measurements were not made to the west of the dredge. Time-series of turbidity measurements from in situ instruments located close to sensitive coral communities did not identify any changes in turbidity associated with dredging. During the trunkline dredging, the median turbidity (seven-day rolling statistics) of the in situ sites adjacent to coral never exceeded the 80th percentiles of turbidity at coral reference sites.

The modelled plume was consistent with both the boat-based and MODIS imagery. Indications were that the plume tended to move west from the dredge and did not impact on the Burrup Peninsula shoreline. The consistency between modelled and measured turbidity indicates the model may be useful for planning future trunkline dredging programs when weather conditions may be different and for prediction of both intensity and duration of turbidity change. Woodside will complete dredge plume modelling specific to the Scarborough Project to inform the impacts from this project. The outcomes

of this modelling will be incorporated into a Dredging and Spoil Disposal Management Plan (DSDMP) that will be submitted for regulatory review and approval. As described, dredge plume models in the Dampier Archipelago are conservative in the prediction of impacts as demonstrated by the Pluto water quality monitoring program.

Further analysis of the Pluto trunkline monitoring program (MScience, 2018) compared the results of the monitoring program with recent research conducted by the Western Australian Marine Science Institute's Dredging Science Node. That research has indicated that at distances greater than 500 m from dredging, reduction in light available for photosynthesis represents the major source of dredging-related stress on corals. While the 2009 monitoring program did not measure light attenuation impacts, there is a strong correlation between light attenuation and turbidity elevation. The outcome of that comparison was that the minimal impacts shown by the various components of the monitoring were well below light attenuation and turbidity thresholds which might indicate a source of physiological stress. Under thresholds consistent with the WAMSI studies and EPA management guidance, areas >500 m from trunkline dredging would have been categorised as a Zone of Influence, but not as a Zone of Moderate Impact.

Future trunkline dredging programs are likely to have a similar minimal impact, if conducted with characteristics similar to that of the 2009 dredging. Should weather patterns during future dredging be less favourable to moving plumes away from sensitive receptor communities (i.e. if winds are of a more westerly nature than in the 2009 program), the relatively rapid progress of trunkline dredging along linear structures and the flexibility in operations to manage dredging effort over the extent of the trunkline would likely maintain the duration and frequency terms of any intensity-duration-frequency threshold of turbidity elevation below that currently predicted as required to generate material levels of coral stress. Both the relatively short period of trunkline dredging and daily movement of the dredge mean the potential for elevated turbidity at any site, other than a spoil ground, is expected to be of short duration (i.e. likely less than five days).

Based on the above, there is a high level of certainty that the proposed Scarborough trunkline is highly unlikely to have a significant impact on BCH. To provide additional certainty, plume modelling will be undertaken to determine zones of high/moderate impacts and a zone of influence. In addition, habitat surveys of the area will also be conducted, this combined with modelling outputs will be used to establish adequate management measures to avoid and/or minimise impacts.

4.3.5.2 Local assessment units

Current technical guidance for the protection of benthic communities and habitats (BCHs) from the EPA (EPA, 2016c) identifies the implementation of spatially based evaluations of BCH and refers to the adoption of a local assessment unit (LAU). The LAU is a spatially defined area, established to allow proponents to quantify historical and proposed loss of BCH. LAUs are location specific and should be configured to account for aspects of the local marine environment such as bathymetry and position of offshore reefs/islands, substrate type, water circulation patterns, exposure to waves and currents and biological attributes such as habitat types. Wherever possible, other variables related to the functional ecology of the system should be considered when defining LAUs.

Between 2012–2014, the Dampier Port Authority (DPA, now the Pilbara Ports Authority (PPA)) engaged MScience to assess the status of benthic primary producer habitat (BPPH) within Port limits, establish potential LAUs and undertake an initial assessment of historic loss of each BPPH by LAU (Figure 4-4). The intention by DPA, was to align with EPA guidelines and to provide a common framework for assessments within the Port by establishing agreed local assessment units within the Port and to become the custodian of BPPH data for these LAUs. Development proponents would then use this framework to avoid repeating the work of others and to operate within a set of guidelines agreed by the DPA and the EPA. In developing these LAUs, MScience and DPA considered the EPA guidelines, the previous use of Management Zones for development projects within the Port's jurisdiction, current and planned usages (e.g. establishing safe anchorages/moorings) and the natural ecology and physical characteristics of the Dampier Archipelago. For consistency, Woodside proposes to use these LAUs when assessing any loss of

BCH associated with the project, which will be discussed with the EPA and defined further in the relevant management plans.

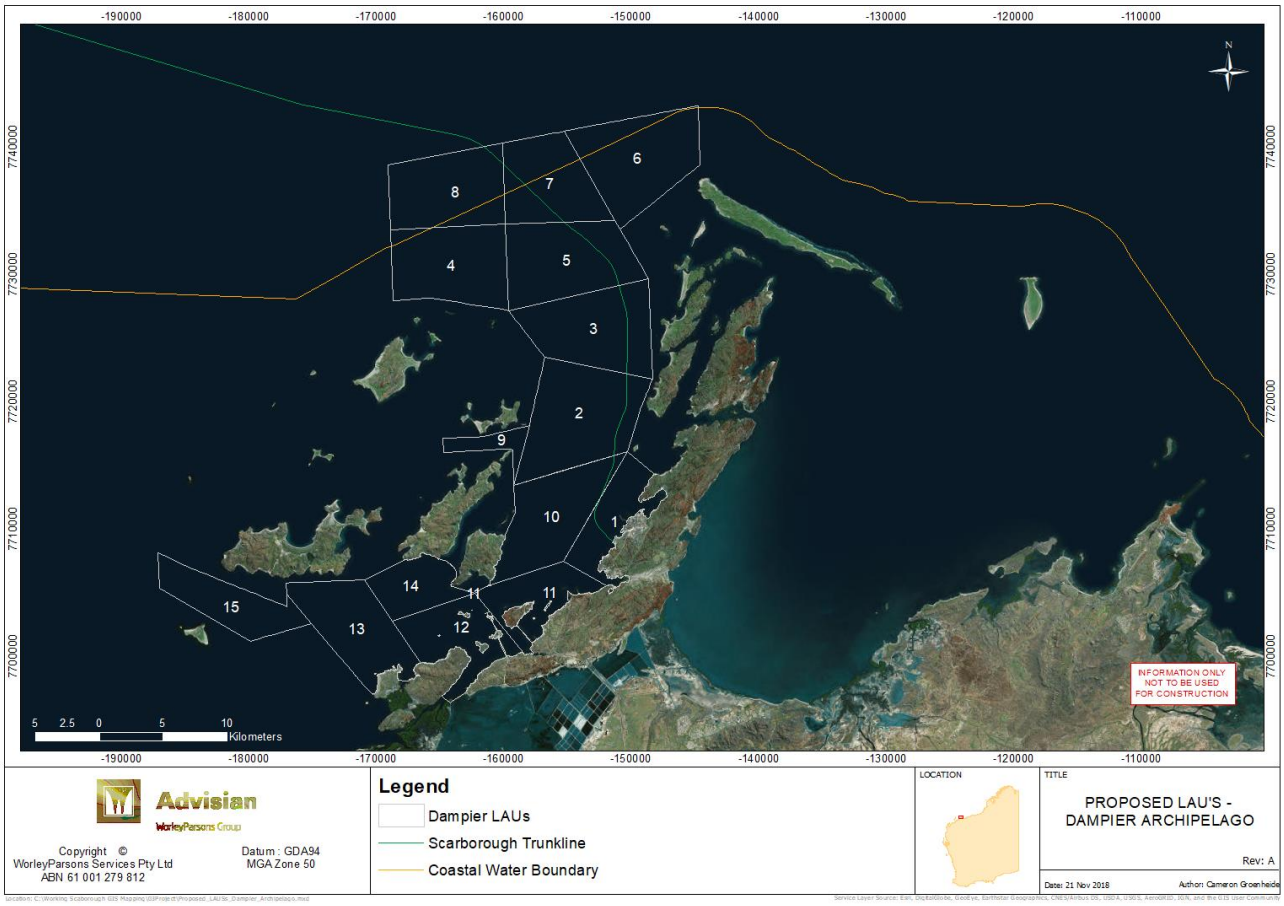


Figure 4-4: Proposed LAUs for the Scarborough trunkline dredging impact assessment

4.3.5.3 Impact assessment

Table 4-4 summarises the various aspects of the Proposal that would result in a potential impact on BCH. It also details additional studies that would be undertaken to determine the extent of the potential impacts.

Table 4-4: Preliminary EIA for BCH

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Potential impacts during construction						
Benthic Communities – Corals (High)	Planned – Physical removal of benthic communities and habitat	Direct removal of BCH within the trenching footprint may be required. The proposed trunkline route has been selected to avoid sensitive habitats as far as practicable and utilise existing routes established as part of the Pluto LNG Facility project. The majority of impacted habitat is not expected to support coral communities as described by previous habitat mapping studies (Section 4.3.4.5). Trunkline stabilisation and burial through dumping of coarse rock, may result in the establishment of additional hard substrate habitat, which has the potential to support future coral larvae settlement. Potential impacts to coral communities due to physical removal is expected to be minor as the majority of corals occur outside the trunkline footprint. Corals at the trunkline crossing have been previously disturbed and removed as part of the Pluto LNG Facility foundation project. Direct removal of any BCH will be further quantified, reported as a % loss for the LAU following completion of dredge plume modelling.	N/A	Slight	Minor	The spatial distribution of existing BCH will be confirmed through additional survey work to provide additional confidence in the distribution of BCH that may be impacted by the project (Table 4-2). LAUs will be established and direct habitat loss will be determined quantitatively.

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Planned – Indirect impacts from dredging and spoil disposal activities	<u>Increased turbidity</u> Studies by the Western Australian Marine Science Institute (WAMSI) found that a sustained reduction in light available for photosynthesis of the coral symbionts (algae) was likely to be the most significant impact mechanism for corals outside the area immediately surrounding dredging (notionally 500 m). Previous assessments by Western Australia's Environmental Protection Authority (WAEPA) have determined that the coral communities of this area are the habitats most sensitive to the effects of elevated suspended sediments (e.g. EPA, 2006; EPA, 2007). The level of impact to corals will depend on the degree of susceptibility of different corals, and the intensity and duration of reductions in light. Gilmour et al. (2006); Jones et al. (2015b) suggests that there would be a gradient of coral sensitivity to elevated suspended sediment, which increases as the trunkline route becomes more distant from its shore crossing. That would also be consistent with the exposure of communities on the southern section of the trunkline route to greater intensity-frequency-duration events of elevated suspended sediments than those communities in the outer areas of Mermaid Sound (MScience, 2010a). Current habitat mapping suggests that the more sensitive coral communities, in outer Mermaid Sound would be further from the pipeline trenching activity. The communities closer to the shore crossing would be in closer proximity to the trunkline, but are better adapted to tolerate light reductions due to the naturally higher turbidity in inner Mermaid Sound. As discussed in Section 4.3.5, impacts to coral communities due to increased turbidity from dredging and spoil disposal are predicted to be minor. <u>Sedimentation</u> Physical impacts to corals from the introduction of additional sediment to the water column includes physical burial and smothering of colonies as the sediment settles out of the water column. Physical scouring of coral colonies can also occur as courser sediments are carried with tidal current flow. Coral have coping mechanisms to remove settled material to some degree, though they have little defence against physical scouring by entrained sediment. Corals in the area are much better understood due to recent studies into impacts of dredging on corals (Jones et al., 2017), coral demographics and disturbance susceptibility (Babcock et al., 2017), in addition to sediment transport processes within coral systems (Lowe and Ghisalberti, 2016). This knowledge coupled with outputs from plume modelling would provide a high level of confidence in the degree of any impact that may occur. As discussed above and in Section 4.3.5, the proximity of major coral communities is farther than the notional impact zone surrounding dredging (500 m) and impacts are predicted to be minor. <u>Spawning and recruitment – CWES</u> Dredge plumes can impact settlement and early development of coral larvae following spawning events when most larval metamorphosis and recruitment occurs. Timing of mass coral spawning events in the Dampier Archipelago are well understood and with consideration of recommended management measures in Section 4.3.6, which may include selective positioning of dredging activities during this critical window of environmental sensitivity, impacts are predicted to be minor.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-2).
	Planned – Project vessel discharges	Routine discharges from construction vessels (sewage and greywater, food waste, deck drainage and bilge) will comply with MARPOL requirements with sewage and putrescible wastes discharges beyond 3 nm. Construction activities would be located away from any high density coral communities within the Dampier Archipelago, which would minimise impacts. Management measures have been recommended to further avoid/minimise impacts to water quality (Section 4.4.6).	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP) (Table 4-5).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Unplanned – Impacts from oil spill	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main environmental effects commonly associated with these spills can be considered as physical (coating/smothering) and chemical (including toxicity and bioaccumulation). Receptor responses may be sub-lethal through to outright mortality. Coral larvae are likely to be sensitive to surface slicks in the 1–3-week period following spawning events, during which, most larval metamorphosis and recruitment occurs. When eggs or larvae are released by corals into the surface waters, they are generally positively buoyant and float on or near to the water surface, increasing the risk of contact with the spill. Potential impacts to corals from hydrocarbon spills are most likely to be experienced by shoreline communities exposed to the sea surface, or subtidal corals exposed to exceptionally low tides and hydrocarbons that are entrained with the water column. However, the risk of a spill occurring is considered highly unlikely as assessed in Section 4.4.5.1 and after implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted. In the event of a small or medium sized hydrocarbon spill within Mermaid Sound, from occurrences such as vessel refuelling accidents, potential impacts to coral communities will be low.	Highly unlikely	Moderate	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – Introduction of IMS impacting benthic communities	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago from contaminated hulls and/or ballast waters which could impact coral communities. The risk can be mitigated by implementing the management measures proposed in Section 4.3.6, including the requirement to have vessels adequately checked and certified prior to entering the waters of the Dampier Archipelago. While the likelihood is considered highly unlikely, the magnitude should they occur would likely be long term and considered major.	Highly unlikely	Major	Moderate	Impact addressed within management plans (DSDMP) (Table 4-5).
Benthic Communities – Seagrass (High)	Planned – Physical removal of benthic communities and habitat	Seagrass is sparse in Mermaid Sound, found predominantly in the bays along the Burrup Peninsula and in Mermaid Strait (Section 4.3.4.6). The direct removal of sandy substrates along the trunkline will not intersect these seagrass communities.	N/A	No lasting effect	Slight	Existing habitat information will be supplemented with additional studies (habitat mapping and community assessment) (Table 4-2). LAUs will be established and habitat loss will be determined quantitatively.
	Planned – Indirect impacts from dredging and spoil disposal activities	Indirect impacts of dredging on seagrasses are similar to those experienced by other benthic primary producers, such as those described for corals above and will be temporary. Furthermore, some seagrass meadows have the capacity to die back when environmental conditions, such as temperature or light are outside of the species tolerance range but then re-establish from seed when favourable conditions return (McMahon et al., 2017).	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-2).
	Planned – Project vessel discharges	Routine discharges from construction vessels (sewage and greywater, food waste, deck drainage and bilge) have the potential to impact the benthic habitats through alteration of the surrounding water quality. Construction activities would be located away from any seagrass communities within the Dampier Archipelago, which would minimise potential impacts. Management measures have been recommended to further avoid/minimise impacts to water quality (Section 4.4.6).	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP) (Table 4-5).
	Unplanned – Impacts from oil spill	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1. The risk of a spill occurring is considered highly unlikely as assessed in Section 4.4.5.1 and after implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted. Given the sparse distribution of seagrasses in the project envelope (Section 4.3.4.6) and their subtidal nature, potential impact to seagrasses is considered low level.	Highly unlikely	Moderate	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – Introduction of IMS impacting seagrass communities	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago from contaminated hulls and/or ballast waters which could impact coral communities. The risk can be mitigated by implementing the management measures proposed in Section 4.3.6, including the requirement to have vessels adequately checked and certified prior to entering the waters of the Dampier Archipelago. While the likelihood is considered highly unlikely, the magnitude should they occur would likely be long term and considered major.	Highly unlikely	Major	Moderate	Impact addressed within management plans (DSDMP) (Table 4-5).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Benthic Communities – Macroalgae (Medium)	Planned – Physical removal of benthic communities and habitat	Dredging will have no direct impact on macroalgae habitat, as the trunkline mainly passes through sand and silt, bypassing limestone reefs along Conzinc, Angel and Gidley islands which have been mapped as habitat where macroalgae can potentially occur (Section 4.3.4.7).	N/A	No lasting effect	Slight	Existing habitat information will be supplemented with additional studies (habitat mapping and community assessment) (Table 4-2). LAUs will be established and habitat loss will be determined quantitatively.
	Planned – Indirect impacts from dredging and spoil disposal activities	Indirect impacts of dredging on macroalgae are similar to those experienced by other benthic primary producers, such as those described for corals above, though the impact thresholds are expected to be greater for macroalgae.	N/A	No lasting effect	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-2).
	Planned – Project vessel discharges	Routine discharges from construction vessels (sewage and greywater, food waste, deck drainage and bilge) have the potential to impact the benthic habitats through alteration of the surrounding water quality. This may result in a temporary increase in macroalgal cover due to any brief increase in nutrient availability. Construction activities would be located away from major communities within the Dampier Archipelago, which would minimise potential impacts. Management measures have been recommended to further avoid/minimise impacts to water quality (Section 4.4.6).	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) (Table 4-5).
	Unplanned – Impacts from oil spill	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1. However, the risk of a spill occurring is considered highly unlikely as assessed in Section 4.4.5.1 and after implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted. Field studies conducted after spill events by Connell and Miller (1981) indicate a high degree of variability in the level of impact to algae. In all instances the algae appeared to be able to recover rapidly from even very heavy oiling. Algae communities are widespread within the Dampier Archipelago and are commonly associated with submerged limestone pavement habitat (Section 4.3.4.7). A small sized hydrocarbon spill (such as marine diesel) within the Archipelago is unlikely to significantly affect submerged algae communities, and potential impacts are considered low.	Highly unlikely	Slight	Low	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – Introduction of IMS impacting macroalgae communities	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago from contaminated hulls and/or ballast waters which could impact coral communities. The risk can be mitigated by implementing the management measures proposed in Section 4.3.6, including the requirement to have vessels adequately checked and certified prior to entering the waters of the Dampier Archipelago. While the likelihood is considered highly unlikely, the magnitude should they occur would likely be long term and considered major.	Highly unlikely	Major	Moderate	Impact addressed within management plans (DSDMP) (Table 4-5).
Benthic Communities – Mangroves (High)	Planned – Physical removal of benthic communities and habitat	Dredging activities will not directly remove any mangrove habitat.	N/A	No lasting effect	Slight	Existing habitat information will be supplemented with additional studies (habitat mapping and community assessment) (Table 4-2). LAUs will be established and habitat loss will be determined quantitatively.
	Planned – Indirect impacts from dredging and spoil disposal activities	Installation of the subsea infrastructure including the trunkline is expected to result in localised seabed disturbance that will occur over a short duration, resulting in temporary increase in suspended sediments. During periods of dredging near coastlines, sediments entrained in the water column may be carried into mangrove habitat during high tides and potentially deposited there, increasing burial of pneumatophores to some extent. However, modelling results from the Pluto LNG Facility Development dredging programme did not indicate the dispersion of turbid plumes from dredging towards mangrove areas. Levels of sedimentation are not expected to be high enough to impact mangrove habitat in the long term. Potential indirect impacts on mangroves from sedimentation created by dredging are therefore considered slight.	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-2).
	Planned – Project vessel discharges	Routine discharges from construction vessels (sewage and greywater, food waste, deck drainage and bilge) have the potential to impact the benthic habitats through alteration of the surrounding water quality. This may result in a temporary increase in macroalgal cover due to any brief increase in nutrient availability. Construction activities would be located away from major communities within the Dampier Archipelago, which would minimise potential impacts. Management measures have been recommended to further avoid/minimise impacts to water quality (Section 4.4.6).	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) (Table 4-5).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Unplanned – Impacts from oil spill	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1. The risk of a spill occurring is considered highly unlikely as assessed in Section 4.4.5.1 and after implementing the management measures recommended (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted. Typically, oil spill slicks enter mangrove communities during high tides, and are deposited on the aerial roots and sediment surface as the tide recedes. Direct mortality of mangroves can occur from heavy oiling that covers breathing pores (lenticels) and from toxic substances contained within the oil which may impair the salt exclusion process (IPIECA, 1993). Mangrove communities are found throughout the coastlines of the Dampier Archipelago region (Section 4.3.4.8). The recovery of mangroves from exposure to a hydrocarbon spill is considered slow, though impacts are dependent on the size of the spill. A small diesel spill during refuelling as part of construction activities is likely to result in low level impacts to existing mangrove communities if it occurs in the vicinity of mangrove habitat.	Highly unlikely	Moderate	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – Introduction of IMS impacting mangrove communities	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago from contaminated hulls and/or ballast waters though would likely cause little impact directly to existing mangrove communities. The risk, however, can be avoided by implementing the management measures proposed in Section 4.3.6, including the requirement to have vessels adequately checked and certified prior to entering the waters of the Dampier Archipelago. Some preliminary studies into the effect of IMS on mangroves suggest that impacts can involve impairment of succession of disturbed mangrove communities (Biswas et al, 2012). Since the risk is considered highly unlikely and impacts, should they occur, would be of very little magnitude to mangrove communities the potential impact of an introduction of IMS is considered moderate.	Highly unlikely	Minor	Moderate	Impact addressed within management plans (DSDMP) (Table 4-5).
Benthic Communities – Marine invertebrate fauna (Med)	Planned – Physical removal of benthic communities and habitat	Dredging activities would remove benthic communities and habitats within the trunkline footprint. Previous habitat mapping studies indicate there are no major mixed sessile benthic invertebrate communities in proximity of the trunkline footprint (Figure 4-3). Infauna present within the trunkline footprint would be removed but this would be a small proportion of infauna in the Dampier Archipelago. Potential impacts to marine invertebrate fauna from direct removal are likely to be negligible.	N/A	No lasting effect	Negligible	Existing habitat information will be supplemented with additional studies (habitat mapping and community assessment) (Table 4-2). LAUs will be established and habitat loss will be determined quantitatively.
	Planned – Indirect impacts from dredging and spoil disposal activities	Many benthic marine fauna are filter feeders (such as bivalves and sponges) and can be affected by increased suspended solid concentrations that may block or partially clog their feeding interstices. Most filter feeders have coping mechanisms to deal with temporary sediment load increases, such as rejecting inorganic particles and reducing flow rates (those that can, including bivalves). Suspended sediments may also cause abrasion and damage to the surface of sponges, exposing them to disease. This is especially the case where particle size of the agitated material is larger than usual and during severe storms (Schönberg, 2016). Dredging associated with trunkline installation through Mermaid Sound and the disposal of dredged material may result in temporarily elevated suspended sediments levels over existing benthic invertebrate communities in proximity. Schönberg (2016) notes that impacts to sponges due to increased suspended sediments are most severe when they occur over long durations. Previous modelling of those concentrations predicted relatively low levels of suspended sediments. The exposure to any elevated turbidity would also be short-lived. Therefore, potential impacts resulting from trunkline dredging and disposal are considered slight.	N/A	Slight	Slight	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-2).
	Planned – Project vessel discharges	Routine discharges from construction vessels (sewage and greywater, food waste, deck drainage and bilge) have the potential to impact the benthic habitats through alteration of the surrounding water quality. Construction activities would be located away from major invertebrate communities within the Dampier Archipelago, which would minimise potential impacts. Management measures have been recommended to further avoid/minimise impacts to water quality (Section 4.4.6).	N/A	Slight	Slight	Impact addressed within management plans (DSDMP) (Table 4-5).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Unplanned – Impacts from oil spill	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1. Invertebrates are at risk of being coated in and ingesting oil with lethal and various sub-lethal effects. Sub-lethal effects can include alteration in respiration rates, decrease in filter feeding activity, reduced growth rates, biochemical effects, increased predation, reproductive failure and mechanical destruction by waves from an inability to maintain attachment to the substrate. Credible spill events are likely to have low level impacts.	Highly unlikely	Minor	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – Introduction of IMS impacting benthic invertebrate communities	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago from contaminated hulls and/or ballast waters which could impact coral communities. The risk can be mitigated by implementing the management measures proposed in Section 4.3.6, including the requirement to have vessels adequately checked and certified prior to entering the waters of the Dampier Archipelago. While the likelihood is considered highly unlikely, the magnitude should they occur would likely be long term and considered major.	Highly unlikely	Major	Moderate	Impact addressed within management plans (DSDMP) (Table 4-5).
Potential impacts during operation						
Benthic Communities (High)	Planned – Physical presence of trunkline on seabed	The trunkline would be laid on the seabed parallel and close to the existing Pluto trunkline. The shore crossing site is located at the Pluto LNG facility in previously disturbed area in an industrial zone. It is unlikely to negatively impact benthic communities and may provide a source of new habitat.	N/A	Slight	Minor	Final alignment of the trunkline will be determined during FEED.
	Unplanned – Hydrocarbon leak from the trunkline	The trunkline would be protected by being buried within a trench below sediment and/or rock which would prevent physical damage from accidental collisions with external elements (e.g. anchors) and therefore has a remote chance of occurring. Given the trunkline will contain gas the impact to benthic communities is expected to be low.	Remote	Minor	Low	Impact addressed in OSCP and supported by additional studies to be undertaken (hydrocarbon spill modelling for credible spill scenarios, Table 4-2).

4.3.6 Mitigation

Table 4-5 provides a summary of mitigation measures that would be implemented to avoid and/or mitigate potential impacts from the Proposal.

4.3.7 Assumptions and predicted outcome

Based on the preliminary impact assessment using available information, including insights from previous monitoring and plume modelling undertaken for the existing Pluto trunkline (MScience, 2018), the Proposal is unlikely to significantly harm benthic communities and habitats. Additionally studies as detailed in Table 4-2 will be used to inform the management plans. It would therefore meet the EPA objectives:

- Long term impacts as a result of the physical presence of a trunkline within Mermaid Sound are likely to be minor. The proposed trunkline has been positioned parallel and close to an existing trunkline, and the shore crossing site has been located at the Pluto LNG Facility in a previously disturbed area.
- Construction impacts would generally be minor and temporary, and mostly related to the presence of construction vessels within Mermaid Sound and/or temporary impacts to water quality from dredging activities during the construction period. Based on the MScience (2018) review of the Pluto dredging program, there is a high level of certainty that the proposed Scarborough trunkline will not have a significant impact on BCH.
- Proposed mitigation measures (Section 4.3.6) have been recommended to avoid and/or minimise expected impacts and there is unlikely to be significant residual impacts. Management measures would be further refined following completion and integration of data from planned additional studies.

Table 4-5: BCH – Mitigation measures

Receptor	Impact	Mitigation
All	Physical removal of benthic communities and habitat	Trunkline route selected to minimise disturbance to sensitive areas.
	Indirect impacts from dredging and spoil disposal activities	A detailed Dredging and Spoil Disposal Management Plan (DSDMP) will be developed outlining specific mitigation and monitoring measures. This will be submitted to the relevant regulatory agencies for approval prior to dredging commencing.
	Project vessel discharges	Mitigation for impacts to water quality resulting from vessel discharges are described in Section 4.4.6.
	Impacts from hydrocarbon spill	Mitigation for impacts to water quality resulting from a potential hydrocarbon spill are described in Section 4.4.6.
	Introduction of IMS impacting benthic communities	• Implementation of Woodside's IMS Management Plan (including risk based assessment and implementation of management options as required by the plan) to reduce the risk of introducing IMS to Australian waters. This may include inspections before entering Australian waters and use of antifouling coating. • All vessels will be required to meet both Commonwealth and State ballast water and biofouling legislation including the Ballast Water Management Requirements and the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry.

4.4 Marine environmental quality

4.4.1 EPA objective

The EPA objective in relation to key environmental factor 'Marine Environmental Quality' is: 'To maintain the quality of water, sediment and biota so that environmental values are protected'.

4.4.2 Policy and guidance

The following EPA guidance has been considered in evaluating potential impacts on this factor:

EPA (2016e). Environmental Factor Guideline: Marine Environmental Quality, EPA, Western Australia

EPA (2016f). Technical Guidance – Protecting the Quality of Western Australia's Marine Environment, EPA, Western Australia

EPA (2016d). Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals, EPA, Western Australia.

4.4.3 Studies and information sources

Various studies and surveys have been completed within the Dampier Archipelago describing the existing environment, particularly during the Pluto Development. Table 4-6 lists the relevant studies and publications for Marine Environmental Quality. These have helped inform the description of the existing environment and assessment of impacts for the Proposal. Furthermore, additional studies have been commissioned and will be available for inclusion in any formal environmental impact assessments to be submitted in relation to the Proposal.

Table 4-6: Relevant studies undertaken that support the Proposal

Author	Study (Date)
Existing studies/surveys/databases used	
Advisian	Chemical and Ecological Monitoring of Mermaid Sound: 2017 Compliance Report (2017)
GHD	Chemical Analysis Sediment Report Port of Dampier Doc No 156180 RevA (2016)
Jacobs	Port of Dampier Marine Sediment Sampling Report (2015)
MScience	Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program (2009)
	Pluto LNG Development: Final Report on Coral and Water Monitoring (2010)
SKM	Pluto LNG Development: Dredging and Spoil Disposal Management Plan / Dredge Impact Management Plan (2009)
Woodside Energy Limited	Pluto LNG Development: Draft Public Environment Report/Public Environment Review (2006), and associated studies
	Pluto Baseline Water Quality Report (2007)
Planned studies/surveys	
Advisian	Trunkline dredging plume modelling study (2018)
TBC	Sampling and Analysis Plan implementation report
TBC	Hydrocarbon spill modelling study

4.4.4 Receiving environment

'Marine Environmental Quality' refers to variation from the natural state of the waters, sediments and biota contained within the marine environment. This includes any changes in physical or chemical properties, though does not include noise pollution.

4.4.4.1 Environmental quality

As described above, the EPA's objective for this factor is: "To maintain the quality of water, sediment and biota so that environmental values are protected". Environmental value (EV) is defined under the *Environmental Protection Act 1986* as "a beneficial use or an ecosystem health condition". Beneficial uses are uses of the environment which are conducive to public benefit, safety or health or to aesthetic enjoyment. Ecosystem health condition is the condition of the environment itself and is measured in terms of ecological structure, function or processes. Both types of EVs can be affected by emissions, degradation of the environment, or by loss or damage to natural habitats. In the context of the EPA's objective for marine environmental quality it is only 'emissions' and, to a lesser extent, 'degradation of the environment' that are relevant considerations. A set of five EVs that require protection from the effects of pollution, waste discharges and deposits in marine environments have been agreed by all State, Territory and Commonwealth governments through the National Water Quality Management Strategy (NWQMS). The factor and objective for marine environmental quality recognises that the quality of the marine environment is important for protecting ecosystem health and supporting beneficial uses such as swimming that rely on good water quality.

The EPA expects proponents to present marine related development proposals within the context of the environmental quality management framework (EQMF) recommended through the NWQMS and as modified through the EPA's Guidance for Protecting the Quality of Western Australia's Marine Environment. The EVs form the basis of the framework and, in combination with associated environmental quality objectives (EQOs), represent the community's and other stakeholders' desired outcome for marine environmental quality.

In accordance with guidance provided in EPA (2016f), the key factors considered in identifying the EVs and associated EQOs that are applicable to the Proposal Area were:

- the existing Environmental Quality Management Framework (EQMF) described for Mermaid Sound in the Pilbara Coastal Water Quality Consultation Outcomes (DoE, 2006)
- the ecological values of the marine waters, including the presence of BCH (Section 4.3) and marine fauna (Section 4.5) that utilise the area
- established operations in the Dampier Industrial area, including the Karratha and Pluto gas plants
- recreational and commercial use of the marine waters by the local community, industry and tourism operators (Section 4.6.4)
- the use of the marine waters to support commercial fishing operations (refer to 4.6.4)
- the cultural values of the marine waters
- requirement for industrial water supply within Damper Industrial area.

The EVs and associated EQOs, as defined in EPA (2016f), that are considered relevant to the Proposal are presented in Table 4-7.

Table 4-7: Environmental values and environmental quality objectives related to the Proposal

Environmental Values	Environmental Quality Objectives
Ecosystem Health	There are four levels of ranking for maintenance of ecosystem health, known as levels of ecological protection (LEP), these are maximum, high, moderate and low. The maximum, high and moderate LEPs are relevant to the Proposal (Figure 4-5).
Fishing and aquaculture	Seafood (wild caught) is safe for human consumption.
Recreation and aesthetics	Water quality is safe for primary contact recreation (e.g. swimming and diving). Water quality is safe for secondary contact recreation (e.g. fishing and boating). Aesthetic values of the marine environment are protected.
Industrial water supply	Water quality is suitable for industrial use.
Cultural and spiritual	Protection of cultural and spiritual values of the marine environment

4.4.4.2 Levels of ecological protection

As per the EQMF set out by the DoE (2006), most of Mermaid Sound is afforded a high to maximum Level of Ecological Protection. Areas where infrastructure and industrial activity are common, such as Karratha Gas Plant nearshore infrastructure and dredge spoil disposal grounds, have been allocated a moderate Level of Ecological Protection and areas around saltworks and sewage wastewater discharges have been allocated a low to moderate Level of Ecological Protection (Figure 4-5).

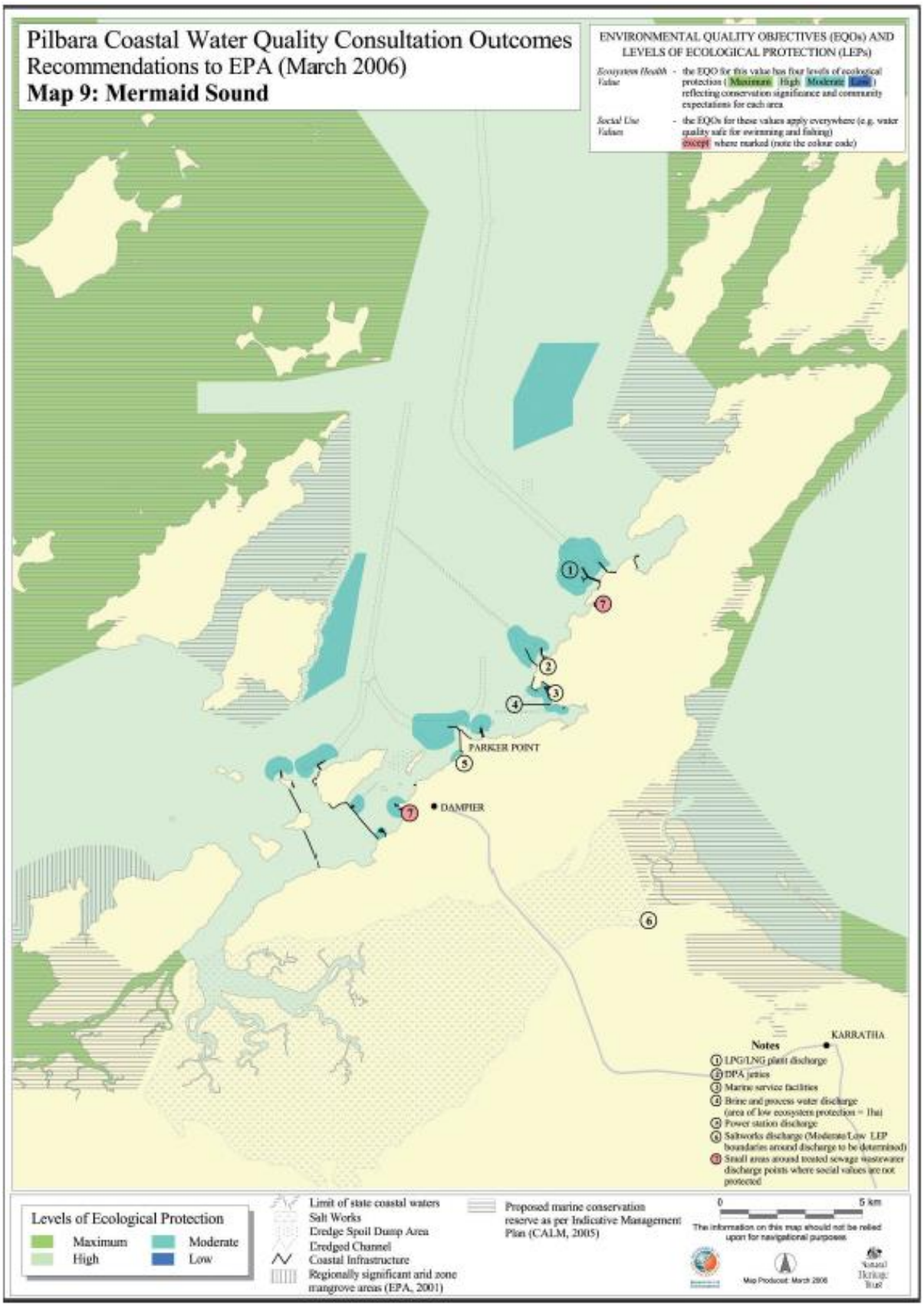


Figure 4-5: Environmental Quality Plan for Mermaid Sound (DoE, 2006)

4.4.4.3 Marine water quality and characteristics

Water temperature and salinity

Mean water temperature of the nearshore waters of the Dampier Archipelago range from 22.5°C in July/August to 30.4°C in February (Pearce et al., 2003). These nearshore waters are semi-enclosed from the offshore waters by the islands of the Archipelago resulting in warmer temperatures in summer and cooler temperatures in winter. Monitoring conducted for the Pluto LNG Facility Project found that water temperature at locations in the inner and middle of Mermaid Sound remained higher for longer compared with the sites further offshore over summer periods (MScience, 2010).

Similarly, in contrast to offshore waters where salinity remains relatively uniform, within the Dampier Archipelago salinity is generally vertically stratified, wedging seaward beneath the open waters of the Continental Shelf. Though typically the nearshore waters are more saline, dilution of surface water salinity occurs during periods of cyclonic activity and heavy rainfall within the Archipelago.

Turbidity and suspended solids

Typically, the waters in the inner Archipelago, closer to the mainland, are characterised as having naturally higher levels of turbidity than the clearer, offshore environment. This is predominantly related to the continual resuspension of fine sediment material through natural inputs such as winds, tidal currents and wave energy, which is exacerbated in shallow areas where strong tidal flows exist (such as through Flying Foam Passage) or where high volume of vessel movements occur (such as shipping channel and berthage areas). Periodic events, such as major sediment transport associated with tropical cyclones, may influence turbidity on a regional scale (CSIRO, 2007).

Monitoring at 25 sites (outside dredging periods) spread throughout Mermaid Sound for dredging associated with the Pluto LNG Facility Project found that long term median turbidity (recorded as NTU) ranged from 2-3.2 NTU. Variations was experienced between locations with higher median turbidity values in the inner archipelago. Monitoring was typically completed in winter months when turbidity is generally lower (MScience, 2010).

Trace metals and organics

A study measuring dissolved concentrations of cadmium, chromium, copper, lead and zinc, total mercury, PAHs, phenols, BTEX chemicals and petroleum hydrocarbons, found that water quality in the Dampier Archipelago met the guidelines for a ‘very high’ level of ecological protection (99% species protection) based on the recommended guidelines and approaches in ANZECC and ARMCANZ (2000) (McAlpine et al., 2004). At the time of sampling, all metals measured in King Bay, adjacent to an industrial centre, achieved the national guidelines for 99% species protection, although cadmium, copper and zinc were elevated compared to all other sites surveyed in the Dampier Archipelago.

The study (McAlpine et al., 2004) found no detectable levels of organics in the waters of the Dampier Archipelago.

Nutrients

Waters in the Dampier Archipelago are considered oligotrophic. However, on occasions, blooms of nitrogen-fixing microbes such as *Trichodesmium* or mangrove mud-flat cyanobacterium may contribute significant amounts of nutrients into the marine environment. High spatial and seasonal variability are evident in nutrient and chlorophyll-a concentrations within the Dampier Archipelago (Pearce et al., 2003).

4.4.4.4 Marine sediment quality and characteristics

Contaminants

Past studies have rarely found contaminants in sediments of the Dampier Archipelago. This is considered attributable to the lack of riverine inputs and controls on discharges associated with low levels of industrial development (MScience, 2004). Historically, sediments in Mermaid Sound have been considered to be generally clean (in that they were below screening levels of National Ocean Disposal Guidelines for Dredged Material (NODGM), with Tributyltin (TBT) the only contaminant of concern (Woodside, 2006; DEC, 2006). TBT, which has been used as an anti-foulant on ships, is a compound acutely toxic to many species of marine animals as it inhibits growth. It leaches from treated surfaces, such as ship hulls, and is further introduced to the marine environment through paint flaking (Laughlin et al., 1986). TBT thus accumulates in sediments in areas of heavy shipping such as harbours and wharves. The elevated concentrations found in previous sampling programmes have been in the upper sediment layer in areas used by the shipping industry (IRCE, 2003a; 2003b).

In January 2006, an extensive sediment survey of Mermaid Sound covering the proposed Pluto LNG Facility channel and gas trunkline route screened the upper 1 m of seabed for TBT. Overall the 95% Upper Confidence Limit of TBT for all areas was below screening level as stipulated by the then guideline at the time (NODGM), and the sediments were therefore considered acceptable for ocean disposal. Of the 98 sites screened only two sites, located in the vicinity of existing shipping channels, contained TBT above detection levels (20 µg Sn/kg and 3.85 µg Sn/kg (normalised to 1% Total Organic Carbon). Both samples were taken from the upper 50 cm of seabed, with the lower 50 cm of the same sites containing no detectable TBT, indicating TBT contamination was confined to the upper layer of seabed. The sample containing 20 µg Sn/kg was one of three taken at the same location as part of a triplicate series for analysis of inter-sample variation. The other two samples in this triplicate series contained no detectable levels of TBT. This is not unusual given paint flakes from ships can cause highly localised elevated levels of TBT in sediments (Woodside, 2006).

It is expected that the complete prohibition on the presence of TBT paints on ships since 2008 will have resulted in a continuing reduction of TBT levels in sediments in the Dampier Archipelago. A study conducted by Jacobs (2015), where sediment samples were taken at 200 m and 500 m distances from existing developments/infrastructure within Mermaid Sound (including shipping channels and spoil grounds) found that, when normalised to 1% total organic carbon (TOC), levels of TBT were below the screening level of current guidelines, National Assessment Guidelines for Dredging (NAGD).

In the first quarter of 2006, a further 35 sediment samples were collected at 15 borehole locations from the lower seabed (that is, below 1 m) during a geotechnical survey undertaken by Woodside in Mermaid Sound. Sporadic traces of petroleum based hydrocarbons were found, with no detectable levels of any polyaromatic hydrocarbons listed by the current guidelines at the time (NODGM). The sediments were also tested for metals, with levels of arsenic, chromium, nickel and silver found slightly above screening level in a few individual samples (Woodside, 2006).

More recent studies undertaken throughout the Archipelago, within Port limits have indicated that surficial sediments (upper 1 m of sediment) were still considered generally clean. The only analytes to exceed NAGD screening levels were arsenic and nickel and only at a small subset of sampling locations (Advisian, 2017; Jacobs, 2015; GHD, 2016). These elevated levels were considered attributable to the natural geology of the region, which is in line findings of studies conducted in 2006 (DEC, 2006; Woodside, 2006). The GHD study also determined that locations with the smallest particle grain size had higher adsorption potential and generally had higher concentrations of metals, metalloids and total organic carbon (GHD, 2016). The analysis for the intermediate suite of parameters of sediments at the three sites sampled by Jacobs (2015) recorded no detectable concentrations of hydrocarbons, phenols/phenolics or chlorobenzenes. Similarly, there were no detectable concentrations of pesticides, PCBs, herbicides or cyanides recorded as part of the analysis for the detailed suite of parameters.

Information on sediment quality directly related to the Proposal footprint will be ascertained by the development and implementation of a detailed Sampling and Analysis Plan (SAP) that will be undertaken in support of a Sea Dumping Permit Application, planned for 2019.

Grain size

Seabed sediment grain size in the Dampier Archipelago region is highly variable, due to the presence of strong tidal currents, periodic cyclones, protected embayments and sediment-producing organisms such as coral reefs (Talbot et al., 1985). Analysis of particle size distribution sediment survey for the Pluto LNG Facility dredging footprint in January 2006, found sediments adjacent to Holden Point to be predominately sand (particle size of 0.06–2.0 mm). Further offshore, within the navigation channel the sediments were comprised of sand (particle size of 0.06–2.0 mm); silt (0.002–0.06 mm) and clay (≤0.002 mm) (Woodside, 2006). Similarly, most sites sampled by Jacobs (2015) within Mermaid Sound were dominated by silt and clay.

4.4.5 Potential impacts

Table 4-9 summarises the aspects of the Proposal that would result in a potential impact on MEQ. It also details additional studies that would be undertaken to determine the extent of the potential impacts where information is currently limited.

4.4.5.1 Hydrocarbon spills

Unplanned hydrocarbon spills have the potential to occur during the construction and/or operation of the Proposal. Some potential scenarios are presented in Table 4-8.

Table 4-8Potential unplanned hydrocarbon spill scenarios

Proposal phase	Scenario	Likelihood
Construction	Hydrocarbon spill at the shore crossing (plant refueling/loss of containment from storage)	Highly unlikely
	Vessel related hydrocarbon spill event (refueling/collision/grounding/deck spills)	Highly unlikely
Operation	Gas leak/rupture from the trunkline	Remote
	Vessel related hydrocarbon spill event (refueling/collision/grounding/deck spills)	Highly unlikely

Of the unplanned events, reduced water quality due to a hydrocarbon spill from the operation of the trunkline is considered a remote possibility of occurring for the following reasons:

- The trunkline will be designed in accordance with strict adherence to relevant standards to avoid potential defects.
- The trunkline will undergo pre-commissioning testing to ensure its integrity is verified prior to commissioning.
- The trunkline will be buried and/or protected from potential physical damage.

Reduced water quality due to a vessel collision is considered highly unlikely. Registered vessels or foreign flag vessels in Australian waters are required to report events to the Australian Transport Safety Bureau (ATSB), AMSA or Australian Search and Rescue (AusSAR).

From a review of the ATSB marine safety and investigation reports, one vessel collision occurred in 2011–2012 that resulted in a spill of 25–30 L of oil into the marine environment as a result of a

collision between a tug and support vessel off Barrow Island. Two other vessel collisions occurred in 2010, one in the port of Dampier, where a support vessel collided with a barge being towed. Minor damage was reported and no significant injury to personnel or pollution occurred. The second 2010 collision involved a vessel under pilot control in a port colliding with a vessel alongside a wharf, causing it to sink. No reported pollution resulted from the sunken vessel. These incidents demonstrate the likelihood of only minor volumes of hydrocarbons being released during the event of a vessel collision.

From 2010 to 2011, the ATSB's annual publication defines the individual safety action factors identified in marine accidents and incidents: 42% related to navigation action (2011). Of those, 15% related to poor communication and 42% related to poor monitoring, checking and documentation. Most of these related to the grounding instances. For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmental receptor, several factors must align:

- The identified causes of vessel interaction must result in a collision.
- The collision must have enough force to penetrate the vessel hull.
- The collision must be in the exact location of the fuel tank.
- The fuel tank must be full, or at least have a volume 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.

Refuelling incidents and/or deck spills on deck or on shore are also highly unlikely and would involve minor volumes with appropriate containment measures being implemented and appropriate refuelling protocols.

Woodsides oil spill preparedness process would be followed to further define the Worst Case Credible Spill Scenarios during FEED. This will include an assessment of vessel fuel type, volumes and risk. Oil spill trajectory modelling will be undertaken for the prediction of oil fate and relevant potential environmental impacts for a number of scenarios (including the worst-case scenario). This will allow the development of a project specific Oil Spill Contingency Plan (OSCP).

Table 4-9: Preliminary EIA for marine environmental quality

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Potential impacts during construction						
Water quality (High)	Planned – Indirect impacts from dredging and spoil disposal activities	Trunkline dredging and spoil disposal activities have the potential to cause the following impacts to marine water quality: alteration to the existing hydrodynamic regime temporary increases in suspended sediments and turbidity levels from dredging and disposal operations which can: – adversely affect marine biota by reducing light penetration through the water column, thereby temporarily reducing productivity and growth rates – cause clogging and damage to the feeding and breathing apparatus of filter feeding organisms (Parr et al., 1998) – cause localised and temporary reduction in oxygen levels due to the release of potentially organic rich sediments into the water column – increase organic matter and nutrient availability to marine organisms subsequently resulting in eutrophic waters with knock-on effects for the productivity of marine ecosystems – cause toxicological effects to marine organisms associated with the potential re-suspension of previously contaminated sediments as part of either the dredging or disposal operation. The impacts of altered water quality on benthic communities and habitats is covered in Section 4.3.5 and marine fauna in Section 4.4.5. Impacts to marine water quality in the Dampier Archipelago that are attributable to the dredging of the trunkline and subsequent spoil disposal would likely be spatially discrete and acute, and similar in nature and scale to the impacts described for the Pluto LNG Facility in Section 4.3.5.1. Furthermore, when considering the mitigation measures recommended in Section 4.4.6 the significance is considered minor.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-6).
	Planned – Project vessel discharges	Routine discharges from construction vessels (sewage and greywater, food waste, deck drainage and bilge) have the potential to alter water quality through eutrophication, increased particulate concentration and introducing toxicants. Subsequently the change to water quality can impact the benthic communities and habitats and also marine fauna of the Archipelago, though this would largely depend on the proximity and susceptibility of the receptor to the discharge event. Any discharge events would likely be small and management measures have been recommended to avoid/minimise impacts to water quality (Section 4.4.6). Therefore, there is not likely to be any lasting effect on water quality and any potential impacts would be slight.	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP) (Table 4-10).
	Unplanned – impacts from oil spill	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. Potential impacts would likely be moderate given the likelihood, recommended management and relatively small spill volume.	Highly unlikely	Moderate	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
Sediment quality (High)	Planned – Indirect impacts from dredging and spoil disposal activities	Sedimentation resulting from trunkline dredging and spoil disposal is likely to change the particle size distribution of receiving sediments, with larger particles tending to settle out closer to the suspension source, with finer particles likely to stay suspended for longer and drift further away prior to settling. The variation in particle size distribution throughout the trunkline footprint is large, especially in close proximity to shore, where pockets of both very fine and very coarse sand are found together. The impact by settling particles will therefore vary depending on the receiving sediments. Alteration of seabed characteristics is considered to be of minor significance.	N/A	Slight	Minor	Impact addressed within relevant management plans (DSDMP)and supported by additional studies to be undertaken (dredge plume modelling; SAP) (Table 4-6).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
		During dredging and spoil disposal, common contaminants re-suspended by dredging in ports and harbours include hydrocarbons, heavy metals and anti-foulants, including TBT. These contaminants have the potential to impact various sensitive receptors in various ways and can alter community structure and ecosystem stability. Previous investigations of sediments within the proposed trunkline have been shown to contain concentrations of contaminants below guideline screening levels. This will be confirmed prior to dredging taking place through additional studies. Potential impacts of toxic sediment disturbance are therefore considered moderate.	N/A	Minor	Moderate	
	Unplanned – impacts from oil spill	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine sediment quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. The more susceptible sediments would be those that exist in the intertidal areas of the Archipelago, since this is the most credible end point for any hydrocarbons entrained in surface waters. The intertidal sandy beaches and mudflats of Dampier Archipelago support mangroves, seabirds and sea turtles, which would be at the highest risk of impact (impacts assessed for each in BCH Section 4.3 and Marine Fauna Section 4.5). The risk of a spill occurring is considered highly unlikely and accounting for the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would be limit the overall extent of the area impacted and limit the exposure to sensitive receptors. Potential impacts would likely be moderate given the likelihood, recommended management and relatively small spill volume.	Highly unlikely	Moderate	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
Potential impacts during operation						
Water quality (High) Sediment quality (High)	Unplanned – Hydrocarbon leak from the trunkline	The trunkline would be protected by being buried within a trench below sediment and/or rock which would prevent physical damage from accidental collisions with external elements (e.g. anchors). A hydrocarbon leak from the trunkline would be a remote event taking into consideration the management measures recommended in Section 4.4.5. Given the trunkline will be contain gas the impact to water quality and sediment quality is expected to be low.	Remote	Slight	Low	Impact addressed within management plans and supported by additional studies to be undertaken (hydrocarbon spill modelling; SAP) (Table 4-6)

4.4.6 Mitigation

Table 4-10 provides a summary of mitigation measures that would be implemented to avoid and/or mitigate potential impacts from the Proposal.

4.4.7 Assumptions and predicted outcome

Impacts would be further addressed within management documentation, through the additional studies described in Section 4.4.3 and through consultation with relevant stakeholders as described in Section 3. However, based on the preliminary impact assessment using available information, the Proposal would meet the EQOs set out by the EQMF and is not likely to compromise the environmental values of the Dampier Archipelago, so would therefore meet the EPA objectives:

- Long term impacts as a result of the physical presence of a trunkline within Mermaid Sound are likely to be minor. The proposed trunkline has been positioned parallel and close to an existing trunkline and the shore crossing site has been located at the Pluto LNG Facility in a previously disturbed area.
- Construction impacts would generally be minor and temporary and mostly related to the presence of construction vessels within Mermaid Sound and/or temporary impacts to water quality from dredging activities during the construction period. These would possibly have a minor impact on some sensitive benthic communities and would likely result in modification to the sediment regime in the direct vicinity of the trunkline in relation to sediment particle size and distribution, which would be negligible in a regional context.
- Proposed mitigation measures (Section 4.4.6) have been recommended to avoid and/or minimise expected impacts and there is unlikely to be significant residual impacts.

Table 4-10: Marine environmental quality – Mitigation measures

Aspect	Impact	Mitigation
All	Indirect impacts from dredging and spoil disposal activities	• Approved Permit for Disposal of Dredged Material at Sea (Sea Dumping Permit) through appropriate regulatory authorities and integration of supporting studies data to other management documentation. • A detailed Dredging and Spoil Disposal Management Plan (DSDMP) would be developed outlining specific mitigation and monitoring measures. This will be submitted to the relevant regulatory agencies for approval prior to dredging commencing.
	Unplanned hydrocarbon release	• An oil spill contingency plan will be prepared and implemented in the event of an oil spill. The plan must include as a minimum an assessment of the oil spill risk, ensure the effective and timely management of hydrocarbon spills, describe the procedure for management of hydrocarbon spills and provide for prompt notification of regulatory agencies in the event of a spill. • Liaison and agreement with the Pilbara Ports Authority for the integration/application of their OSCP.
	Project vessel discharges	• Waste on vessels and on shore must be securely stored through the provision of appropriate waste receptacles and suitable containment measures such as lids or netting to minimise the likelihood of any loss of wastes to the marine environment. • Generated inorganic non-hazardous solid waste will be transported onshore to a appropriate waste disposal site in accordance with MARPOL 73/78 Annex V: Garbage (as implemented in Commonwealth waters by the Protection of the Sea (Prevention of Pollution from Ships) Act 1983) and Marine Orders – Part 95: Marine Pollution Prevention – Garbage. • No routine discharge of inorganic non-hazardous solid waste will take place at sea in accordance with Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 – Parts IIIA and IIIC.

4.5 Marine fauna

4.5.1 EPA objective

The EPA objective in relation to key environmental factor 'Marine Fauna' is 'To protect marine fauna so that biological diversity and ecological integrity are maintained'.

4.5.2 Policy and guidance

The following EPA guidance has been considered in evaluating potential impacts on this factor:

- EPA (2016g). Environmental Factor Guideline: Marine Fauna, EPA, Western Australia.

4.5.3 Studies and information sources

Table 4-11 lists the relevant databases, studies and publications for Marine Fauna. These have helped inform the description of the existing environment and assessment of impacts for the Proposal. Furthermore, additional studies have been commissioned and will be available for inclusion in any formal environmental impact assessments to be submitted in relation to the Proposal.

Table 4-11: Relevant studies undertaken that support the Proposal

Author	Study (Date)
Existing studies/surveys/databases used	
MScience	Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program (2009)
	Pluto LNG Development: Final Report on Coral and Water Monitoring (2010)
Woodside Energy Limited	Pluto LNG Development: Draft Public Environment Report/Public Environment Review (2006), and associated studies
	Pluto Baseline Water Quality Report (2007)
SKM	Pluto LNG Development: Dredging and Spoil Disposal Management Plan/Dredge Impact Management Plan (2009)
DoEE	EPBC Act Protected Matters Search Tool of the trunkline corridor including a 10 km buffer (October 2018)
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions NatureMap tool for the section of trunkline corridor (with a 10 km buffer) within State waters (October 2018)
CALM	Dampier Archipelago Nature Reserves Management Plan (1990-2000)
Woodside	Pluto LNG Project Sea Turtle Management Plan – Operations and maintenance (2018)
Woodside	Pluto LNG Development Summary Sea Turtle Monitoring Report (2007-2017) (2017)
Pendoley Environmental	Artificial light at night (ALAN) Facility Audit – October 2017 (2017)
Commonwealth of Australia	Recovery Plan for Marine Turtles in Australia (2017)
Planned studies/surveys	
Advisian	Trunkline dredging plume modelling study (2018)
	Noise modelling study (2018)

4.5.4 Receiving environment

4.5.4.1 Protected species

The Dampier Archipelago is an important area for protected species listed under the EPBC Act and/or the WA Wildlife Conservation Act (WC Act). Protected species that may occur within the vicinity of the development envelope have been identified through the following searches:

- EPBC Act Protected Matters Search Tool for the development envelope (with a 10 km buffer)
- Western Australian Department of Biodiversity, Conservation and Attractions NatureMap tool for the development envelope (with a 20 km buffer) within State waters.

The searches identified protected species of bird, mammal, fish and reptiles that may be present within the vicinity of the Proposal; and these are summarised in the following sections. The database search results included some terrestrial species. These have not been considered in the assessment as they are unlikely to be impacted by the proposal activities. (The proposed activities are marine based and the shore crossing is within an industrial zone in a highly disturbed zone.) Database search reports have been included as Appendix A. Table 4-12 summarises the protected, threatened and/or migratory species under both the EPBC Act and WC Act likely to be present within the development envelope or potential zone of influence. The likelihood of their presence was based on an assessment of their ecology and habitat requirements and is assessed in Appendix B. Of the listed species all but six of the species listed under the WC Act are also listed under the EPBC Act.

Table 4-12: Listed threatened and migratory species likely to be present within the development envelope and/or potential zone of influence. Species highlighted in green have BIAs that intersect the development envelope.

Species	Status EPBC Act	Status WC Act
Birds		
Actitis hypoleucos Common Sandpiper	Migratory	
Anous stolidus Common Noddy	Migratory	
Ardenna pacifica Wedge-tailed Shearwater	Migratory	
Arenaria interpres Ruddy Turnstone	Migratory	
Calidris acuminate Sharp-tailed Sandpiper	Migratory	
Calidris alba Sanderling	Migratory	
Calidris canutus Red Knot	Endangered, Migratory	Vulnerable
Calidris ferruginea Curlew Sandpiper	Critically Endangered, Migratory	Vulnerable
Calidris melanotos Pectoral Sandpiper	Migratory	
Calidris ruficollis Red-necked Stint	Migratory	
Calidris subminuta Long-toed Stint	Migratory	
Calidris tenuirostris Great Knot	Critically Endangered, Migratory	Vulnerable
Calonectris leucomelas Streaked Shearwater	Migratory	
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover	Vulnerable, Migratory	Vulnerable
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	Endangered, Migratory	Endangered
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory	
Fregata ariel Lesser Frigatebird, Least Frigatebird	Migratory	
Falco peregrinus Peregrine Falcon		Other Protected Fauna
Gelochelidon nilotica Gull billed Tern		Protected under international agreement
Glareola maldivarum Oriental Pratincole	Migratory	
Hydroprogne caspia Caspian Tern	Migratory	
Limicola falcinellus Broad-billed Sandpiper	Migratory	
Limosa lapponica Bar-tailed Godwit	Migratory	Vulnerable

Species	Status EPBC Act	Status WC Act
Limosa lapponica baueri Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	Vulnerable	Vulnerable
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit	Critically Endangered	Vulnerable
Limosa limosa Black-tailed Godwit	Migratory	
Macronectes giganteus Southern Giant-Petrel	Endangered	
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew	Critically Endangered, Migratory	Vulnerable
Numenius phaeopus Whimbrel	Migratory	
Oceanites oceanicus Wilson's Storm Petrel		Protected under international agreement
Onychoprion anaethetus Bridled Tern	Migratory	
Puffinus pacificus Wedge-tailed Shearwater		Protected under international agreement
Pandion haliaetus Osprey	Migratory	
Phalaropus lobatus Red-necked Phalarope	Migratory	
Pluvialis fulva Pacific Golden Plover	Migratory	
Pluvialis squatarola Grey Plover	Migratory	
Sterna dougallii Roseate Tern	Migratory	
Sternula nereis nereis Australian Fairy Tern	Vulnerable	Vulnerable
Sula leucogaster Brown Booby		Protected under international agreement
Thalasseus bergii Crested Tern	Migratory	
Tringa brevipes Grey-tailed Tattler	Migratory	
Tringa nebularia Common Greenshank, Greenshank	Migratory	
Tringa stagnatilis Marsh Sandpiper, Little Greenshank	Migratory	
Tringa totanus Common Redshank, Redshank	Migratory	
Xenus cinereus Terek Sandpiper	Migratory	
Mammals		
Dugong dugon Dugong	Migratory	Other Protected Fauna
Megaptera novaeangliae Humpback Whale	Vulnerable, Migratory	Conservation Dependent

Species	Status EPBC Act	Status WC Act
Sousa chinensis Indo-Pacific Humpback Dolphin	Migratory	
Stenella longirostris Spinner Dolphin		P4
Tursiops aduncus Spotted Bottlenose Dolphin	Migratory	
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake	Critically Endangered	Critically Endangered
Caretta caretta Loggerhead Turtle	Endangered, Migratory	Endangered
Chelonia mydas Green Turtle	Vulnerable, Migratory	Vulnerable
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered, Migratory	Vulnerable
Eretmochelys imbricata Hawksbill Turtle	Vulnerable, Migratory	Vulnerable
Natator depressus Flatback Turtle	Vulnerable, Migratory	Vulnerable
Fish		
Anoxypristis cuspidate Narrow Sawfish, Knifetooth Sawfish	Migratory	
Carcharias Taurus Grey Nurse Shark	Vulnerable	Vulnerable
Carcharodon carcharias White Shark, Great White Shark	Vulnerable, Migratory	Vulnerable
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	Migratory	
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	Migratory	
Pristis clavata Dwarf Sawfish, Queensland Sawfish	Vulnerable, Migratory	
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable, Migratory	Vulnerable

4.5.4.2 Biologically important areas

Biologically important areas (BIAs) are areas that are particularly important for the conservation of protected species and where aggregations of individuals display biologically important behaviour such as breeding, foraging, resting or migration. The presence of the observed behaviour is assumed to indicate that the habitat required for the behaviour is also present. BIAs have been identified for the following EPBC Act listed species with a potential to occur within the Dampier Archipelago, using expert scientific knowledge about species' distribution, abundance and behaviour in the region:

- wedge-tailed shearwater, roseate tern and Australian fairy tern
- humpback whales
- loggerhead, green, hawksbill and flatback turtles.

Further details about the BIAs are included in the following sections.

4.5.4.3 Seabirds and migratory shorebirds

A large number of seabird and shorebird species (or species habitat) may occur within the vicinity of the Proposal; this includes species classified as threatened and migratory under the EPBC Act or specially protected under the WA Wildlife Conservation Act (Table 4-12). Most species identified are also migratory, so their presence would only be expected during part of the year.

The following summary focuses on the subset of species that have been identified as having ecologically significant interactions (e.g. breeding BIA) in the North West Marine Region.

Wedge-tailed shearwater

The wedge-tailed shearwater is a marine migratory bird that is common off the Western Australian coast from August to April (DEWHA, 2012a). Known breeding locations in the North-west Marine Region include Dampier Archipelago where the trunkline would traverse; a BIA for breeding extends through this shelf region (Figure 4-6). The species will also forage relatively close to their breeding islands, and diet consists of squid, fish and crustaceans (DEWHA, 2012a).

Roseate tern

The roseate tern is a marine migratory bird that is common in waters off northern Australia. Northern populations of the roseate tern breed on offshore islands, cays and banks; a number of small BIAs for breeding have been identified within the North-west Marine Region (Figure 4-6). Breeding populations are known to occur within the Dampier Archipelago (DEWHA, 2012a). Throughout the year the species often rests and forages in sheltered estuaries, creeks, inshore waters. Roseate terns will predominantly eat small pelagic fish; although are also known to consume insects and marine invertebrates such as crustaceans (DEWHA, 2012a).

Australian fairy tern

The Australian fairy tern is listed as vulnerable under the EPBC Act, and occurs mainly on sandy beaches within sheltered coasts. Dampier Archipelago is the northern extent of known habitat for the species (DEWHA, 2012a). A number of small BIAs for breeding have been identified within the North-west Marine Region (Figure 4-6); known breeding areas include Shark Bay and the Dampier Archipelago. Breeding period is typically August to February. Fairy terns will feed predominantly on fish, foraged in inshore waters around island archipelagos and on the Australian mainland (DEWHA, 2012a).

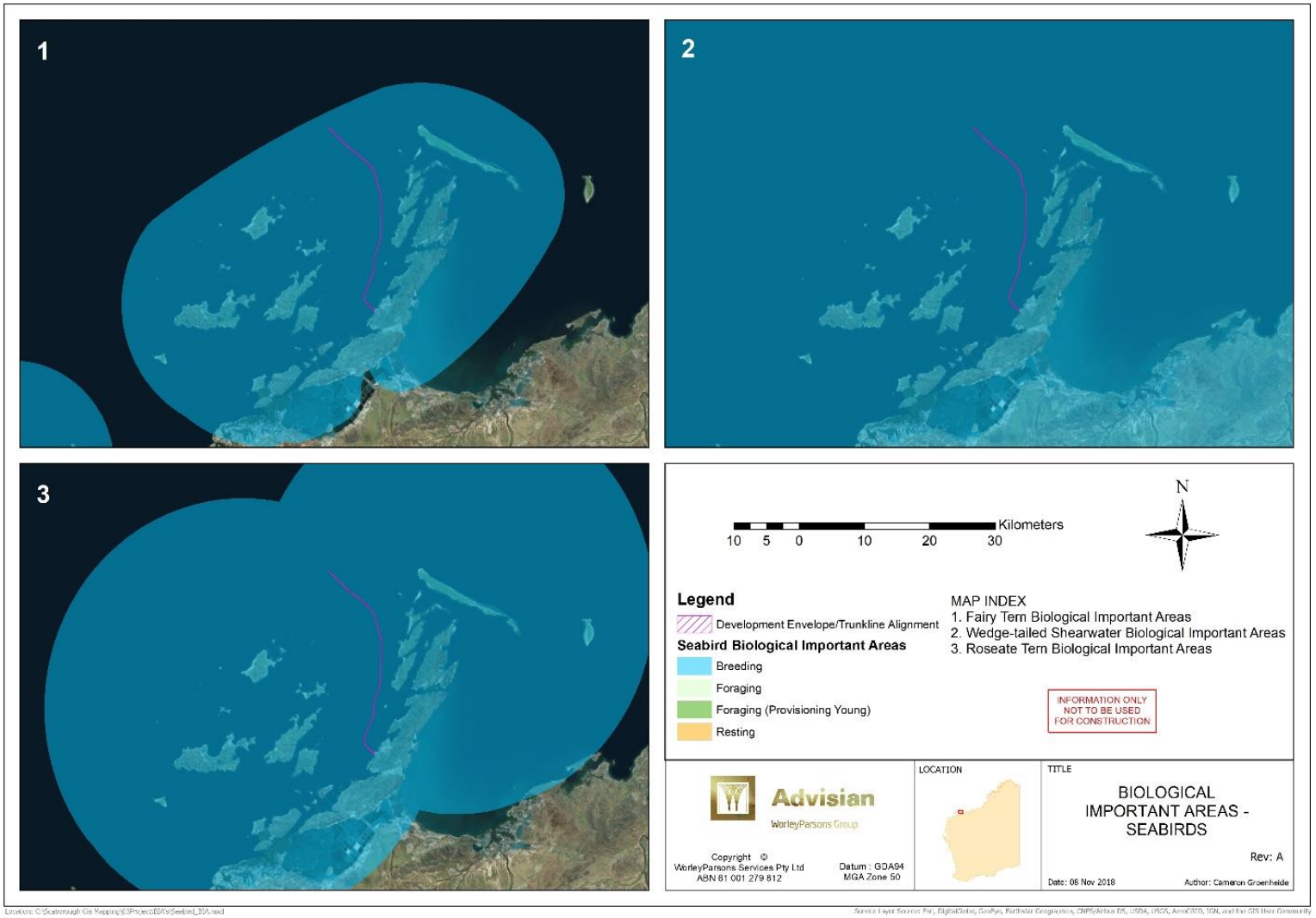


Figure 4-6: Biologically important areas for the wedge-tailed shearwater, roseate tern and Australian fairy tern

4.5.4.4 Marine mammals

Cetaceans (whales and dolphins) and dugongs may occur within the vicinity of the Proposal; including species classified as threatened and migratory under the EPBC Act or specially protected under the *WA Wildlife Conservation Act* (Table 4-12).

Cetaceans within the region include those that are predominantly found in shallow coastal waters (e.g. Indo-Pacific humpback dolphin). Furthermore, the North-west Marine Region is thought to be an important migratory pathway between feeding grounds in the Southern Ocean and breeding grounds in tropical waters for several cetacean species (DEWHA, 2012b).

The following summary focuses on the subset of species that have been identified as having ecologically significant interactions (e.g. migration BIA) in the area or that are considered 'iconic' (e.g. dolphins and dugongs):

Dugong

Dugongs (*Dugong dugon*) are associated with tropical and sub-tropical coastal waters, particularly shallow, protected waters such as sheltered bays, mangrove channels and in the lee of large inshore islands (UNEP, 2002). Dugongs are herbivores that feed on seagrass. The dugong's reproductive cycle is sensitive to food availability; with breeding delayed if sufficient food is not available (UNEP, 2002).

The distribution of dugong in the Pilbara region is widespread, including Barrow Island and the Montebello Islands, the Dampier Archipelago and the mainland coastal waters. They have been recorded near various islands including Rosemary Island, East Lewis Island, West Lewis Island, Keast Island, Legendre Island and Little Rocky Island (CALM, 2005; URS, 2000). Dugongs have also been sighted in shallow, sheltered bays of the Burrup Peninsula and mainland such as Regnard Bay and Nickol Bay (CALM, 2005).

Humpback whale

Humpback whales are listed as vulnerable and migratory under the EPBC Act, and specially protected under the WA Wildlife Conservation Act (Table 4-12). The Western Australian population of humpback whales is genetically distinct from the eastern Australian population.

Breeding and calving grounds occur between Broome and the northern end of Camden Sound, with breeding typically occurring between August and September (DEWHA, 2012b). Feeding occurs primarily during summer in Antarctic waters, with krill forming the major part of the diet (DEWHA, 2012b). A BIA for migration has been identified on the inner shelf, including within the vicinity of the proposed trunkline (Figure 4-7). Although the north and south-bound migratory routes for most whales are further offshore than the Dampier Archipelago waters (up to 70 nm from the coast), during the south-bound migration it is likely that most individuals, particularly cow/calf pairs, stay closer to the coast, than the northern migratory path (Double et al., 2010). During the south-bound migration, it is likely some whales may travel through Dampier Archipelago waters, either passing the open outer waters, or travelling into the Mermaid Sound proper and continuing westwards, likely through the channel bounded by West Lewis Island and Enderby Island to the south and Rosemary Island to the north (with reference to Jenner et al., 2001). The peak of the northward migration in Dampier Archipelago waters is during July, while the southern migration peaks in late August/early September.

Indo-Pacific humpback dolphin

In Australia, humpback dolphins are thought to be widely distributed along the northern Australian coastline from about the Queensland–New South Wales border to western Shark Bay, Western Australia (Parra & Cagnazzi, 2016). While coastal waters are arguably the primary habitat of Australian humpback dolphins, most survey work has been conducted close to the coast; thus, the extent to which humpback dolphins use offshore waters is not yet fully understood. No studies on habitat use have been conducted in Western Australia. Preliminary surveys and ongoing studies in

a few locations indicate that Australian humpback dolphins appear to use a wide range of near-shore habitats. For example, around the North West Cape, dolphins have been sighted in clear waters over Ningaloo Reef, and in turbid waters in Exmouth Gulf and in depths ranging from 1 to 40 m deep (T. Hunt, personal communication, 19 February 2015, cited in Parra & Cagnazzi, 2016).

Bottlenose dolphin

Bottlenose dolphins are distributed continuously around the Australian mainland. Indian Ocean Bottlenose Dolphins have been confirmed to occur in estuarine and coastal waters of eastern, western and northern Australia (Hale et al., 2000; Möller & Beheregaray, 2001; Ross & Cockcroft, 1990). In Australia, the Indian Ocean Bottlenose Dolphin is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters including coastal areas around oceanic islands (Hale et al., 2000; Kogi et al., 2004; Möller & Beheregaray, 2001; Wang et al., 1999).

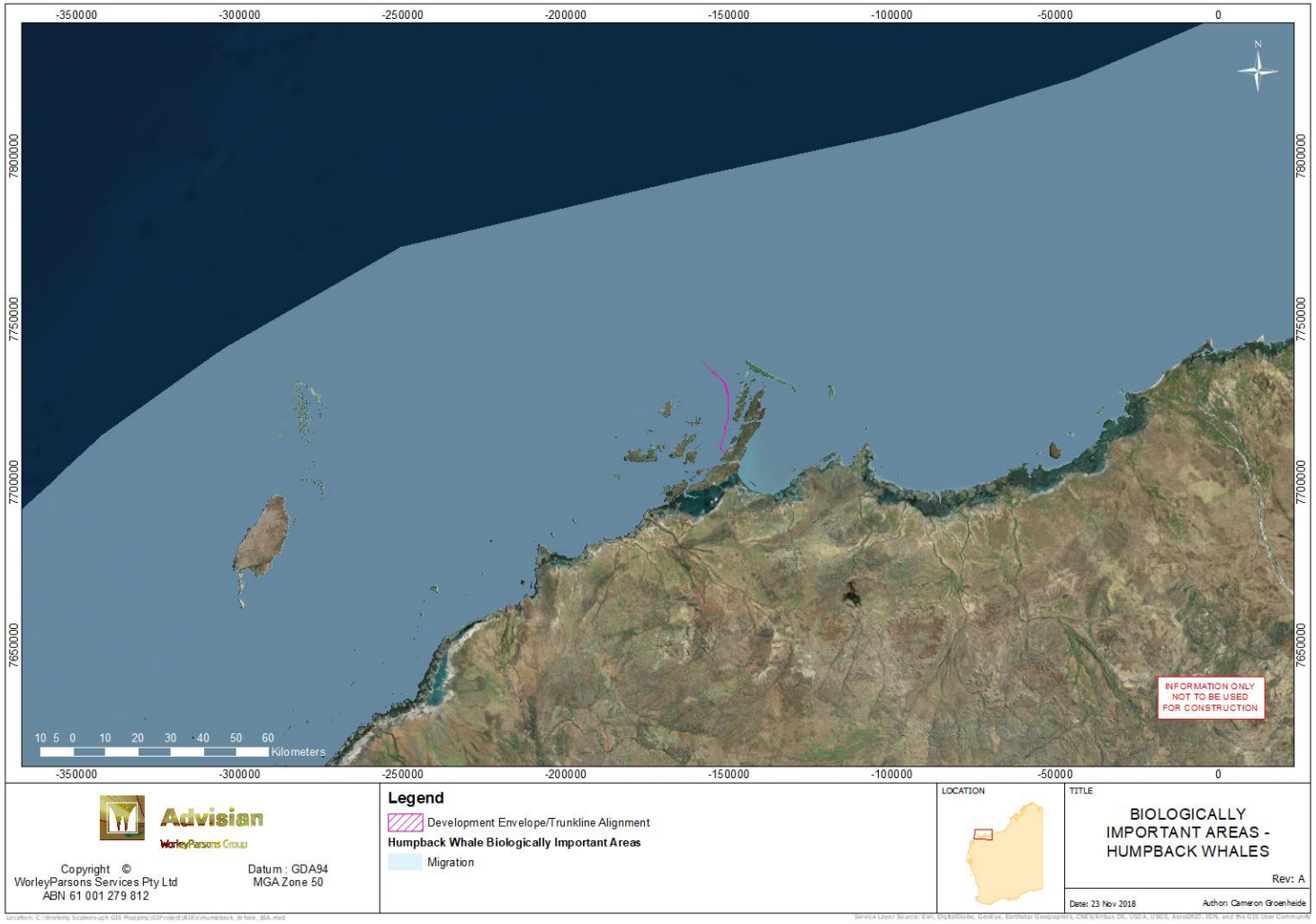


Figure 4-7: Biologically important areas for humpback whales

4.5.4.5 Fish

There are more than 650 species of fish that occur within the waters of the Dampier Archipelago; this includes species classified as threatened and migratory under the EPBC Act (Table 4-12).

The following summary focuses on the subset of species that may be considered 'iconic' (e.g. sawfishes, sharks and rays).

Sawfishes

Sawfishes generally inhabit inshore coastal, estuarine and riverine environments. Important areas for sawfishes adjacent to the North-west Marine Region include the Pilbara coast, King Sound, and lower reaches of the Fitzroy, May and Robinson rivers for the dwarf sawfish; and Cape Keraudren for the green sawfish (DEWHA, 2012d).

Grey nurse shark

The Grey Nurse Shark (west coast population) has a broad inshore distribution, primarily in sub-tropical to cool temperate waters (Last & Stevens, 1994). The population of Grey Nurse Shark (west coast population) is predominantly found in the south-west coastal waters of Western Australia (Environment Australia 2002a) and has been recorded as far north as the North West Shelf (Stevens, 1999; Pogonoski et al., 2002). Grey Nurse Sharks are often observed hovering motionless just above the seabed, in or near deep sandy-bottomed gutters or rocky caves, and in the vicinity of inshore rocky reefs and islands (Pollard et al., 1996). It is therefore unlikely to be present near the development envelope but may occur around the Dampier Archipelago islands.

Great white shark

In Australia, Great White Sharks have been recorded from central Queensland around the south coast to north-west Western Australia, but may occur further north on both coasts (Bonfil et al., 2005; Bruce et al., 2006; Last & Stevens, 2009; Paterson, 1990). It has been sighted in all coastal areas except in the Northern Territory. Within Australian waters, the majority of recorded great white shark movements occur between the coast and the 100 metre depth contour. Great White Sharks can be found from close inshore around rocky reefs, surf beaches and shallow coastal bays to outer continental shelf and slope areas (Pogonoski et al., 2002 in DEWHA, 2009). Great White Sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA, 2009). White sharks were identified as potentially occurring within the development envelope, but given the migratory nature of the species, its low abundance, broad distribution in temperate waters across southern Australia and absence of preferred prey (pinnipeds), white sharks are unlikely to occur in large numbers.

Manta rays

The reef manta ray is commonly sighted inshore, but also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al., 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest this species is more resident in tropical waters and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations (Deakos et al., 2011; Marshall et al., 2009).

The Giant Manta Ray is broadly distributed in tropical waters of Australia. The species primarily inhabits nearshore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al., 2011).

4.5.4.6 Marine reptiles

Seasnakes and turtle species may occur within the vicinity of the Proposal. This includes species classified as threatened and migratory under the EPBC Act (Table 4-12).

The following summary focuses on the subset of species that have been identified as having ecologically significant interactions (e.g. foraging, nesting, internesting BIAs) in the area.

Loggerhead turtle

Loggerhead turtles are listed as endangered and migratory under the EPBC Act, and the western breeding stock is the larger of the two stocks in Australia. Loggerhead turtles occur throughout the North-west Marine Region and forage across a wide range of habitats including rocky and coral reefs, seagrass pastures and estuaries (DEWHA, 2012e). In the North-west Marine Region, loggerhead turtles breed principally from Dirk Hartog Island in the south, along the Gnaraloo and Ningaloo coast to North West Cape and the Muiron Islands region in the north; with occasional records from Varanus and Rosemary islands and Ashmore Reef. BIAs have been identified for loggerhead turtles intersecting the development envelope (Figure 4-8).

Green turtle

Green turtles are listed as vulnerable and migratory under the EPBC Act, and are the most common marine turtle breeding in the North-west Marine Region (DEWHA, 2012e). Three distinct breeding stocks of green turtles occur in the region: the North West Shelf stock, the Scott Reef stock and the Ashmore stock. Principal near-coastal rookeries include the Lacepede Islands, some islands of the Dampier Archipelago, Barrow Island, the Montebello Islands, and North West Cape and the Muiron Islands (DEWHA, 2012e). The nesting period for the North West Shelf stock is expected to begin in November, peak in January–February, and end in April (DEWHA, 2012e). Green turtles forage for seagrass and algae in estuarine, rocky and coral reef and seagrass habitats. BIAs for the green turtles have been identified intersecting the development envelope (Figure 4-8).

Leatherback turtle

Leatherback turtles are listed as endangered and migratory under the EPBC Act, and have the broadest distribution worldwide but are uncommon within their Australian range (DEWHA, 2012e). Leatherback turtles are rarely recorded breeding within Australia, however are known to regularly forage within continental shelf waters. The leatherback turtle is an oceanic, pelagic species that feeds primarily on jellyfish, sea squirts and other soft-bodied invertebrates (DEWHA, 2012e). They do not have BIAs intersecting the development envelope.

Hawksbill turtle

Hawksbill turtles are listed as vulnerable and migratory under the EPBC Act, and are generally associated with rocky and coral reef habitats, foraging on algae, sponges and soft coral (DEWHA, 2012e). There is a single breeding stock in the region: the Western Australian stock, which is centred on the Dampier Archipelago. The most significant breeding areas include Rosemary Island in the Dampier Archipelago, Varanus Island in the Lowendal group, and some islands in the Montebello group (DEWHA, 2012e). Hawksbill turtles nest in the region all year round with a peak between October and January. BIAs for the hawksbill turtles have been identified intersecting the development envelope (Figure 4-8).

Flatback turtle

Flatback turtles are listed as vulnerable and migratory under the EPBC Act, and are endemic to the northern Australia/southern New Guinea continental shelf. There are two breeding stocks within the North-west Marine Region, one of which (the North West Shelf stock) has significant rookeries on Thevenard Island, Barrow Island, the Montebello Islands, Varanus Island, the Lowendal Islands, islands of the Dampier Archipelago, and coastal areas around Port Hedland or along the Kimberly coast where suitable beaches occur (DEWHA, 2012e). Nesting begins in late November–December, peaks in January, and finishes by February–March. Flatback turtles differ from other marine turtles in that they do not have a pelagic phase to their lifecycle; instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches. BIAs for the flatback turtles have been identified intersecting the development envelope (Figure 4-8).

Turtle nesting beach – Holden Beach

The nearest turtle nesting beach to the Proposal is Holden Beach to the south west of the shore crossing location. This nesting beach is currently impacted by existing external light sources from the industrial zone. Systematic turtle monitoring has been undertaken on Holden Beach adjacent to Site A of the Pluto LNG Plant throughout the construction and operational phases between 2007 and 2017, the key findings from the monitoring are as follows Pendoley (2017):

- Holden Beach is a north-west facing beach, approximately 590 m in length, situated immediately south of the existing Pluto LNG jetty, on the western coast of the Burrup Peninsula. The beach is split into two beaches by a rocky outcrop, which extends into the intertidal zone. Surveys conducted in 2005/2006 and 2006/2007 seasons by Pendoley Environmental (Pendoley 2005b and 2006) suggested body pits observed on Holden Beach were characteristic of flatback and green turtles.
- A number of existing and external sources of light are located within close proximity to Holden Beach including lighting from the Pluto LNG Project jetty, Pluto LNG Site A infrastructure and other nearby facilities.
- A total of 63 turtle tracks have been identified on Holden Beach since monitoring began, creating 73 body pits which resulted in 35 successful nests. Turtle track activity on Holden Beach peaked between November and January during the 2007-2017 seasons.
- A total of 822 hatching tracks were observed between 2007 and 2017 seasons. Incubation time is not presented due to varying frequency of monitoring surveys. Hatchling emergence on Holden Beach peaked between December and February during the 2007-2017 seasons.
- The results indicate that Holden Beach is not a major sea turtle rookery, supporting Pendoley 2010 which proposed that key sea turtle nesting locations are located towards the outer Dampier Archipelago on Rosemary and Legendre Islands.

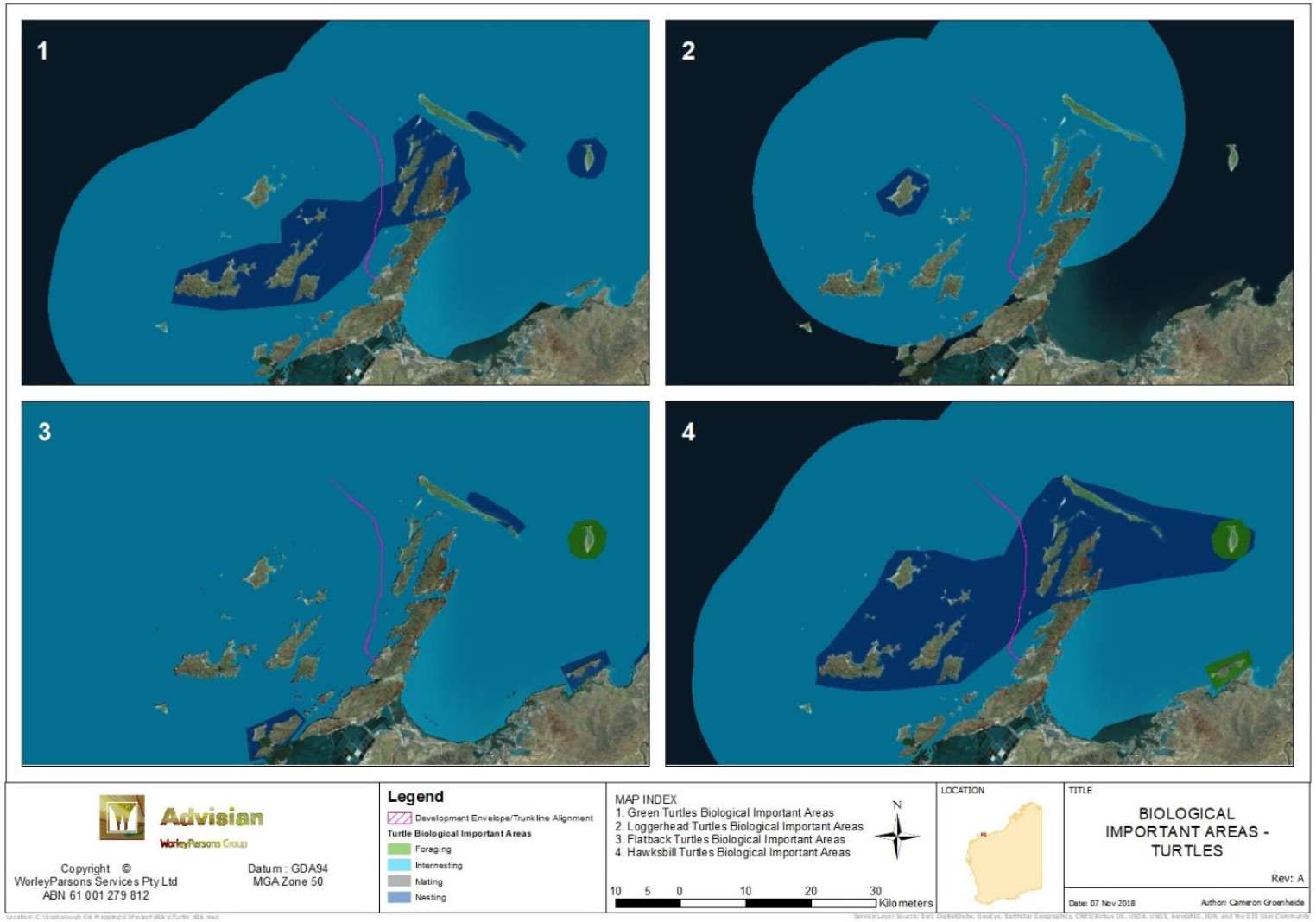


Figure 4-8: Biologically important areas for marine turtles

4.5.4.7 Planktonic communities

In the North West Marine Bioregion, productivity is typically greater during the wet season when the weakening of surface currents allows for increased upwelling (DEWHA, 2008a; Brewer et al., 2007). Areas of enhanced production are also observed at the interface between stable waters warmed by solar heating and unstable waters mixed by tidal turbulence, which is more prevalent in nearshore environment where depths are greater than 40 m (Heyward et al., 2000). Productivity is greater in shallow nearshore environments within State waters than in the offshore waters. During the warmer months, extensive blooms of *Trichodesmium* occur on a regional scale, including within the Dampier Archipelago. It's role in the trophic system and the nutrient cycle is not well understood though it may contribute significantly to the nitrogen budget. There have been no known deleterious water quality impacts caused by toxic algal blooms in the region (Heyward et al., 2000).

A study by Jones (2001) determined that a total of 22 zooplankton species and 45 other planktonic taxa, including, crustaceans, molluscs, polychaete worms, arrow worms, sea squirts and coelenterates have been introduced into Dampier Archipelago via vessel ballast water.

4.5.5 Potential impacts

A detailed impact assessment on species listed under the EPBC Act has been undertaken in Section 5 in accordance with the EPBC significance impact guidelines. The assessment concluded that no species listed as threatened under the EPBC Act would be significantly impacted by the Proposal, taking into account the management measures listed in Section 5.4.1. The majority of the WC Act listed species in Table 4-12 are also listed under the EPBC Act. Therefore, the conclusions of the EPBC assessments of significance would also apply to these. For the six species listed under the WC Act and not the EPBC Act (Peregrine Falcon, Gull-billed Tern, Wilson's Storm Petrel, Wedge-tailed Shearwater, Brown Booby), the conclusions of the assessment on similar avian species and the proposed management measures would apply. The management measures would avoid and/or minimise impacts to all species of the relevant groups of marine fauna, not just threatened or other listed species.

Table 4-13 summarises aspects of the Proposal that would result in a potential impact on marine fauna.

Table 4-13: Preliminary EIA for marine fauna

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Potential impacts during construction						
Seabirds and migratory shorebirds (High)	Planned – Noise and Light emissions	Generally, the proposal area is a highly disturbed habitat due to surrounding industrial developments resulting in noise and light emissions and physical disturbances. Piling activities would be the highest noise source and would be undertaken close to the shore crossing location in an industrial zone unlikely to offer important foraging and/or breeding habitat for birds. Higher quality habitats are present throughout the Dampier Archipelago islands and mainland outside the development envelope.	N/A	Slight	Minor	Impact addressed through further development and implementation of mitigation measures (Section 4.5.6).
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	Some species forage in open waters that would be temporarily and locally impacted during the Proposal from dredging activities (e.g. increased turbidity). However, the Proposal would not affect important/critical habitat and these species are highly mobile and would be able to forage in non-impacted waters.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Planned – Removal of important/critical habitats	The onshore crossing site and immediate adjacent shoreline areas provides some marginal habitat for some species. However, it is highly disturbed habitat due to surrounding industrial developments resulting in noise and light emissions and physical disturbances. Higher quality habitats are present throughout the Dampier Archipelago islands and mainland outside the development envelope.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Planned – Sedimentation of important/critical habitats	Dredging may impact some shoreline habitats as a result of sedimentation but impacts are unlikely to affect extensive areas of habitat, important/critical habitat or foraging behaviour.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Unplanned – Vessel strikes	These species are highly mobile and unlikely to be directly impacted from vessel strikes.	Remote	Slight	Low	No further work proposed
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. Potential impacts would likely be moderate given the likelihood, recommended management and relatively small spill volume.	Highly unlikely	Minor	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – introduction of IMS	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago which could impact food sources for foraging avifauna. Woodside IMS risk assessment procedure would be implemented on the project to reduce the IMS risk (Section 4.3.6).	Highly unlikely	No lasting effect	Low	Impact addressed within management plans (DSDMP) (Table 4-14).
Marine mammals (High)	Planned – Noise and Light emissions	Marine mammals are unlikely to be substantially impacted by light emissions during construction as lighting would only be required on vessels and at the shore crossing site and the waters of the Dampier Archipelago. The small number of additional vessels that would result from construction activities is unlikely to increase any potential impacts. Noise from construction activities including piling activities has the potential to result in some disturbance to movements of marine mammals. This has the potential to disturb migrating whales, dugongs and dolphins. While impacts from noise emissions have the potential to be moderate, they are unlikely to be significant based on the magnitude of impacts assessed in Appendix C and assessment of significance detailed in Appendix D and the mitigation measures recommended in Section 4.5.6. Marine mammals are likely to exhibit an avoidance behaviour before any physical trauma occurs, however this is influenced by vessel speeds. Noise modelling would also be undertaken to determine the area (radius) around which piling activities and other noise generating activities would have a potential physical trauma to marine mammals.	N/A	Minor	Moderate	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (noise modelling) (Table 4-11).
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	Marine mammals occurring within the waters of the Dampier Archipelago have potential to be impacted indirectly from changes to marine water quality, such as increased turbidity from dredging activities. Impacts would be temporary and considering the extent of habitat in the wider archipelago, the naturally turbid waters in the area and the mobility of the species present, impacts would be minor.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Planned – Removal of important/critical habitats	The Proposal is unlikely to remove important/critical habitats for marine mammals.	N/A	No impacts	No impacts	No further work proposed
	Planned – Sedimentation of important/critical habitats	The Dugong has been previously recorded in the waters of the Dampier Archipelago where it forages among seagrass habitats. It has the potential to be indirectly impacted from habitat disturbances, though as discussed in Section 4.3 impacts from sedimentation of seagrass is likely to be minor.	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Unplanned – Vessel strikes	While highly unlikely, some marine mammals, such as the Dugong, have the potential to be directly impacted by vessel collisions though this is only likely to affect individual marine mammals rather than cause a population level impact. Measures to minimise direct vessel strikes have been proposed.	Highly unlikely	Slight	Low	Impact addressed within management plans (DSDMP)
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. Potential impacts would likely be moderate given the likelihood, recommended management and relatively small spill volume.	Highly unlikely	Minor	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – introduction of IMS	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago which could impact food sources for foraging marine mammals. Woodside IMS risk assessment procedure would be implemented on the project to reduce the IMS risk (Section 4.3.6).	Highly unlikely	No lasting effect	Low	Impact addressed within management plans (DSDMP) (Table 4-14).
Fish (High)	Planned – Noise and Light emissions	Fish are unlikely to be substantially impacted by light emissions during construction as lighting would only be required on vessels and at the shore crossing site and the waters of the Dampier Archipelago. The small number of additional vessels that would result from construction activities is unlikely to increase any potential impacts. Noise from construction activities including piling activities has the potential to result in some disturbances. This has the potential to disturb fish including threatened species. However, fish would likely display avoidance before any physical trauma occurs, and most of the proposed work would be located away from any important fish habitats (rocky reefs, coral communities, etc). Impacts are therefore likely to be minor from noise emissions.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (noise modelling) (Table 4-11).
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	Fish species occurring within the waters of the Dampier Archipelago have the potential to be impacted indirectly from changes to marine water quality, such as increased turbidity as a result of dredging activities. Impacts would be temporary and minor considering the extent of habitat in the wider archipelago, the naturally turbid waters in the area and the mobility of the species present.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Planned – Removal of important/critical habitats	The Proposal is unlikely to remove important/critical habitats for fish.	N/A	No impacts	No impacts	No further work proposed
	Planned – Sedimentation of important/critical habitats	Fish which would forage in seagrass or reef habitats have the potential to be indirectly impacted from habitat disturbances including sedimentation, though as discussed in Section 4.3 impacts from sedimentation of seagrass is likely to be minor.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Unplanned – Vessel strikes	These species are highly mobile and unlikely to be directly impacted from vessel strikes.	Remote	Slight	Low	No further work proposed

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. Potential impacts would likely be moderate given the likelihood, recommended management and relatively small spill volume.	Highly unlikely	Minor	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – introduction of IMS	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago which could impact food sources for foraging fish. Woodside IMS risk assessment procedure would be implemented on the project to reduce the IMS risk (Section 4.3.6).	Highly unlikely	Slight	Low	Impact addressed within management plans (DSDMP) (Table 4-14).
Marine reptiles (High)	Planned – Light emissions	Marine turtles use light as an orientation cue. Artificial light can inhibit nesting by females and can disrupt hatchling orientation and sea finding behaviour. When hatchlings are attracted to light inland they may be exposed to increased mortality from avian and terrestrial predators, trapped in vegetation or killed on roads. If hatchlings do reach the ocean they may have used valuable energy reserves required to reach pelagic feeding areas. Lighting of jetties, vessels or platforms can create pools of light that attract swimming hatchlings and increase their risk of predation. Potential impacts from vessel lighting may include: • sea turtle hatchings being attracted to lights onboard dredge vessel(s) • adult sea turtle being deterred from nesting/foraging activities. Potential consequences may include: • hatchlings trapped by the light spill from vessel lights being concentrated within a small area exposing them to predation • physical exhaustion of hatchlings from maintaining position under dredge lighting, after entering the water • nesting and foraging activity by adult sea turtle being reduced leading to a loss of available habitat. Lighting for the Proposal would only be required during construction and be limited to the shore crossing location and construction vessels. The shore crossing location is located within an industrial zone already impacted by lighting impacts. Vessels would be required along the trunkline alignment away from any shoreline and where vessel lighting would be common (Mermaid Sound). While impacts from light emissions have the potential to be moderate, they are unlikely to be significant based on the magnitude of impacts assessed in Appendix C and assessment of significance detailed in Appendix D and the mitigation measures recommended in Section 4.5.6.	N/A	Minor	Moderate	Impact addressed within management plans (DSDMP) (Table 4-14).
	Planned – Noise emissions	Noise from construction activities including piling activities has the potential to result in some disturbance to movements of marine reptiles, particularly turtles. This has the potential to disturb nesting, internesting, mating and foraging behaviours and/or cause physical trauma. While impacts have the potential to be moderate from noise emissions they are unlikely to be significant based on the magnitude of impacts assessed in Appendix C and assessment of significance detailed in Appendix D and the mitigation measures recommended in Section 4.5.6. Turtles are likely to exhibit an avoidance behaviour before any physical trauma occurs. Noise modelling would also be undertaken to determine the area (radius) around which piling activities and other noise generating activities would have a potential physical trauma to turtles.	N/A	Minor	Moderate	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (noise modelling) (Table 4-11).
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	Marine reptiles, including threatened turtles, occurring within the waters of the Dampier Archipelago have the potential to be impacted indirectly from changes to marine water quality, such as increased turbidity as a result of dredging activities. Impacts would be temporary and minor considering the extent of habitat in the wider archipelago, the naturally turbid waters in the area and the mobility of the species present.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Planned – Removal of important/critical habitats	The Proposal is unlikely to remove important/critical habitats for fish.	N/A	No impacts	No impacts	No further work proposed

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Planned – Sedimentation of important/critical habitats	Reptiles such as turtles which would forage in seagrass or reef habitat have the potential to be indirectly impacted from habitat disturbances, though as discussed in Section 4.3 impacts from sedimentation of seagrass is likely to be minor.	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Unplanned – Vessel strikes	While highly unlikely, turtles have the potential to be directly impacted by vessel collisions though this is only likely to affect individual turtles rather than cause a population level impact. Measures to minimise direct vessel strikes have been proposed.	Highly unlikely	Slight	Low	Impact addressed within management plans (DSDMP).
	Unplanned – entrainment during dredging	Direct impacts from entrainment during dredging could occur. Dredges can be a direct source of turtle mortality where animals become caught in the dredge (entrainment)Dredging operations is only likely to affect individual turtles rather than cause a population level impact. Measures to minimise entrainment have been proposed.	Highly likely	Slight	High	Impact addressed within management plans (DSDMP) (Table 4-14).
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. Potential impacts would likely be moderate given the likelihood, recommended management and relatively small spill volume.	Highly unlikely	Minor	Moderate	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – introduction of IMS	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago which could impact food sources for foraging reptiles. Woodside IMS risk assessment procedure would be implemented on the project to reduce the IMS risk (Section 4.3.6).	Highly unlikely	No lasting effect	Low	Impact addressed within management plans (DSDMP) (Table 4-14).
Planktonic communities (Medium)	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	As discussed in Section 4.4, the Proposal has the potential to impact water quality which in turn would impact planktonic communities. The potential impact on coral larvae is discussed in Section 4.3. Generally, water quality impacts are likely to be localised around the dredging spoil disposal activities and move with the dredge. No long term impacts are therefore anticipated. Additional studies would be undertaken including dredge plume modelling as well as investigations on potential risks of disturbing contaminated sediments and making contaminants bioavailable.	N/A	Minor	Slight	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling) (Table 4-11).
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. Potential impacts would likely be Low given the likelihood, recommended management and relatively small spill volume and the fact planktonic communities would likely recover quickly.	Highly unlikely	No lasting effect	Low	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – introduction of IMS	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago which could impact the plankton community composition structure. Woodside IMS risk assessment procedure would be implemented on the project to reduce the IMS risk (Section 4.3.6).	Highly unlikely	Moderate	Moderate	Impact addressed within management plans (DSDMP) (Table 4-5).
Potential impacts during operation						
Seabirds and migratory shorebirds (High)	Planned – New habitat created due to presence of trunkline	The proposed trunkline is unlikely to provide new habitat for avifauna.	N/A	No lasting effect	Slight	No further work proposed
	Unplanned – Reduced water quality due to oil spill from trunkline	A hydrocarbon spill (gas) from the trunkline is unlikely to impact seabirds or migratory shorebirds.	Remote	No lasting effect	Slight	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Marine mammals (High)	Planned – New habitat created due to presence of trunkline	The proposed trunkline is unlikely to provide new habitat for marine mammals.	N/A	No lasting effect	Slight	No further work proposed
	Unplanned – Reduced water quality due to oil spill from trunkline	A hydrocarbon spill (gas) from the trunkline has the potential to have a minor impact on marine mammals. However, there is only a remote chance of such an event occurring based on proposed design parameters, therefore the residual consequence is considered to be low.	Remote	Minor	Low	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
Fish (High)	Planned – New habitat created due to presence of trunkline	The existing Pluto LNG Facility trunkline is popular with recreational fishers as it has attracted fish. This is likely to be the case for the proposed Scarborough trunkline which would be located adjacent to the existing Pluto LNG Facility trunkline.	N/A	Minor	Slight (positive)	No further work proposed
	Unplanned – Reduced water quality due to oil spill from trunkline	A hydrocarbon spill (gas) from the trunkline has the potential to have a minor impact on marine fauna, including fish and their foraging resources, within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on proposed design parameters, therefore the residual consequence is considered to be low.	Remote	Minor	Low	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
Marine reptiles (High)	Planned – New habitat created due to presence of trunkline	The proposed trunkline has the potential to provide some additional foraging habitat for certain turtles. This habitat would be similar to the adjacent Pluto LNG Facility trunkline and therefore would not bring turtles to a new area and increase risks of vessel strikes.	N/A	Minor	Slight (positive)	No further work proposed
	Unplanned – Reduced water quality due to oil spill from trunkline	A hydrocarbon spill (gas) from the trunkline has the potential to have a minor impact on marine fauna, including reptiles and their foraging resources, within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on proposed design parameters, therefore the residual consequence is considered to be low.	Remote	Minor	Low	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
Planktonic communities (Medium)	Unplanned – Reduced water quality due to oil spill from trunkline	A hydrocarbon spill (gas) from the trunkline would have a minor impact on planktonic communities and may result in a decrease of planktonic biomass and change in the composition of the community in the short term in the region. However, there is only a remote chance of such an event occurring based on proposed design parameters, therefore the residual consequence is considered to be low.	Remote	Minor	Low	Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).

4.5.6 Mitigation

Table 4-14 provides a summary of mitigation measures that would be implemented to avoid and/or mitigate potential impacts from the Proposal.

4.5.7 Assumptions and predicted outcome

Impacts would be further addressed within management documentation, through the additional studies described in Section 4.5.3 and through consultation with relevant stakeholders as described in Section 3.However, based on the preliminary impact assessment using available information, the Proposal is unlikely to result in the significant harm to marine fauna. It would therefore meet the EPA objectives:

- Long term impacts from the physical presence of a trunkline within Mermaid Sound are likely to be minor. The proposed trunkline has been positioned parallel and close to an existing trunkline and the shore crossing site has been located at the Pluto LNG Facility in a previously disturbed area. The proposed trunkline has the potential to provide some additional habitat for marine fauna.
- Construction impacts would generally be minor and temporary. Some impacts such as those relating to light emissions on marine turtles and underwater noise have the potential to have more than a minor impact. However, assessments of significance prepared for threatened species in accordance with EPBC guidelines have shown these are unlikely to be significant with the proposed management measures.
- Proposed mitigation measures (Section 4.5.6) have been recommended to avoid and/or minimise expected impacts and there is unlikely to be significant residual impacts. Management measures would be further refined during the development of the relevant management plans and completion and integration of data from planned additional studies, including noise modelling, hydrocarbon spill modelling and dredge plume modelling.

Table 4-14: Marine fauna – Mitigation measures

Receptor	Impact	Mitigation
Marine Fauna	All impacts	Marine fauna will be considered in the Dredging and Spoil Disposal Management Plan (DSDMP) to avoid and minimise impacts. As a minimum the plan will include the following mitigation measures: • Requirement for inductions for onsite personnel which will highlight the MNES potentially occurring within the waters of the Dampier Archipelago and the need to avoid impacts. • Measures to avoid direct vessel strikes with marine fauna. Support vessels will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1. • Noise management procedures to avoid permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine fauna and minimise behavioural responses, particularly during any pile driving activities will be developed. The procedure must determine the area (radius) around which piling activities and other noise generating activities would have a potential PTS/TTS and include a soft start approach to enable any fauna to move away. • Measures to avoid and/or minimise direct and indirect impacts on turtles (e.g. vessel strikes, entrainment, lighting). • Measures to avoid the introduction of invasive marine species (IMS) including: – Implementation of Woodside's IMS Management Plan (including risk based assessment and implementation of management options as required by the plan) to reduce the risk of introducing IMS to Australian waters. This may include inspections prior to entry into Australian waters and the use of antifouling coating. – All vessels will be required to meet both Commonwealth and State ballast water and biofouling legislation and guidelines including the Ballast Water Management Requirements and the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry. • Sightings and locations of marine fauna must be recorded in the vessel's daily log book. • Any incidents relating to marine fauna injury/mortality must be documented and reported to relevant regulators.
	Water quality impacts from waste	Mitigation for impacts to water quality are described in Section 4.4.6
	Water quality impacts from dredging	
	Water quality impacts from accidental oil spill	

4.6 Social surroundings

4.6.1 EPA objective

EPA's objective in relation to the key environmental factor 'Social Surroundings' is 'to protect social surroundings from significant harm'.

4.6.2 Policy and guidance

The following EPA guidance has been considered in evaluating potential impacts on this factor:

- EPA (2016h), Environmental Factor Guideline: Social Surroundings, EPA, Western Australia.

4.6.3 Studies and information sources

Readily available information has been used to describe social surroundings of the Proposal and inform the assessment of impacts for the Proposal. Additionally, a cultural heritage impact assessment will be completed before construction and stakeholders consulted throughout the development, as per Section 3.

4.6.4 Receiving environment

4.6.4.1 Land use

The Proposal is located within the Pilbara region in the Port of Dampier limits managed by PPA and within the City of Karratha council limits. Dampier Port is a major industrial port in the northwest of Western Australia. It is one of the world's largest bulk export ports by tonnage and services including; petrochemical, salt, iron ore and natural gas export industries.

The onshore crossing site is located adjacent to the Pluto LNG Facility in an industrial zone. The shoreline crossing and the State waters component of the trunkline are within the Dampier Port Boundary. The closest residential township is Karratha which lies 15 km to the South East of the shoreline crossing. Surrounding land uses are shown in Figure 2-5 and include:

- The North West Shelf project – one of the world's largest LNG producers supplying oil and gas to the Western Australian and international markets from offshore gas and condensate fields located 135 km north-west of Karratha in the Carnarvon Basin.
- Pluto LNG Facility project – a major LNG gas project with onshore gas processing facilities that process gas from the Pluto and Xena gas fields located 190 km north-west of Karratha in the Carnarvon Basin.
- Rio Tinto Iron Ore operations – a major iron ore producer that exports iron ore from inland mines from their export facilities at Parker Point and East Intercourse Island.
- Rio Tinto Dampier Salt operations – world's largest exporter of salt.
- Yara Pilbara Fertilisers operations – one of the world's largest ammonia producers.

Access to the Pluto LNG Facility and other industrial zones on the Burrup Peninsula from Dampier Port and/or Karratha is via existing roads able to carry heavy vehicles:

- Dampier Road
- Burrup Road
- King Bay Road
- MOF Road.

4.6.4.2 Shipping

The region supports significant commercial shipping activity, mostly associated with the mining and oil and gas industries. Major shipping routes in the area are associated with vessels entering the ports of Dampier and Barrow Island. The relevant port authority for Dampier Port is PPA.

Commercial shipping activities in the region include:

- international bulk freighters/tankers arriving and departing from Dampier including mineral ore, hydrocarbons (LNG, liquefied petroleum gas, condensate) and salt carriers
- domestic support/supply vessels servicing offshore facilities and the Barrow Island development
- construction vessels/barges/dredges
- offshore survey vessels.

The Australian Maritime Safety Authority (AMSA) has introduced a network of commercial shipping fairways on the NWS to reduce the risk of vessels colliding with offshore infrastructure. The fairways are not mandatory, but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region.

Sea access to the Port is via the three major and three minor shipping channels (Table 4-15 and Figure 2-5).

Table 4-15: Shipping channels within Port waters (Dampier Port Authority, 2014)

Channel	Declared depth (chart datum)	Provides access to
NWSV Channel	12.2 m	NWSV LNG and LPG jetties
Rio Tinto Iron Ore (RTIO) Channel	15.4–15.5 m	East Intercourse Island, Parker Point and Mistaken Island wharves
Pluto Channel	12.5 m	Pluto LNG Facility jetty
Mermaid Marine Australia Supply Base (MMASB) Channel	5.2 m	MMASB wharves
King Bay Supply Base (KBSB) Channel	6.0 m	KBSB tug pens, Pluto Supply Base berths
Dampier Bulk Liquids Berth (DBLB) Channel	11.0 m	Dampier Cargo Wharf (DCW), DBLB, Heavy Load Out Facility (HLO), Alternate Load Out Facility (ALF), FDTS

4.6.4.3 Tourism

Charter fishing, diving, snorkelling, whale watching, marine turtle and dolphin watching and cruising are the main commercial tourism activities in and adjacent to the North-west Marine Region. Except for offshore charter fishing, most marine tourism activities occur in State waters, including in the Dampier Archipelago (DEWHA, 2008a).

Recreational fishing tends to be concentrated in State Waters adjacent to population centres, with highest records typically recorded in areas such as Point Samson, Coral Bay and Carnarvon (DEWHA, 2008a). The Dampier Archipelago is also a popular recreational fishing area.

Recreational fishing

Around one third of Western Australians, or about 600,000 people, regularly participate in recreational fishing activities (CALM, 2000). In 2003–2004, the Pilbara and Kimberley regions accounted for 5% of the state's recreational fishing effort (Penn et al., 2005), and in 1999–2000, an estimated 300 tonnes of scalefish was taken recreationally throughout the region from Onslow to Broome, excluding Thevenard Island and Barrow Island charter vessel catches (Williamson et al., in preparation).

The popularity of recreational fishing has grown substantially in the Pilbara region over recent years, with a distinct seasonal peak in winter when significant numbers of metropolitan and interstate tourists travel through the area and visit the Dampier Archipelago. The high tidal range in the area means beach fishing is limited to periods of flood tides and high water (Penn et al., 2005). Consequently, much of the angling activity is boat-based. The Pilbara region has the highest boat ownership per capita in Australia (CALM, 2000).

Licensed fishing tours in the region are also a popular tourism attraction, and at the end of 2003 the Pilbara and Kimberley regions had 97 licensed fishing tour operators providing 2846 recreational fishing tours (Penn et al., 2005).

Several methods of recreational fishing are used throughout the Dampier Archipelago, including line fishing, netting and spear fishing, with line fishermen targeting deepwater large pelagic species and trolling for smaller fish within the Archipelago nearshore areas. Creek systems, mangroves, rivers, and beaches also support a variety of recreationally targeted species including blue-lined emperor (*Lethrinus laticaudis*), spangled emperor (*Lethrinus nebulosus*), sweetlip emperor (*Lethrinus miniatus*), red emperor (*Lutjanus sebae*), estuary cod (*Epinephelus coioides*), sea perches such as mangrove jack, trevally species (*Gnathanodon speciosus*, *Caranx ignobilis* and *Caranx sexfasciatus*), sooty grunter, threadfin salmon species (*Eleutheronema tetradactylum*, *Polydactylus macrochir* and *Polydactylus plebius*), and mud and blue manna crabs.

Offshore islands, coral reef systems and continental shelf waters provide species of major recreational interest including sharks, tunas, billfish, trevally species, mackerel (*Scomberomorus* spp.), tuskfish (*Choerodon* spp.), coral trout (*Plectropomus leopardus*), coronation trout (*Variola louti*) and bar-cheeked coral trout (*Plectropomus maculatus*) (Penn et al., 2005).

Offshore areas containing coral and subtidal rocky reefs are targeted. Artificial habitat created by existing gas trunklines is also popular.

4.6.4.4 Fisheries

Commonwealth and State Fisheries

A number of Commonwealth and State fisheries are located within and in proximity of the development envelope. Table 4-16 provides further detail on the fisheries that have been identified through desktop assessment.

Figure 4-9 and Figure 4-10 provide the designated fisheries management areas in relation to the development envelope.

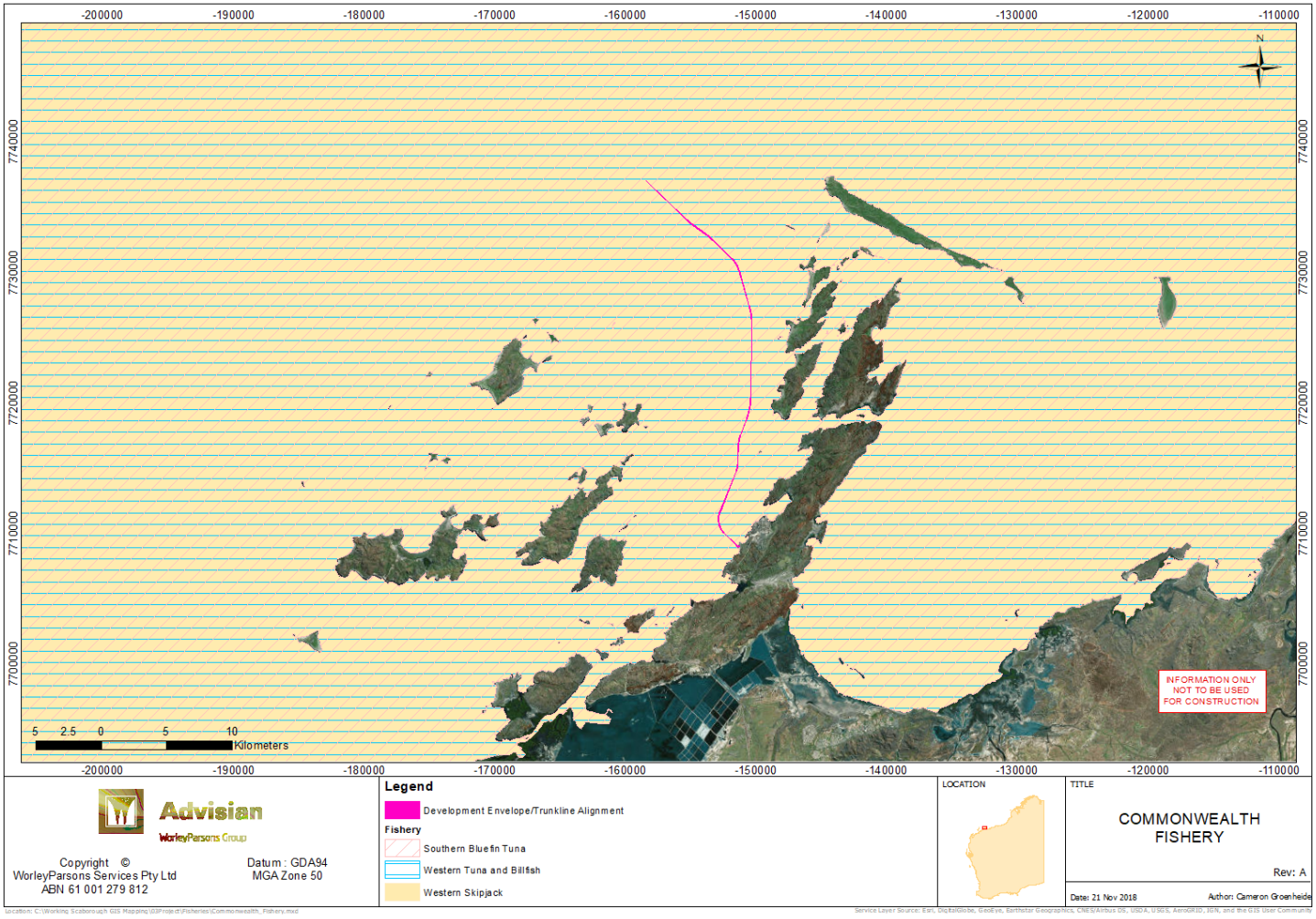


Figure 4-9: Designated Commonwealth Fisheries Management Areas in relation to the development envelope

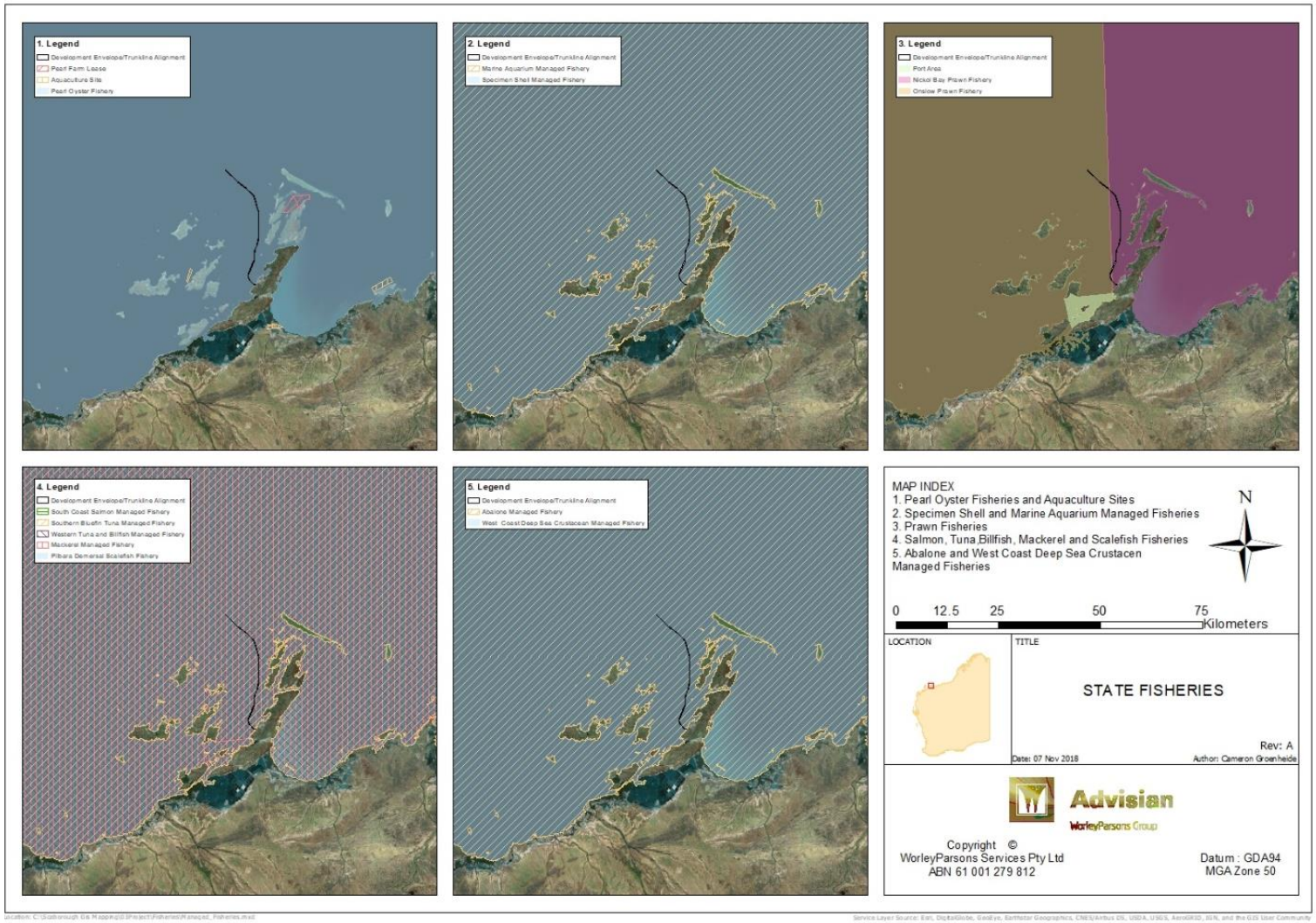


Figure 4-10: Designated State Fisheries Management Areas in relation to the development envelope

Table 4-16: Commonwealth and State fisheries

Fishery	Description
Commonwealth Managed Fisheries	
Southern Bluefin Tuna Fishery	**Description:** The Southern Bluefin Tuna Fishery boundary overlaps the development envelope, but current effort within the fishery is largely confined to southern Australia, with most effort occurring in the Great Australian Bight (Australian Fisheries Management Authority, 2010; Patterson et al., 2016). Southern bluefin tuna are known to spawn in the north-eastern Indian Ocean (Davis et al., 1990; Matsuura et al., 1997). The species has been heavily exploited by commercial fisheries worldwide. **Relevance:** The fishery employs both longlining and purse seine net fishing methods. Given the current distribution of fishing effort and fishing methods used by the industry, fishing for bluefin tuna is unlikely to occur in the development envelope or surrounding areas. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** Six purse seine vessels, 18 longline vessels (Patterson et al., 2016).
Western Skipjack Fishery	**Description:** The combined western and eastern skipjack tuna (*Katsuwonus pelamis*) fisheries encompass the entire Australian Exclusive Economic Zone (EEZ), including the development envelope. The target species has historically been used for canning, and with the closure of canneries at Eden and Port Lincoln, effort in the fishery has declined and there have been no active vessels operating since 2009 (Patterson and Bath, 2016). **Relevance:** Given the fishery has been inactive for a number of years and the distribution of fishing effort when the fishery was active, fishing for skipjack tuna in the development area is highly unlikely. Should the fishery commence efforts in the area in the future, fishing effort in the development envelope and surrounding area is considered unlikely, given the historical fishery was concentrated off southern Australia. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** Not applicable (fishery inactive).
Western Tuna and Billfish Fishery	**Description:** The West Tuna and Billfish Fishery is currently active, running throughout the year. The fishery zoning extends to the Australian EEZ boundary in the Indian Ocean, overlapping the development envelope. The fishery targets four pelagic species, which are all highly mobile: • broadbill swordfish (Xiphias gladius) • bigeye tuna (Thunnus obesus) • yellowfin tuna (T. albacares) • albacore tuna (T. alalunga). The number of vessels operating in the fishery has declined in recent years, with less than five vessels operating since 2005 (Patterson and Stephan, 2014; Williams et al., 2016). Effort data shows fishing effort is concentrated off south-west Western Australia and South Australia (Williams et al., 2016). The methods used by the fishery are mainly pelagic longline and some minor-line fishing. No significant effort in the vicinity of the development envelope has been documented. **Relevance:** Given the current level and recent distribution of effort, it is unlikely fishing by the Western Tuna and Billfish Fishery will occur within the development envelope or surrounding area. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** Three vessels (two pelagic longline, one minor longline) (Williams et al., 2016).

Fishery	Description
State Managed Fisheries	
Pilbara Demersal Scalefish Fishery (fish trawl, trap and line)	**Description:** The State-regulated Pilbara demersal scalefish fishery is managed as part of the North Coast Demersal Scalefish Fisheries (NCDSF). The NCDSF comprises several management units in the Pilbara and Kimberley regions, targeting a range of low and high value finfish species. The Pilbara demersal scalefish fishery is managed through area closures, gear restrictions and allocating individual effort (Newman et al., 2017). Gear used in the Pilbara demersal scalefish fishery includes trawl, trap and line fishing, with trawl fishing accounting for the bulk of landings (Newman et al., 2017). The managed fishery boundary overlaps the development envelope and wider zone of influence, although most of the fishery management area overlapping the development envelope is closed to fishing. **Relevance:** Fishing is unlikely to occur within the development envelope, given most of the area overlapped is currently closed except for the northern most section. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** It is estimated that ~10 fishers on 2 vessels were directly employed during 2016 in the trawl sector, and 8 fishers on 3 vessels in the trap sector, and at least ~15 fishers on 5 vessels in the line sector. Overall, at least ~33 people (e.g. 3-4 crew per vessel) were directly employed in the PDSF (Gaughan, 2018).
West Coast Deep Sea Crustacean Managed Fishery	**Description:** The West Coast Deep Sea Crustacean Managed Fishery extends north from Cape Leeuwin to the WA/Northern Territory border in water depths greater than 150 m within the Australian Fishing Zone, including the Operational Area. The fishery targets deepwater crustaceans, with the vast majority (> 99%) of the catch landed in 2015 comprising crystal crabs (How and Yerman, 2017). Two vessels operated in the fishery in 2015, using baited pots in a longline formation in the shelf edge waters, mostly in depths between 500 and 800 m (How and Yerman, 2017). Fishing effort was concentrated between Fremantle and Carnarvon. **Relevance:** Given fishing effort is concentrated beyond the development envelope and surrounding area, interaction between participants in the fishery during the proposal activities is unlikely. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** Two active in 2015 (How and Yerman, 2017).
Specimen Shell Managed Fishery	**Description:** The Specimen Shell Managed Fishery (SSF) can operate in Western Australian waters, next to the development envelope. The SSF collects specimen shells for display, collections, cataloguing and sale. Specimens are predominantly collected by hand when diving or wading in shallow coastal waters, though a deeper water collection aspect to the fishery has been initiated by employing ROVs operating at depths up to 300 m (Hart and Crowe, 2015). **Relevance:** The fishery encompasses the entire WA coastline but effort is concentrated in area adjacent to the largest population centres such as Broome, Karratha, Shark Bay, Mandurah, Exmouth, Capes area, Albany and Perth (Hart and Crowe, 2015). Therefore, fishing may occur within the development envelope. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** In 2016 there were 31 authorisation holders in this fishery with around seven licences recording consistent activity, the number of people employed regularly in the fishery is likely to be around 11. There were also around 17 people that operated occasionally in this fishery (Gaughan, 2018).

Fishery	Description
Onslow Prawn Managed Fishery	**Description:** The Onslow Prawn Managed Fishery encompasses a portion of the continental shelf off the Pilbara region. The fishery targets a range of penaeids (primarily king prawns) which typically inhabit soft sediments < 45 m water depth. Fishing is done using trawl gear over unconsolidated sediments (sand and mud). Total prawn catches in 2015 were about 10.1 tonnes, considerably lower than other prawn fisheries (total north coast prawn landings in 2015 were 175 tonnes) (Sporer et al., 2017). **Relevance:** Fishing may occur in the development envelope, given the water depths and sediment types. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** One boat fished in the OPMF in 2016. However, because this boat can operate in other fisheries where catches were more profitable, this fishery recorded very low effort and catch (Gaughan, 2018).
Nickol Bay Managed Prawn Fishery	**Description:** The Nickol Bay Prawn Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear. The target species typically inhabits sandy and muddy substrate in < 45 m water depth. About 87 tonnes were landed in 2015, comprised largely of banana prawns (Sporer et al., 2017). **Relevance:** Fishing may occur within the development envelope. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** The total landings of major penaeids for the 2016 season were 17 t, the second lowest catch since 1966 (North Coast Prawn). This comprised 16 t of banana prawns, which was below the predicted range (35–53 t, based on updated data), 1 t of brown tiger prawns, negligible quantity of endeavour prawns and no recorded landings of western king prawns (Gaughan, 2018).
Pearl Oyster Managed Fishery	**Description**: The Western Australian Pearl Oyster Managed Fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. Pearl oysters (*Pinctada maxima*) are collected by divers in shallow coastal waters (> 23 m) along the North West Shelf and Kimberley, which are mainly used to culture pearls (Hart et al., 2017). The fishery is separated into four zones; the development envelope overlaps Zone 1. Fishing recently recommenced in Zone 1 after a hiatus of several years (Hart et al., 2017). The portion of the total catch in Zone 1 was minor in 2016–2017 (3%) (Hart et al., 2017). **Relevance:** Fishing may occur in the development envelope, given the water depths. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels**: The number of vessels fishing in 2016 was six. Most vessels presently operate 10–14 crew for the fishing of pearl oysters between March and August each year (Gaughan, 2018).
Marine Aquarium Managed Fishery	**Description:** The Marine Aquarium Managed Fishery can operate in all State waters, with effort typically concentrated around the Capes region, Perth, Geraldton, Exmouth and Dampier (Molony et al., 2017). The fishery is diver-based, which typically restricts effort to safe diving depths (< 30 m). **Relevance:** Fishing may occur in the development envelope, given the water depths. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** Eight licences were active in the MAFMF and three in the HCF during 2016. The total catch in the MAFMF and the HCF in 2016 was 128,610 fishes, 16.4 t of coral, live rock & living sand and 75 L of marine plants (Gaughan, 2018).

Fishery	Description
West Australian Abalone Fishery	**Description:** The Western Australian abalone fishery includes all coastal waters from the Western Australian and South Australian border to the Western Australian and Northern Territory border. The fishery is concentrated on the south coast (greenlip and brownlip abalone) and the west coast (Roe's abalone). Abalone are harvested by divers, limiting the fishery to shallow waters (typically < 30 m). **Relevance:** No commercial fishing for abalone north of Moore River (Zone 8 of the managed fishery) has taken place since 2011–2012 (Strain et al., 2017); interactions with participants in the fishery would not occur during the proposal activities. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** There are 22 vessels commercially fishing for Roe's abalone, employing approximately 45 people across WA. There are 17 vessels operating in the Commercial Greenlip/Brownlip Abalone Fishery, employing approximately 35 divers and deckhands (Gaughan, 2018).
Mackerel Managed Fishery	**Description:** The Mackerel Managed Fishery targets Spanish mackerel (*Scomberomorus commerson*) using near-surface trawling gear from small vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture grey mackerel (*S. semifasciatus*), with other species from the genera *Scomberomorus* (Molony et al., 2015). The commercial fishery extends from Geraldton to the Northern Territory border. There are three managed fishing areas: Kimberley (Area 1), Pilbara (Area 2), and Gascoyne and West Coast (Area 3). Most of the catch is taken from waters off the Kimberley coast (Lewis and Jones, 2017), reflecting the tropical distribution of mackerel species (Molony et al., 2015). Most fishing activity occurs around the coastal reefs of the Dampier Archipelago and Port Hedland area, with the seasonal appearance of mackerel in shallower coastal waters most likely associated with feeding and gonad development before spawning (Mackie et al., 2003). **Relevance:** Fishing may occur within the development envelope. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** About 33 people were directly employed in the MMF during the 2016 mackerel fishing season, primarily from May–November.
South West Coast Salmon Managed Fishery	**Description:** The South West Coast Salmon Managed Fishery operates on various beaches south of the metropolitan area, and includes all Western Australian waters north of Cape Beaufort except Geographe Bay. This fishery uses beach seine nets to take Western Australian salmon (*Arripis truttaceus*). No fishing occurs north of the Perth metropolitan area, despite the managed fishery boundary extending to Cape Beaufort (Western Australia/Northern Territory border). **Relevance:** No interactions with participants in the fishery will occur during the proposal activities. **Fishery boundary distance from development envelope:** Overlaps the development envelope. **Licences/vessels:** Not applicable (shore-based).

Aquaculture

Aquaculture development in the north coast bioregion is dominated by the production of pearls from the species *Pinctada maxima* (Gaughan and Santoro, 2018). A large number of pearl oysters for seeding are obtained from wild stocks and supplemented by hatchery-produced oysters, with major hatcheries operating at Broome and around the Dampier Peninsular (Gaughan and Santoro, 2018).

The development envelope does not intersect with any known aquaculture leases (Figure 4-10). The closest is the Flying Foam Passage lease, around five kilometres east of the development envelope.

4.6.4.5 Heritage

Aboriginal Heritage

The Dampier Archipelago (including Burrup Peninsula) is an indigenous class feature on the National Heritage List (Figure 2-5). Aboriginal people have a strong on-going association with the North-west Marine Region. The saltwater peoples of the north-west continue to rely on coastal and marine environments and resources for their cultural identity, health and wellbeing, as well as their domestic and commercial economies (DEWHA, 2008a).

The Western Pilbara region and associated islands contain a prolific and diverse range of Aboriginal heritage sites and objects. Aboriginal heritage sites types represented include petroglyph (rock art) sites, ethnographic sites, standing stones, shell middens, artefact scatters, quarries and grinding patches. It has been estimated that the Dampier Archipelago may contain around 1 million rock art images known as petroglyphs (Woodside, 2006), at a density of between 17 and 76 heritage sites per square kilometre (National Trust, 2006). State records and Woodside's own surveys during the operation of the Pluto LNG Project have identified a range of Aboriginal heritage site types, inside and adjacent the Pluto LNG Project facilities, including adjacent to the shore crossing location. The shore crossing site for the Scarborough trunkline has been disturbed by the trenching for the Pluto trunkline and the construction of the Pluto jetty and is unlikely to contain heritage sites. A thorough audit of Aboriginal heritage sites within Woodside Pluto LNG Project confirmed the presence of Aboriginal heritage sites preserved *in situ* within lease areas. Woodside maintains a database of Aboriginal heritage sites and restricts access to identified features within the operating site. Quarterly heritage update meetings are held with traditional owners to discuss Woodside activities and ongoing heritage management requirements. Annual Aboriginal heritage sites audits are conducted with traditional owners and a qualified archaeologist, to inspect, monitor and report on the conditions of the sites within Woodside leases boundaries. These sites are managed through existing cultural heritage management plans implemented at the Pluto LNG facility (Woodside 2012) (Table 4-17).

A Native Title (WC 1996/089 by the Yaburara and Mardudhunera people) partially extends into waters through which the trunkline would traverse near the State Waters boundary.

Shipwrecks and maritime archaeology

Australia protects its shipwrecks and their associated relics that are older than 75 years through the *Historic Shipwrecks Act 1976* and Heritage (Historical Shipwrecks) Regulations 2007, administered in collaboration between the Commonwealth and the States, Northern Territory and Norfolk Island.

No listed historic shipwrecks or maritime archaeological sites within 10 kilometres of the development envelope were identified on the Australian National Shipwreck database and State Maritime Archaeology database.

National and Commonwealth Heritage listed places/items

There is no heritage listed sites within or in proximity to the development envelope except the Dampier Archipelago (including Burrup Peninsula), classified as an indigenous class feature on the National Heritage List (see above).

State Heritage listed places/items

The State Heritage Office InHerit search tool was used to locate any heritage places/items within the City of Karratha council boundary. The Dampier Archipelago (including Burrup Peninsula) is also listed as a heritage place on the City of Karratha Municipal Inventory (see above). The next closest place is Sam's Island seven kilometres to the south west of the shore crossing site.

Table 4-17: Heritage items and places in priximity to the development envelope

Item/Place	Listing	Location relative to development envelope (closest distance)
Dampier Archipelago (including Burrup Peninsula)	National Heritage Place City of Karratha Municipal Inventory	1.5 kilometres to the east
Sam's Island	City of Karratha Municipal Inventory	7 kilometres to the south west
Aboriginal heritage site 19675 (Holden Point Quarry A and accompanying conservation zone) also known as the 'Tool Shed'.		Adjacent and to the north of the shore crossing location. Currently separated from the shore crossing site by a fence.

4.6.5 Potential impacts

Table 4-18 provides a preliminary assessment of potential environmental impacts on social surroundings and additional work proposed to confirm these impacts.

Table 4-18: Preliminary EIA for social surroundings

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Potential impacts during construction						
Land use and settlements (High)	Planned – Land use impacts	Construction activities would be conducted within Port of Dampier waters and would require the approval of PPA as well as other regulatory authorities. Consultation with PPA and other relevant stakeholders has commenced and will continue to be undertaken to understand their requirements. Considering similar activities have been undertaken in the region in the past, issues relating to approvals are not expected. Land use impacts applying to the construction period would be temporary. The shore crossing site is located at the location of the Woodside Pluto LNG Facility and therefore temporary impacts from using a portion of the land for construction purposes would be managed internally and are likely to be minor. Some land may be required to temporary store rock material if this is brought from overseas using bulk carriers and it needs to be unloaded at the wharf area prior to loading on rock dumpers (Section 2.3.2.5). Any storage requirement would need to be investigated and be approved and therefore this temporary impact would be minor.	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a Stakeholder Engagement Plan (SEP).
	Planned – Air quality impacts	Air quality impacts from the Proposal would relate to emissions from construction plant and vessels. Excavations, with a potential to create dust emissions, would only be required at existing rock quarries for the supply of rock material and at the location of the shore crossing to remove rocks from the pre-excavated trench. Loaded trucks, if uncovered, and rock/sediment stockpiles would also be potential dust sources. Sensitive receivers such as residential areas are located away from any construction activities that may lead to substantial air quality impacts. Trucks may, however, have temporary and minor impacts on sensitive receivers if loads are uncovered and routes taken pass through residential or other sensitive locations. Rock quarries would be required to comply with their approval conditions in terms of dust emissions.	N/A	No lasting effect	Slight	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Details of potential road transport routes to be determined. Location of potential quarries to be determined.
	Planned – Noise impacts	Noise generating activities would include road transport of material for construction purposes (including rocks from local quarries), dredging and rock dumping activities, and piling activities at the shore crossing location, which is likely to be the highest noise source. An existing quarry would be used for the supply of rocks which would have a permit to operate. Sensitive receivers such as residential areas are located away from any construction activities that may lead to substantial noise impacts. Construction traffic may impact sensitive receivers if routes taken pass through residential or other sensitive locations. Impacts would be temporary.	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts. Details of potential road transport routes to be determined. Location of potential quarries to be determined.
	Planned – Light emissions	Sensitive receivers such as residential areas are located away from any construction activities and impacts from light emissions are unlikely.	N/A	No impacts predicted	No impacts predicted	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
	Planned – Road traffic and access impacts	Construction would require the transport of construction plant and material to the shore crossing site and/or to an appropriate wharf/jetty for the loading of material on construction vessels. Traffic would include 4WDs and other similar vehicles to transport personnel as well as heavy vehicles for material, including any rock quarried locally. The location of the quarry is yet to be determined. Vehicles would use existing roads and no new access tracks would be required. The shore crossing site is located in an industrial zone and the wharves/jetties to be used would either be the Woodside Jetty at the shore crossing site and/or at the Port of Dampier.	N/A	Minor	Moderate	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Assess number of construction plant/vehicles that would be required. Details of potential road transport routes to be determined. Location of potential quarries to be determined.
Shipping (High)	Planned – Physical presence of construction vessels displacing other users	Mermaid Sound is used by commercial and recreational vessels. The construction period would see a minor increase in the number of vessels in the area with potential for vessel interactions. However, standard communication between vessels and PPA would be required to ensure navigational safety is maintained. The NWSV shipping channel crossing is expected to be constructed using a similar method to the Pluto LNG Facility trunkline to avoid impacts to shipping. This is described in Section 2. It is anticipated that the trunkline would be pre-laid at the north side of the channel and pulled across along the seabed using a shallow water pipelay barge. Impacts would be temporary and be restricted to the construction period.	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Tourism (High)	Planned – Physical presence of construction vessels displacing other users	The Proposal would result in the presence of construction vessels within Mermaid Sound. These would progressively move along the trunkline alignment as dredging and the trunkline installation takes place. The duration of the construction period for the installation of the trunkline would be approximately 12 months. While the presence of construction vessels within Mermaid Sound has the potential to create a negative visual impact, impacts are considered minor considering the high traffic of other commercial and construction vessels in the region, including Mermaid Sound. The small number of additional vessels during the construction period is unlikely to substantially impact tourism. The proposed trunkline alignment is also located away from any popular tourist destinations within the Dampier Archipelago.	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
	Planned – Visual impacts from dredge plumes	A turbid plume would be created by dredging activities and/or rock/sediment dumping. The plume would move as dredging takes place along the trunkline. This has the potential to temporarily impact the visual amenity of the impacted area. Dredging activity is a relatively common activity in Mermaid Sound and the waters in Mermaid Sound tend to be seasonally turbid (refer to Section 4.4.4.3). Section 4.4 has assessed the potential impacts of the Proposal on water quality and additional modelling will be completed to determine the extent of turbid plumes. A Dredge Management Plan will also be developed which will outline the ZoI (the area in which plumes may be visible) and associated management and monitoring measures. The dredging activities and turbid plumes are expected to remain distant from popular tourist areas within the Dampier Archipelago.	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Development and implementation of management plans (DSDMP), supported by additional studies to be undertaken (dredge plume modelling) (Table 4-6).
	Planned – Visual impacts from routine vessel discharges	Routine discharges from construction vessels (sewage and greywater, food waste, deck drainage and bilge) will comply with MARPOL requirements with sewage and putrescible wastes discharges beyond 3 nm. Given the expected discharge volumes any discharges are not expected to remain visible at the surface for prolonged periods and will rapidly dilute. Additionally construction activities would be located away from any popular tourist destinations within the Dampier Archipelago which would minimise impacts and management measures have been recommended to further avoid/minimise impacts to water quality (Section 4.4.6).	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
	Unplanned – Water quality impacts from oil spill preventing water based activities	As discussed in Section 4.4.5, oil spills may result from: • refuelling activities at sea or along the shore • accidental collisions of vessels • inappropriate storage of chemicals/hydrocarbons, in particular on vessels and/or at the shore crossing site. However, the risk of a spill occurring is considered highly unlikely as assessed in Section 4.4.5 and after implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted. Spills have the potential to result in short to medium terms impacts on tourism by reducing tourism at impacted sites.	Highly unlikely	Major	Moderate	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Fisheries (Moderate)	Planned – Physical presence of construction vessels displacing other users	Commercial fisheries, which intersect the development envelope and have the potential to be impacted by the Proposal during construction, include: • Mackerel Managed Fishery • Marine Aquarium Managed Fishery • Pearl Oyster Managed Fishery • Nickol Bay Managed Prawn Fishery • Onslow Prawn Managed Fishery • Specimen Shell Managed Fishery The Proposal has the potential to have direct impacts through interactions between commercial fishing vessels and construction vessels. Mermaid Sound is regularly used by commercial and recreational vessels. The construction period would see a minor increase in the number of vessels in the area and standard communication between vessels and PPA would be required to ensure navigational safety. The Proposal would temporarily prevent access to discrete locations within Mermaid Sound where construction activities are taking place but no important fishing grounds are likely to be impacted. Other fisheries and aquaculture operations described in Section 4.6.4.4 are unlikely to be directly or indirectly impacted as they do not operate in areas that are likely to be directly or indirectly impacted.	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
	Planned – Impacts to BCH (Section 4.3)	Impacts to BCH have been assessed as Minor, consequently any impacts to fisheries are expected to be minor.	N/A	Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Development and implementation of management plans, supported by additional studies to be undertaken for impacts to BCH (Table 4-2) and water quality (Table 4-6).
	Unplanned – Impacts to BCH (Section 4.3)	Impacts to BCH have been assessed as Minor, consequently any impacts to fisheries are expected to be minor.	Possible	Slight	Moderate	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Development and implementation of management plans, supported by additional studies to be undertaken for impacts to BCH (Table 4-2) and water quality (Table 4-6).
	Unplanned – Water quality impacts from oil spill	As discussed in Section 4.4.5, oil spills may result from • refuelling activities at sea or along the shore • accidental collisions of vessels • inappropriate storage of chemicals/hydrocarbons, particularly on vessels and/or at the shore crossing site. However, the risk of a spill occurring is considered highly unlikely as assessed in Section 4.4.5 and after implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted. Spills have the potential to result in short to medium term impacts on fisheries by temporarily reducing the areas that can be fished or impacting the resource being fished.	Highly unlikely	Major	Moderate	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Planned – Impacts to Marine Fauna of commercial value	Direct and indirect impacts on marine fauna with commercial value have the potential to impact relevant fisheries. Direct and indirect impacts on marine fauna would be assessed and results used to inform the impacts on commercial fisheries. However, a preliminary impact assessment (Section 4.5) has determined that direct and indirect impacts to Marine Fauna from planned events are likely to be minor. Furthermore, no important fishing grounds are likely to be impacted.		Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Development and implementation of management plans, supported by additional studies to be undertaken for impacts to BCH (Table 4-2) and water quality (Table 4-6).
	Unplanned – Impacts to Marine Fauna of commercial value	Direct and indirect impacts on marine fauna with commercial value have the potential to impact relevant fisheries. Direct and indirect impacts on marine fauna would be assessed and results used to inform the impacts on commercial fisheries. However, a preliminary impact assessment (Section 4.5) has determined that direct and indirect impacts to Marine Fauna from unplanned events are likely to be minor. Furthermore, no important fishing grounds are likely to be impacted.	Highly unlikely	Slight	Low	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Development and implementation of management plans, supported by additional studies to be undertaken for impacts to BCH (Table 4-2) and water quality (Table 4-6).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
	Unplanned – Introduction of IMS impacting fisheries resources	The use of interstate and/or overseas vessels has the potential to introduce IMS to the Dampier Archipelago from contaminated hulls and/or ballast waters which could impact fisheries resources. The risk, however, can be avoided by implementing the management measures proposed in Section 4.6.6, including the requirement to have vessels adequately checked and certified prior to entering the waters of the Dampier Archipelago. While the risk is considered highly unlikely, impacts should they occur would likely be long term.	Highly unlikely	Major	Moderate	Impact addressed within management plans (DSDMP) (Table 4-5).
Heritage (High)	Unplanned – Impacts to Aboriginal heritage sites/places	The trunkline alignment has been selected to avoid any impacts to the site adjacent to the shore crossing. Direct impacts to the heritage site adjacent to the shore crossing site would be avoided by implementing the management measures proposed in Section 4.6.6, which includes the requirements to appropriately fence the area and include appropriate inductions for site personnel. All other construction activities would be undertaken in previously disturbed areas and unlikely to impact heritage sites. The Dampier Archipelago (including Burrup Peninsula) is an Indigenous class feature on the National Heritage List and it includes the surrounding waters of some of the islands (Figure 2-5). Direct and indirect impacts to the heritage place because of water quality impacts from planned (dredging activities) and/or unplanned events (risk of an oil spill) have the potential to occur but are unlikely to be significant as discussed in Section 5.	Highly unlikely	Slight	Low	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Impact described qualitatively supported by relevant literature review. Heritage impact assessment to consider impacts of the project on heritage values.
	Unplanned – Impacts to non Aboriginal heritage sites/places	There are no listed shipwrecks and/or maritime archaeological sites or non-Aboriginal heritage sites in close proximity to the development envelope and therefore impacts on these are unlikely.	No impacts predicted	No impacts predicted	No impacts predicted	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
Potential impacts during operation						
Land use and settlements (High)	Planned – Physical presence of trunkline on seabed within Port of Dampier waters displacing other users	The trunkline would be laid on the seabed parallel and close to the existing Pluto LNG Facility trunkline. The shore crossing site is located at the Pluto LNG Facility in a previously disturbed area in an industrial zone. The Proposal is unlikely to substantially affect land use of the area. Consultation and appropriate approvals would be obtained from relevant stakeholders.		Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
Shipping (High)	Planned – Physical presence of trunkline on seabed within Port of Dampier waters displacing other users	The trunkline presents a potential navigational hazard though this is minimised as it would be located away from existing shipping channels except where it crosses the NWSV shipping channel. The Pluto LNG Facility trunkline also crosses this channel and there have not been any prior incidents relating to the presence of this trunkline. The trunkline would be added to navigational charts and is at sufficient depth to allow sufficient clearance.		Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
Tourism (High)	Planned – Physical presence of trunkline on seabed within Port of Dampier waters displacing other users	Existing gas trunklines are currently popular with recreational fishers as they have created an artificial fish habitat. The Proposal is likely to have a similar effect and has the potential to become a destination. No other long term operational impacts on tourism are likely.		Slight	Minor (positive)	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
	Unplanned – Hydrocarbon leak from the trunkline	The trunkline would be protected by being buried within a trench below sediment and/or rock which would prevent physical damage from accidental collisions with external elements (e.g. anchors). Section 4.4.5 has assessed the potential risk and impacts on water and sediment quality resulting from a hydrocarbon leak from the trunkline, which has a remote potential to occur taking into consideration the management measures recommended in Section 4.4.5. It has been assessed impacts to water quality would be highly localised around the release point with no predicted contact with the shoreline. Potential impacts to tourism are therefore likely to be low.	Remote	Minor	Low	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).

Receptor (value)	Aspect/Impact	Assessment of Impact to Receptor	Likelihood (Unplanned impacts only)	Magnitude	Impact Significance Level/Environment Risk Consequence	Further work proposed
Fisheries (Moderate)	Planned – Physical presence of trunkline on seabed within Port of Dampier waters displacing other users	Section 4.3 and Section 4.5 assessed the potential impacts of the trunkline on benthic communities and habitats and marine fauna respectively. The conclusions were that long term impacts would be negligible on these factors. The proposed trunkline would be located parallel and in close proximity to the existing Pluto LNG Facility trunkline to the east. As a result, the proposed trunkline is unlikely to substantially impact commercial fisheries through the removal of potential fishing grounds, including those using trawls/nets. The trunkline has the potential to provide an artificial fish habitat and attract marine fauna.		Slight	Minor	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP.
	Unplanned – Hydrocarbon leak from the trunkline	The trunkline would be protected by being buried within a trench below sediment and/or rock which would prevent physical damage from accidental collisions with external elements (e.g. anchors). Section 4.4.5 has assessed the potential risk and impacts on water and sediment quality resulting from a hydrocarbon leak from the trunkline, which has a remote potential to occur taking into consideration the management measures recommended in Section 4.4.5. Furthermore, no important fishing grounds are likely to be impacted.	Remote	Minor	Low	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
Heritage (High)	Planned – Physical presence of trunkline on seabed within Port of Dampier waters	The trunkline would be located away from any heritage sites and is unlikely to impact these directly or indirectly.	No impacts predicted	No impacts predicted	No impacts predicted	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).
	Unplanned – Hydrocarbon leak from the trunkline	The trunkline would be protected by being buried within a trench below sediment and/or rock which would prevent physical damage from accidental collisions with external elements (e.g. anchors). Section 4.4.5 has assessed the potential risk and impacts on water and sediment quality resulting from a hydrocarbon leak from the trunkline, which has a remote chance of occurring taking into consideration the management measures recommended in Section 4.4.5. A gas leak from the trunkline is unlikely to result in substantial water quality impacts at heritage sites.	Remote	Minor	Low	Stakeholders consulted to discuss the Proposal and potential impacts, development of a SEP. Potential impacts from oil spills will be assessed as part of the Oil Spill Modelling. Environmental Impact Thresholds will be defined and used to assess the potential Zone of Consequence (ZoC).

4.6.6 Mitigation

Table 4-19 details the mitigation measures to be implemented to avoid and minimise impacts to ensure the environmental objectives are met.

4.6.7 Assumptions and predicted outcome

Impacts would be further addressed within management documentation, through the additional studies described in Section 4.6.3 and through consultation with relevant stakeholders as described in Section 3.However, based on the preliminary impact assessment using available information, the Proposal is unlikely to result in the significant harm of the social surrounding and would therefore meet the EPA objectives:

- Long term impacts from the physical presence of a trunkline within Mermaid Sound are likely to be minor. The proposed trunkline has been positioned parallel and close to an existing trunkline and the shore crossing site has been located at the Pluto LNG Facility in a previously disturbed area.
- Construction impacts would generally be minor and temporary and mostly related to the presence of construction vessels within Mermaid Sound and/or temporary impacts to water quality from dredging activities during the construction period. These would generally have a minor impact on social surrounding receptors.
- Proposed mitigation measures (Section 4.6.6) have been recommended to avoid and/or minimise expected impacts and there is unlikely to be significant residual impacts. Management measures would be further refined during the development of the management plans and consultation with relevant stakeholders as described in Section 3.

Table 4-19: Social surrounding – Mitigation measures

Receptor	Impact	Mitigation
All	General impacts on stakeholders	A Stakeholder Engagement Plan (SEP) would be prepared and implemented to ensure all relevant stakeholders are adequately informed of the Proposal, including details of any relevant discrete construction activities and timing, during all stages of the development.
Shipping	Shipping impacts	The final approved alignment of the trunkline will be provided to relevant agencies (Pilbara Ports Authority, Department of Transport) and added to navigational charts. Construction vessel movements and construction activities must be managed to avoid impacting the shipping channels within Mermaid Sound. In particular, the trunkline across the NWS shipping channel must be installed so as to avoid any impacts to shipping. PPA will be consulted on the on the construction methodology and timing for the installation of this section. Appropriate exclusions zones for other vessels around construction activities such as dredging and pipelay activities would be established.
Settlements	Air quality impacts	Rock material to be sourced from approved quarries in the locality or from overseas. All truck loads carrying material with the potential to create dust would be appropriately covered and/or routes selected to avoid sensitive receivers.
	Noise impacts	Where possible, heavy vehicle transport routes will be selected to avoid passing through sensitive noise receivers.
	Traffic and access impacts (road)	Existing access roads complying with required heavy loads will be used to access shore crossing site and/or jetties. These will be identified in the CEMP prior to construction. No new access tracks would be constructed.
Heritage	Aboriginal heritage impacts	The Aboriginal heritage site 19675 (Holden Point Quarry A and accompanying conservation zone) adjacent to the shore crossing site must be appropriately fenced and designated as a no access area during construction. Additionally, the fence will be covered with dust-suppression barrier and signage clearly delineating the heritage no-go area. Regular audits of the heritage site and effectiveness of the barrier fencing will be conducted on at least a quarterly basis and a final inspection, with traditional owners and a qualified archaeologist, will be conducted at the end of the civil works phase to detail all heritage protection works, interim audits and final condition audit. Heritage sites, including the Dampier Archipelago (including Burrup Peninsula), will be identified in the CHMP and construction personnel will be informed during onsite inductions of the sites and their heritage values and requirement to avoid impacts.
Fisheries and Tourism	Water quality impacts	Refer to mitigation measures in Section 4.4.6.
	Marine Fauna impacts	Refer to mitigation measures in Section 4.5.6.
	BCH impacts	Refer to mitigation measures in Section 4.3.6.

5 Matters of National Environmental Significance

5.1 Commonwealth legislation and policy

5.1.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act establishes a requirement for Commonwealth environmental assessment and approval for actions that are likely to have a significant impact on any MNES, including:

- World Heritage properties
- National Heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species and ecological communities
- migratory species protected under international agreements
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mines)
- a water resource, in relation to coal seam gas development and large coal mining development.

Other matters protected under the EPBC Act include:

- the environment where actions proposed are on, or will affect Commonwealth land and the environment
- the environment where Commonwealth agencies are proposing to take an action.

When a proponent proposes to take an action that they believe may need approval under the EPBC Act, they must refer the proposed action to the Australian Government Minister for the Environment (the Minister). The purpose of the referral is to determine whether a proposed action is a 'controlled action' and thereby requires approval under the EPBC Act. If the Minister determines that a proposed action is a controlled action, it would then proceed through the Commonwealth assessment and approval processes.

5.1.2 EPBC Act Environmental Offsets Policy

The EPBC Act Environmental Offsets Policy (2012) (EOP) outlines the Commonwealth Government's approach to the use of environmental offsets under the EPBC Act. The EOP applies to both project-by-project assessments and approvals under Parts 8 and 9 of the EPBC Act.

The EOP provides a framework on the use of environmental offsets under the EPBC Act including when offsets are required, how offsets can be delivered, and the framework under which they operate.

Offsets are not required for all approvals under the EPBC Act and the EOP is only triggered when significant residual adverse impacts to matters protected under the EPBC Act are unavoidable. The EOP relates to all matters protected under the EPBC Act.

The EOP applies to offsetting requirements in both terrestrial and aquatic (including marine) environments. It requires that an environmental offset under the EPBC Act be suitable and 'delivers an overall conservation outcome that improves or maintains the viability of the protected matter(s).'

5.2 Assessment methodology

The assessment of impacts on MNES involved a three step process as illustrated in Figure 5-1:

1. Assess the likelihood of occurrence of the MNES, revealed through the database search and literature review as potentially occurring within the development envelope and/or 10 km buffer around the development envelope (Zone of Influence (ZoI)). Indirect impacts are not expected beyond 10 km based on the assessment of previous approvals and monitoring programs. The assessment process is described further in Section 5.2.1.
2. Where MNES have a moderate or high likelihood of occurring in the development envelope and/or zone of influence, assess the magnitude of the impact on the MNES and the impact significance level/environment risk consequence as per the methodology described in Section 4.2. This assessment is described further in Section 5.2.2.
3. Where the impact significance level or environment risk consequence is more than minor or moderate respectively, assess the significance of the impacts in accordance with relevant EPBC guidelines. This assessment is described further in Section 5.2.3.

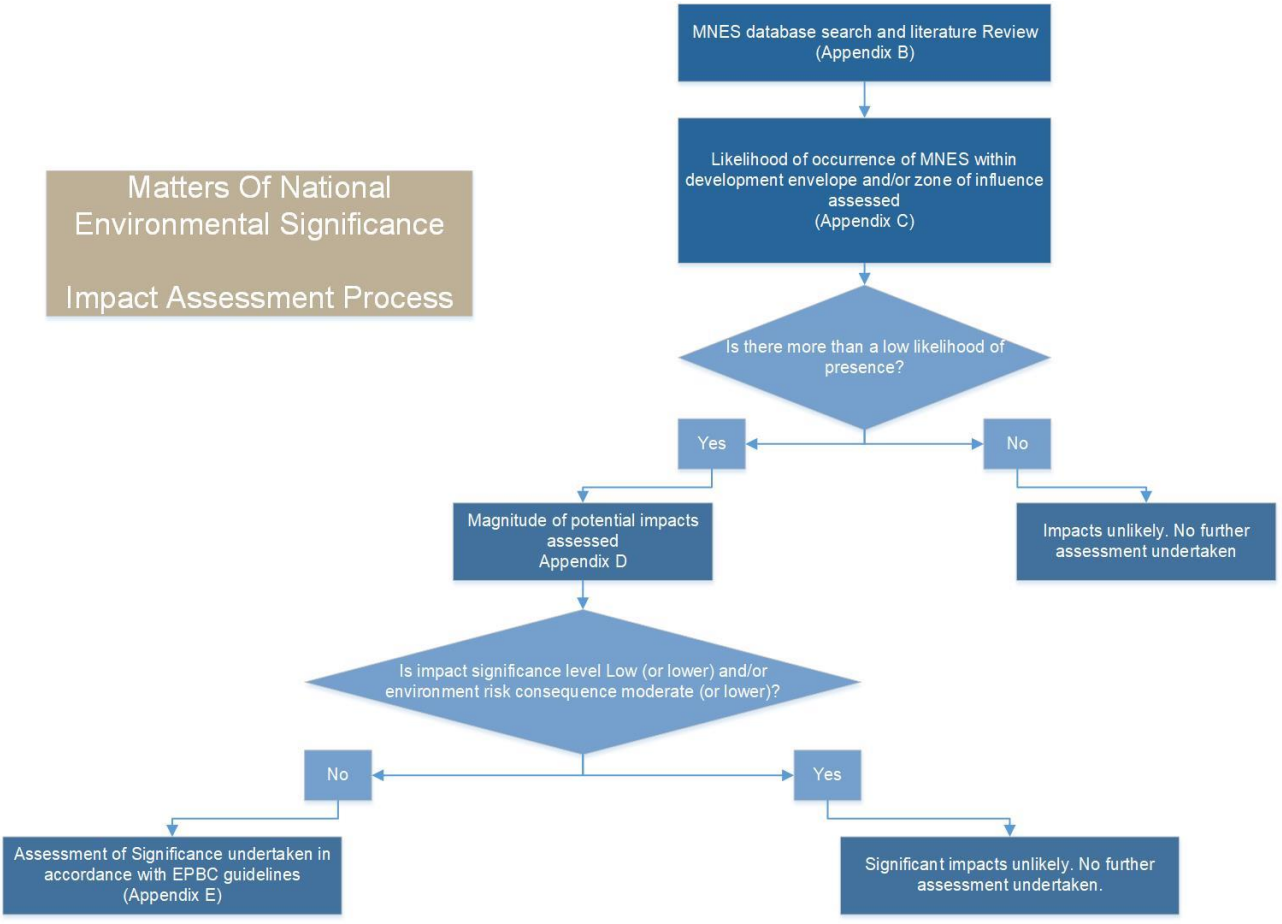


Figure 5-1: Environmental impact assessment process

5.2.1 Likelihood of occurrence

A search and review of the following databases and literature was undertaken to identify any MNES with the potential to occur in and around the development envelope:

- DoEE Protected Matters Search Tool with a 10 kilometre buffer around the development envelope (refer Appendix A)
- Dampier Archipelago Nature Reserves Management Plan 1999-2000 for a list of species known to occur in the Dampier Archipelago (DCLM, 1999).

The likelihood of occurrence assessment for threatened and migratory species was based upon publicly available species records and/or other information sources, such as field guides and web-based species profiles, including the Commonwealth Government's Species Profile and Threats Database (SPRAT) for the threatened species and ecological communities listed under the EPBC Act.

The likelihood of threatened flora and fauna species and ecological communities occurring in the development envelope and/or zone of influence has been assessed against the criteria outlined in Table 5-1.

Table 5-1: Likelihood of occurrence assessment criteria

Likelihood of occurrence	Criteria	Further assessment completed
Low	• Preferred habitat resources are not present in the development envelope/zone of influence. or • Development envelope/zone of influence is beyond the current known geographic range of the species. or • Considered extinct in the wild.	No
Moderate	• Species not previously recorded in the locality but development envelope/zone of influence is within the current known geographic range of the species and preferred habitat resources are present in the development area/zone of influence. or • Species previously recorded in the locality and has potential to pass through the development envelope/zone of influence but species not dependent on habitat resources present in the development envelope/zone of influence (i.e. vagrant individuals).	Yes, magnitude of impact assessed
High	• Species previously recorded in the locality and dependent on habitats or habitat resources that are available in the development envelope/zone of influence.	Yes, magnitude of impact assessed

5.2.2 Magnitude of impacts

Threatened and migratory species

The magnitude of the impact on the MNES and the impact significance level/environment risk consequence are determined in accordance with the methodology described in Section 4.2. When determining the impact significance level/environment risk consequence, the sensitivity of all species is considered high.

When assessing the magnitude of the impact and the impact significance level/environment risk consequence, consideration was given to:

- the likelihood of an impact taking into account the timing of construction activities and whether the species would be able to easily avoid any impact
- whether the impact would be temporary or permanent/long term
- the extent of the impact (e.g. will it affect a population, important or critical habitat; will it affect a small area of habitat relative to that retained).

The implementation of mitigation measures was only considered when determining the risk of impact (and significance of the impact), if the effectiveness of those measures is well-established (for example through demonstrated application, studies or surveys) and there is a high degree of certainty about avoiding impacts or the extent to which impacts will be reduced.

5.2.3 Assessment of significance

Where the impact significance level or environment risk consequence is more than minor or moderate respectively (and the risk is not a remote chance of occurring), the significance of the impacts on relevant species was assessed in accordance with the following guidelines:

- Matters of National Environmental Significance. Significant impact guidelines 1.2 Environment Protection and Biodiversity Conservation Act 1999 (Department of the Environment 2013)
- Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies. Significant impact guidelines 1.2 Environment Protection and Biodiversity Conservation Act 1999 (DSEWPaC, 2013).

The guidelines list criteria that need to be addressed to determine whether a proposal has the potential to have a significant impact on the MNES. The criteria for each relevant MNES that forms part of this Proposal are summarised in Table 5-2.

Table 5-2: Significant impact criteria

EPBC status	Criteria
Critically endangered and endangered species	An action is likely to significantly impact a critically endangered or endangered species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of a population • reduce the area of occupancy of the species • fragment an existing population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of a population • modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat • introduce disease that may cause the species to decline, or • interfere with the recovery of the species.
Vulnerable species	An action is likely to significantly impact a vulnerable species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of an important population of a species • reduce the area of occupancy of an important population • fragment an existing important population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of an important population • modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat • introduce disease that may cause the species to decline, or • interfere substantially with the recovery of the species.
Migratory species	An action is likely to significantly impact a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
National Heritage Place	An action is likely to significantly impact the National Heritage values of a National Heritage place if there is a real chance or possibility that it will cause: • one or more of the National Heritage values to be lost • one or more of the National Heritage values to be degraded or damaged, or • one or more of the National Heritage values to be notably altered, modified, obscured or diminished.

5.3 Summary of the Matters of National Environmental Significance assessment

This section summarises the assessment of the impacts on MNES. The detailed assessment of the potential impacts is presented in Appendix B (likelihood of occurrence), Appendix C (magnitude of impacts) and Appendix D (significance).

5.3.1 Summary of the likelihood of occurrence assessment

Table 5-3 and Table 5-4 assess the likelihood of the MNES, revealed through the protected matters search tool, that may be present within the development envelope and/or zone of influence. Table 5-4 summarises the threatened and/or migratory species likely to be present.

Table 5-3: MNES within or adjacent to the development envelope

Matters of National Environmental Significance	Presence
World heritage properties	No.
National heritage places	Yes, Dampier Archipelago (including Burrup Peninsula) (Section 4.6.4.5).
Wetlands of international importance (listed under the Ramsar Convention)	No.
Listed threatened species and ecological communities	Yes, refer to Appendix B for detailed assessment of likelihood of presence and Table 5-4 for list of species likely to occur.
Migratory species protected under international agreements	Yes, refer to Appendix B for detailed assessment of likelihood of presence and Table 5-4 for list of species likely to occur.
Commonwealth marine areas	Yes, the Proposal is in State waters and extends to the Commonwealth waters limit. Potential indirect impacts may occur.
The Great Barrier Reef Marine Park	No.
Nuclear actions (including uranium mines)	Not applicable.
A water resource, in relation to coal seam gas development and large coal mining development	Not applicable.

A number of the listed species likely to occur within the development envelope and/or zone of influence have Biologically Important Areas (BIAs) that intersect the development envelope and/or zone of influence. BIAs are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting or migration. Species with BIAs that intersect the development envelope and/or zone of influence are highlighted in Table 5-4 and the BIAs are illustrated in Figure 4-6 to Figure 4-8.

Table 5-4: Listed threatened and migratory species likely to be present within the development envelope and/or zone of influence. Species highlighted in green have BIAs that intersect the development envelope and/or zone of influence.

Species	Status EPBC Act	Status WC Act
Birds		
Actitis hypoleucos Common Sandpiper	Migratory	
Anous stolidus Common Noddy	Migratory	
Ardenna pacifica Wedge-tailed Shearwater	Migratory	
Arenaria interpres Ruddy Turnstone	Migratory	
Calidris acuminate Sharp-tailed Sandpiper	Migratory	
Calidris alba Sanderling	Migratory	
Calidris canutus Red Knot	Endangered, Migratory	Vulnerable
Calidris ferruginea Curlew Sandpiper	Critically Endangered, Migratory	Vulnerable
Calidris melanotos Pectoral Sandpiper	Migratory	
Calidris ruficollis Red-necked Stint	Migratory	
Calidris subminuta Long-toed Stint	Migratory	
Calidris tenuirostris Great Knot	Critically Endangered, Migratory	Vulnerable
Calonectris leucomelas Streaked Shearwater	Migratory	
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover	Vulnerable, Migratory	Vulnerable
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	Endangered, Migratory	Endangered
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory	
Fregata ariel Lesser Frigatebird, Least Frigatebird	Migratory	
Glareola maldivarum Oriental Pratincole	Migratory	
Hydroprogne caspia Caspian Tern	Migratory	
Limicola falcinellus Broad-billed Sandpiper	Migratory	
Limosa lapponica Bar-tailed Godwit	Migratory	Vulnerable
Limosa lapponica baueri Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	Vulnerable	Vulnerable
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit	Critically Endangered	Vulnerable
Limosa limosa Black-tailed Godwit	Migratory	

Species	Status EPBC Act	Status WC Act
Macronectes giganteus Southern Giant-Petrel	Endangered	
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew	Critically Endangered, Migratory	Vulnerable
Numenius phaeopus Whimbrel	Migratory	
Onychoprion anaethetus Bridled Tern	Migratory	
Pandion haliaetus Osprey	Migratory	
Phalaropus lobatus Red-necked Phalarope	Migratory	
Pluvialis fulva Pacific Golden Plover	Migratory	
Pluvialis squatarola Grey Plover	Migratory	
Sterna dougallii Roseate Tern	Migratory	
Sternula nereis nereis Australian Fairy Tern	Vulnerable	Vulnerable
Thalasseus bergii Crested Tern	Migratory	
Tringa brevipes Grey-tailed Tattler	Migratory	
Tringa nebularia Common Greenshank, Greenshank	Migratory	
Tringa stagnatilis Marsh Sandpiper, Little Greenshank	Migratory	
Tringa totanus Common Redshank, Redshank	Migratory	
Xenus cinereus Terek Sandpiper	Migratory	
Mammals		
Dugong dugon Dugong	Migratory	Other Protected Fauna
Megaptera novaeangliae Humpback Whale	Vulnerable, Migratory	Conservation Dependent
Sousa chinensis Indo-Pacific Humpback Dolphin	Migratory	
Tursiops aduncus Spotted Bottlenose Dolphin	Migratory	
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake	Critically Endangered	Critically Endangered
Caretta caretta Loggerhead Turtle	Endangered, Migratory	Endangered
Chelonia mydas Green Turtle	Vulnerable, Migratory	Vulnerable
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered, Migratory	Vulnerable
Eretmochelys imbricata Hawksbill Turtle	Vulnerable, Migratory	Vulnerable

Species	Status EPBC Act	Status WC Act
Natator depressus Flatback Turtle	Vulnerable, Migratory	Vulnerable
Fish		
Anoxypristis cuspidate Narrow Sawfish, Knifetooth Sawfish	Migratory	
Carcharias taurus Grey Nurse Shark	Vulnerable	Vulnerable
Carcharodon carcharias White Shark, Great White Shark	Vulnerable, Migratory	Vulnerable
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	Migratory	
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	Migratory	
Pristis clavata Dwarf Sawfish, Queensland Sawfish	Vulnerable, Migratory	
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable, Migratory	Vulnerable

5.3.2 Summary of the magnitude of impacts assessment

An assessment of the magnitude of the impact on MNES with a potential to occur within the development envelope and/or zone of influence is detailed in Appendix C. Planned and unplanned activities/events considered when assessing whether a species has the potential to be directly and/or indirectly impacted are detailed in Table 5-5.

Table 5-5: Potential impacts on MNES

Project phase	Aspect/impact	Direct/indirect impact
Construction	Planned – Noise impacts	Indirect
	Planned – Light emissions	Indirect
	Planned – air quality impacts from emissions during construction	Indirect
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	Indirect
	Planned – Reduced water quality from other construction activities (e.g. routine vessel discharges)	Indirect
	Planned – Removal of important/critical habitats	Indirect
	Planned – Sedimentation of important/critical habitats	Indirect
	Unplanned – Vessel strikes	Direct
	Unplanned – Entrainment during dredging	Direct
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	Indirect
	Unplanned – Introduction of IMS	Indirect
Operation	Planned – New habitat created due to presence of trunkline	Indirect
	Unplanned – Reduced water quality due to hydrocarbon spill from trunkline	Indirect

Based on the assessment in C, the species listed in Table 5-6 have the potential to be impacted with a more than minor impact significance level and/or more than moderate environment risk consequence (and the risk is not a remote chance of occurring). Assessments of significance in accordance with EPBC guidelines have been undertaken for these in Section 5.3.3.

Table 5-6: Threatened and migratory species with the potential to be impacted (at an impact significance level above Minor for planned impacts or risk consequence level above moderate for unplanned impacts) as a result of the Proposal

Species and listing	Impacts as described in Table 5-5	Potential to be impacted at a more than minor impact significance level and/or more than moderate environment risk consequence?
Mammals		
Dugong Dugon Dugong (EPBC – Migratory, WA – Other protected fauna)	Planned – Noise impacts	Y
	Planned – Light emissions	N
	Planned – air quality impacts from emissions during construction	N
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	Y
	Planned – Reduced water quality from other construction activities (e.g. routine vessel discharges)	N
	Planned – Removal of important/critical habitats	N
	Planned – Sedimentation of important/critical habitats	Y
	Unplanned – Vessel strikes	N
	Unplanned – Entrainment during dredging	N
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	N
	Unplanned – Introduction of IMS	N
	Planned – New habitat created due to presence of trunkline	N
	Unplanned – Reduced water quality due to hydrocarbon spill from trunkline	N
Megaptera novaeangliae Humpback Whale (EPBC – Vulnerable, Migratory, WA – Conservation Dependent)	Planned – Noise impacts	Y
	Planned – Light emissions	N

Species and listing	Impacts as described in Table 5-5	Potential to be impacted at a more than minor impact significance level and/or more than moderate environment risk consequence?
Sousa chinensis Indo-Pacific Humpback Dolphin (EPBC – Migratory) *Tursiops aduncus* Spotted Bottlenose Dolphin (EPBC – Migratory)	Planned – air quality impacts from emissions during construction	N
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	N
	Planned – Reduced water quality from other construction activities (e.g. routine vessel discharges)	N
	Planned – Removal of important/critical habitats	N
	Planned – Sedimentation of important/critical habitats	N
	Unplanned – Vessel strikes	N
	Unplanned – Entrainment during dredging	N
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	N
	Unplanned – Introduction of IMS	N
	Planned – New habitat created due to presence of trunkline	N
	Unplanned – Reduced water quality due to hydrocarbon spill from trunkline	N
Reptiles		
Caretta caretta Loggerhead Turtle (EPBC – Endangered, Migratory, WA – Endangered) *Chelonia mydas* Green Turtle (EPBC – Vulnerable, Migratory, WA – Vulnerable) *Dermochelys coriacea* Leatherback Turtle, Leathery Turtle, Luth (EPBC – Endangered, Migratory, WA – Vulnerable) *Eretmochelys imbricata* Hawksbill Turtle (EPBC – Vulnerable, Migratory, WA – Vulnerable)	Planned – Noise impacts	Y
	Planned – Light emissions	Y
	Planned – air quality impacts from emissions during construction	N
	Planned – Reduced water quality from dredging activities (e.g. increased turbidity)	N

Species and listing	Impacts as described in Table 5-5	Potential to be impacted at a more than minor impact significance level and/or more than moderate environment risk consequence?
Natator depressus Flatback Turtle (EPBC – Vulnerable, Migratory, WA – Vulnerable)	Planned – Reduced water quality from other construction activities (e.g. routine vessel discharges)	N
	Planned – Removal of important/critical habitats	N
	Planned – Sedimentation of important/critical habitats	N
	Unplanned – Vessel strikes	N
	Unplanned – Entrainment during dredging	Y
	Unplanned – Reduced water quality due to oil spill from construction vessels/equipment	N
	Unplanned – Introduction of IMS	N
	Planned – New habitat created due to presence of trunkline	N
	Unplanned – Reduced water quality due to hydrocarbon spill from trunkline	N

*Impacts with more than minor impact significance level and/or more than moderate environment risk consequence. Refer to Table 5-5 for a description of impacts assessed and Appendix C for a detailed impact assessment.

5.3.3 Summary of assessments of significance

The detailed assessments of significance are provided in Appendix D and summarised in Table 5-7. In determining whether a potential impact on a MNES is significant, the impact has to have a 'real chance or possibility' of occurring. Of the unplanned events listed in Table 5-5, reduced water quality due to an oil spill from the trunkline is considered a remote possibility of occurring as discussed in Section 4.4.5.1.

As such this potential event is not considered when assessing whether the Proposal has the potential to have a significant impact.

With the implementation of the management measures detailed in Section 5.4, none of the MNES have the potential to be significantly impacted by the Proposal.

Table 5-7: Assessments of significance

MNES	Assessment of significance									Significant impact?
Endangered species*[1]	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	
Caretta caretta Loggerhead Turtle	N	N	N	N	N	N	N	N	N	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality, construction noise and light pollution as well as potential direct impacts from vessel strikes and/or entrainment during dredging. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Vulnerable species*[2]	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	
Megaptera novaeangliae Humpback Whale	N	N	N	N	N	N	N	N	N	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality and construction noise as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Chelonia mydas Green Turtle	N	N	N	N	N	N	N	N	N	The Proposal would not result in permanent or long term impacts to any of the species or their habitats. Impacts would occur during construction and result in temporary localised degradation of water quality, construction noise and light pollution as well as potential direct impacts from vessel strikes and/or entrainment during dredging. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	N	N	N	N	N	N	N	N	N	
Eretmochelys imbricata Hawksbill Turtle	N	N	N	N	N	N	N	N	N	
Natator depressus Flatback Turtle	N	N	N	N	N	N	N	N	N	
Migratory species*[3]	***1***			***2***			***3***			
Dugong dugon Dugong	N			N			N			The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Megaptera novaeangliae Humpback Whale	N			N			N			The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.

MNES	Assessment of significance			Significant impact?
Sousa chinensis Indo-Pacific Humpback Dolphin	N	N	N	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Tursiops aduncus Spotted Bottlenose Dolphin	N	N	N	
Caretta caretta Loggerhead Turtle	N	N	N	The Proposal would not result in permanent or long term impacts to any of the species or their habitats. Impacts would occur during construction and result in temporary localised degradation of water quality, construction noise and light pollution as well as potential direct impacts from vessel strikes and/or entrainment during dredging. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Chelonia mydas Green Turtle	N	N	N	
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	N	N	N	
Eretmochelys imbricata Hawksbill Turtle	N	N	N	
Natator depressus Flatback Turtle	N	N	N	
National Heritage Place*[4]	***1***	***2***	***3***	
Dampier Archipelago (including Burrup Peninsula)	N	N	N	The proposal is highly unlikely to result in significant impacts to the heritage values of the heritage place considering the distance of the proposal to the heritage place and the likely minor impacts that would result from both planned and unplanned events during construction. Management measures have also been recommended to further minimise the risk of any impacts.

*[1] An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of a population
2. reduce the area of occupancy of the species
3. fragment an existing population into two or more populations
4. adversely affect habitat critical to the survival of a species
5. disrupt the breeding cycle of a population
6. modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
7. result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
8. introduce disease that may cause the species to decline, or
9. interfere with the recovery of the species.

*[2] An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species
2. reduce the area of occupancy of an important population

3. fragment an existing important population into two or more populations
4. adversely affect habitat critical to the survival of a species
5. disrupt the breeding cycle of an important population
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
8. introduce disease that may cause the species to decline, or
9. interfere substantially with the recovery of the species.

*[3] An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

1. substantially modify (including by fragmenting or by altering fire regimes, nutrient cycles or hydrological cycles), destroy or isolate an area of important habitat for a migratory species
2. result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or
3. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

*[4] An action is likely to have a significant impact on the National Heritage values of a National Heritage place if there is a real chance or possibility that it will cause:

1. one or more of the National Heritage values to be lost
2. one or more of the National Heritage values to be degraded or damaged, or
3. one or more of the National Heritage values to be notably altered, modified, obscured or diminished.

5.4 Proposed mitigation and offsets

5.4.1 Mitigation

Table 5-8 details the proposed mitigation measures to be implemented to ensure potential impacts to MNES are avoided and/or minimised to an acceptable level and impacts are not significant.

Table 5-8: MNES mitigation measures

Receptor	Impact	Mitigation
Marine Fauna	All impacts	Marine fauna will be considered in the Dredging and Spoil Disposal Management Plan (DSDMP) to avoid and minimise impacts. As a minimum the plan will include the following mitigation measures: • Requirement for inductions for onsite personnel which will highlight the MNES potentially occurring within the waters of the Dampier Archipelago and the need to avoid impacts. • Measures to avoid direct vessel strikes with marine fauna. Support vessels will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1. • Noise management procedures to avoid permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine fauna and minimise behavioural responses, particularly during any pile driving activities will be developed. The procedure must determine the area (radius) around which piling activities and other noise generating activities would have a potential PTS/TTS and include a soft start approach to enable any fauna to move away. • Measures to avoid and/or minimise direct and indirect impacts on turtles (e.g. vessel strikes, entrainment, lighting). • Measures to avoid the introduction of invasive marine species (IMS) including:

Receptor	Impact	Mitigation
		– Implementation of Woodside's IMS Management Plan (including risk based assessment and implementation of management options as required by the plan) to reduce the risk of introducing IMS to Australian waters. This may include inspections prior to entry into Australian waters and the use of antifouling coating. – All vessels will be required to meet both Commonwealth and State ballast water and biofouling legislation and guidelines including the Ballast Water Management Requirements and the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry. • Sightings and locations of marine fauna must be recorded in the vessel's daily log book. • Any incidents relating to marine fauna injury/mortality must be documented and reported to relevant regulators.
	Water quality impacts from waste	• Waste on vessels and on shore must be securely stored through the provision of appropriate waste receptacles and suitable containment measures such as lids or netting to minimise the likelihood of any loss of wastes to the marine environment. • Generated inorganic non-hazardous solid waste will be transported onshore to an appropriate waste disposal site in accordance with MARPOL 73/78 Annex V: Garbage (as implemented in Commonwealth waters by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*) and Marine Orders – Part 95: Marine Pollution Prevention – Garbage. • No routine discharge of inorganic non-hazardous solid waste will take place at sea in accordance with Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act* 1983 – Parts IIIA and IIIC.
	Water quality impacts from dredging	A project Dredge Management Plan will be in place to manage any water quality impacts associated with the trenching and backfill activities.
	Water quality impacts from accidental oil spill	An oil spill contingency plan will be prepared and implemented in the event of an oil spill. The plan must include as a minimum an assessment of the oil spill risk, ensure the effective and timely management of hydrocarbon spills, describe the procedure for management of hydrocarbon spills and provide for prompt notification of regulatory agencies in the event of a spill.
Aboriginal Heritage – Dampier Archipelago (including Burrup Peninsula)	General disturbance	Heritage sites, including the Dampier Archipelago (including Burrup Peninsula), will be identified in the HEMP and construction personnel will be informed during onsite inductions of the sites and their heritage values and requirement to avoid impacts.

5.4.2 Offsets

There were no significant residual impacts of the proposal identified, therefore no offsets are proposed.

6 Holistic impact assessment

The Proposal is not expected to represent a significant environmental risk. The EP Act Principles and relevant EPA guidance have been considered when assessing the potential risks and impacts of the Proposal on the identified Environmental Factors. Potential environmental impacts have been considered in the Proposal design and the trunkline route has been selected to avoid sensitive receptors where possible.

Further studies and management plans have been identified where required to provide additional certainty on the nature and scale of identified impacts and these will be completed prior to the commencement of construction.

Evaluation of impacts against all relevant environmental factors determined that the EPA's objectives were considered to be met. Specifically, for the key environmental factors, the following outcomes were predicted:

- Benthic Communities and Habitats – Significant residual impacts are not predicted from the Proposal and therefore the diversity and ecological integrity of BCH will be maintained.
- Marine Environmental Quality – Significant residual impacts are not predicted from the Proposal and therefore the environmental value and quality of water, sediment and biota will be maintained.
- Marine Fauna – Significant residual impacts are not predicted from the Proposal and therefore the diversity and ecological integrity of Marine Fauna will be maintained.
- Social Surroundings – Significant residual impacts are not predicted from the Proposal and therefore no significant impacts to social surroundings are expected.

The assessment of impacts on matters of national environmental significance demonstrates that no significant impacts are expected from the Proposal.

7 References

Advisian 2017, Chemical and Ecological Monitoring of Mermaid Sound: 2017 Compliance Report. Prepared for Woodside.

AME 2006, Port Phillip Bay Channel Deepening Project, Supplementary Environmental Effects Statement – Marine Ecology Specialist Studies Volume 2: Microphytobenthos, Report 351. *Australian Marine Ecology*. Kensington, Victoria.

Babcock, R, Gilmour, J and Thomson, D 2017, Measurement and modelling of key demographic processes in corals of the Dampier Archipelago. Report of Theme 4 – Project 4.7, prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 43pp.

Baird, AH, Blakeway, DR, Hurley, TJ, Stoddart, JA 2011, *Marine Biology*, 158: 275. https://doi.org/10.1007/s00227-010-1557-7.

Bancroft, KP, and Sheridan, MW 2000, The Major Marine Habitats of the Proposed Dampier Archipelago/Cape Preston Marine Conservation Reserve. Marine Conservation Branch, Department of Conservation and Land Management, MRI/PI/DAR-49/2000.

Beardall, J, and Light, B 1997, Microphytobenthos in Port Phillip Bay: distribution and primary productivity. Technical Report No.30. CSIRO Port Phillip Bay Environmental Study. Canberra.

Bertolino, C 2006, Seagrasses of the Port of Dampier: Distribution, Abundance, and Morphology. Unpublished thesis presented for the degree of Bachelor of Science (Marine Science) Honours of the University of Western Australia, 2006.

Blakeway, DR 2005, Patterns of mortality from natural and anthropogenic influences in Dampier corals: 2004 cyclone and dredging Impacts. In: (ed.) Stoddard, JA and Stoddard, SE 2004, Corals of the Dampier Harbour, their survival and reproduction during the dredging programs of 2004. Report prepared for DPA and Pilbara Iron.

Blakeway, DR, and Radford, B 2005, Scleractinian corals of the Dampier Port and Inner Mermaid Sound: Species list, community composition and distributional data. In: (ed.) Stoddard, JA and Stoddard, SE 2004, Corals of the Dampier Harbour, their survival and reproduction during the dredging programs of 2004. Report prepared for DPA and Pilbara Iron.

Brewer, D, Lyne, V, Skewes, T, and Rothlisberg, P 2007, Tropic systems of the North West Marine Region. A report to the Department of the Environmental, Water, Heritage and the Arts, by CSIRO Marine and Atmospheric Research.

Bonfil, R, Meÿer, M, Scholl, MC, Johnson, R, O'Brien, S, Oosthuizen, H, Swanson, S, Kotze, D and Paterson, M 2005, Transoceanic Migration, Spatial Dynamics, and Population Linkages of White Sharks. *Science*. 310:100–103. Available from: http://www.sciencemag.org/cgi/content/abstract/sci310/5745/100.

Bruce, GD, Stevens, JD and Malcolm, H 2006, Movements and swimming behaviour of white sharks (*Carcharodon carcharias*) in Australian waters. *Marine Biology*. 150:161-172. Available from: http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=5&hid=15&sid=e92b4861-0c33-4972-81be-796819288dd2%40sessionmgr4.

CALM – See Department of Conservation and Land Management.

CSIRO, 2007, Northwest Shelf Joint Environmental Management Study Final Report, CSIRO Marine and Atmospheric Research.

CSIRO – See Commonwealth Scientific and Industrial Research Organisation.

Dampier Port Authority 2014, Port of Dampier Land use and infrastructure plan 2014.

DEC – See Department of Environment and Conservation.

Deakos, MH, Baker, JD, and Bejder, L 2011, Characteristics of a manta ray *Manta alfredi* population off Maui, Hawaii and implications for management. *Marine Ecology Progress Series* 420: 245-260 (PDF) Manta alfredi. Available from: https://www.researchgate.net/publication/263974440_Manta_alfredi [accessed Nov 08 2018].

Department of Conservation and Land Management, 2005, Indicative Management Plan for the Proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area. Department of Conservation and Land Management, Western Australia.

Department of Environment 2006, Pilbara Coastal Water Quality Consultation Outcomes — Environmental Values and Environmental Quality Objectives, Department of Environment, Government of Western Australia, Marine Series Report No. 1.

Department of Environment and Conservation 2006, Background quality of the marine sediments of the Pilbara coast. Department of Environment and Conservation, Marine Technical Report Series, No. MTR 1.

Department of Environment, Heritage, Water and the Arts 2008a, The North-west Marine Bioregional Plan, Bioregional Profile – A description of the ecosystems, conservation values and uses of the North-west Marine Region. Department of the Environment, Water, Heritage and the Arts. Australian Government.

Department of Environment, Heritage, Water and the Arts 2008b, A Characterisation of the Marine Environment of the North-west Marine Region: Perth Workshop Report. A summary of an expert workshop convened in Perth, Western Australia, 5-6 September 2007, Department of the Environment, Water, Heritage and the Arts. Australian Government.

Department of Environment, Heritage, Water and the Arts 2012a, Species group report card – seabirds and migratory shorebirds; Supporting the marine bioregional plan for the North-west Marine Region. Department of the Environment, Water, Heritage and the Arts. Australian Government.

Department of Environment, Heritage, Water and the Arts 2012b, Species group report card – cetaceans; Supporting the marine bioregional plan for the North-west Marine Region. Department of the Environment, Water, Heritage and the Arts. Australian Government.

Department of Environment, Heritage, Water and the Arts 2012c, Species group report card – bony fishes; Supporting the marine bioregional plan for the North-west Marine Region. Department of the Environment, Water, Heritage and the Arts. Australian Government.

Department of Environment, Heritage, Water and the Arts 2012d, Species group report card – sharks and sawfishes; Supporting the marine bioregional plan for the North-west Marine Region. Department of the Environment, Water, Heritage and the Arts. Australian Government.

Department of Environment, Heritage, Water and the Arts 2012e, Species group report card – marine reptiles; Supporting the marine bioregional plan for the North-west Marine Region. Department of the Environment, Water, Heritage and the Arts. Australian.

Department of Sustainability, Environment, Water, Pollution and Communities 2013, Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies. Significant impact guidelines 1.2 Environment Protection and Biodiversity Conservation Act 1999.

Department of the Environment 2013, Matters of National Environmental Significance. Significant impact guidelines 1.2 Environment Protection and Biodiversity Conservation Act 1999.

Department of the Environment 2018a, Species Profile and Threats Database. Department of the Environment. Australian Government. Available from: http://www.environment.gov.au/sprat. Accessed: June 2018.

Department of the Environment 2018b, Key Ecological Features, in Species Profile and Threats Database. Department of the Environment. Australian Government. Available from: https://www.environment.gov.au/sprat-public/action/kef/search. Accessed: June 2018.

DEWHA – See Department of Environment, Heritage, Water and the Arts.

DoE – See Department of Environment.

DotE – See Department of the Environment.

Double, MC, Gales, N, Jenner, KCS and Jenner, MN 2010, Satellite tracking of south-bound humpback whales in the Kimberley region of Western Australia. Report to the Western Australian Marine Science Institution.

DPA – See Dampier Port Authority.

DSEWPaC – See Department of Sustainability, Environment, Water, Pollution and Communities.

Environmental Protection Authority 2001, Guidance Statement for Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline.

Environmental Protection Authority 2016a, Statement of Environmental Principles, Factors and Objectives, EPA, Western Australia.

Environmental Protection Authority 2016b, Environmental Factor Guideline: Benthic Communities and Habitats, EPA, Western Australia.

Environmental Protection Authority 2016c, Technical Guidance – Protection of Benthic Communities and Habitats, EPA, Western Australia.

Environmental Protection Authority 2016d, Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals, EPA, Western Australia.

Environmental Protection Authority 2016e, Environmental Factor Guideline: Marine Environmental Quality, EPA, Western Australia.

Environmental Protection Authority 2016f, Technical Guidance – Protecting the Quality of Western Australia's Marine Environment, EPA, Western Australia.

Environmental Protection Authority 2016g, Environmental Factor Guideline: Marine Fauna, EPA, Western Australia.

Environmental Protection Authority 2016h, Environmental Factor Guideline: Social Surroundings, EPA, Western Australia.

EPA – See Environmental Protection Authority.

ERM 2013a, Scarborough Marine Studies – Environmental Characterisation Report. Report prepared for Esso Australia Pty Ltd, by Environmental Resources Management Australia. Report Reference: 0177357.

ERM 2013b, Scarborough Project – Oil Spill Modelling Study. Report prepared for ExxonMobil Scarborough, by Environmental Resources Management Australia. Report Reference: 0176695.

ERM 2018, Scarborough FLNG Project – Cooling Water Discharge Study. Report prepared for Esso Australia Pty Ltd, by Environmental Resources Management Australia. Report Reference: 0176695.

Fromont, J 2003, Porifera (Sponges) In the Dampier Archipelago: Taxonomic Affinities and Biogeography. In: The Marine Flora and Fauna of Dampier, Western Australia. Eds. Wells, FE, Walker, DI and Jones DS.

Fromont, J 2004, Porifera (Sponges) of the Dampier Archipelago: Habitats and Distribution. In: (ed.). Jones DS, Marine Report on the Results of the Western Australian Museum/Woodside Energy. Exploration of the Marine Biodiversity of the Dampier Archipelago 1998-2002.

Fromont, J, Abdul W, Muhammad A, Gomez O, Ekins M, Grol M and Hooper J 2016, Patterns of Sponge Biodiversity in the Pilbara, Northwestern Australia. *Diversity*. 8. 21. 10.3390/d8040021.

Fugro 2010, Report on the Activity 2a Deepwater Field Development Geophysical AUV Survey, North West shelf, Australia, Volume 1. Report for ExxonMobil, Perth, Australia.

Fugro 2011, Scarborough LNG Project Metocean Measurement Programme. Report for ExxonMobil, Perth, Australia.

Fugro 2012, Scarborough Time Series, Temperature Statistics, and Current Profiles. Report for ExxonMobil, Perth, Australia.

Gage, JD 1996, Why are there so many species in deep-sea sediments? *Journal of Experimental Marine Biology and Ecology* 200:257-286.

Gaughan, DJ, and Santoro, K, (ed.) 2018, Status Reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

GHD 2016, Port of Dampier Sediment Sampling and Analysis: Chemical Analysis. Report prepared for the Pilbara Ports Authority.

Gilmour JP, Cooper TF, Fabricius KE, and Smith, LD 2006, Early Warning Indicators of Change in the Condition of Corals and Coral Communities in Response to Key Anthropogenic Stressors in the Pilbara, Western Australia. Australian Institute of Marine Science, Townsville, Qld.

Gilmour, J, Speed, C and Babcock, R 2016, Coral reproduction in Western Australia. *PeerJ* 4:e2010; DOI 10.7717/peerj.2010.

Griffith, JK 2004, Scleractinian corals collected during 1998 from the Dampier Archipelago, Western Australia. In: (ed.) Jones, DS, Report on the results of the Western Australian Museum/Woodside Energy Ltd. exploration of the marine biodiversity of the Dampier Archipelago 1998-2002.

Hale, PT, Barreto, AS and Ross, GJB 2000, Comparative Morphology and Distribution of the *aduncus* and *truncates* forms of Bottlenose Dolphin *Tursiops* in the Indian and Western Pacific Oceans. *Aquatic Mammals*. 26.2:101-110.

Harris, G, and Batly, G 1996, Port Phillip Bay Environmental Study Final Report. Commonwealth Scientific and Industrial Research Organisation (CSIRO). Canberra.

Heyward, AJ, Revill, AT and Sherwood, CR 2000, Review of Research and Data Relevant to Marine Environmental Management of Australia's North West Shelf. Produced for the Western Australian Department of Environmental Protection.

Huisman, JM 2004, Marine Benthic Flora of the Dampier Archipelago, Western Australia. In: (ed.) Jones DS, Report on the Results of the Western Australia Museum/ Woodside Energy Ltd Partnership to Explore the Marine Biodiversity of the Dampier Archipelago, 1998-2002 Records of the Western Australian Museum, Supplement No 66: pp v-xv, 1-401, Perth, WA, pp. 61–68.

Huisman, JM and Borowitzka, MA 2003, Marine benthic flora of the Dampier Archipelago, Western Australia. In: (ed.) Wells, RE, Walker, DI and Jones, DS 2003, The Marine Flora and Fauna of Dampier, Western Australia. Western Australian Museum, Perth.

International Risk Consultants Environment 2003a, Dampier Wharves and Channels Sediment Quality Survey – November 2002. Report prepared for Hamersley Iron.

International Risk Consultants Environment 2003b, Dampier Capital Dredging Sediment Quality Survey April 2003. Report prepared for Hamersley Iron.

IRCE – See International Risk Consultants Environment.

Jackson, KL, and Paling, EI 2006, Review of the Research and Data Relevant to the Marine and Terrestrial Environment of Dampier. Dampier, WA, Dampier Port Authority.

Jacobs 2015, Port of Dampier Marine Sediment Sampling: Marine Sediment Sampling Report. Report prepared for the Pilbara Ports Authority.

Jenner, KCS, Jenner, MN and McCabe, KA 2001, Geographical and temporal movements of humpback whales in Western Australian waters. *APPEA journal*. Page(s) 749-765.

Jones, DS 2001, Introduced Marine Species in the Dampier Archipelago. Report to Woodside Energy Ltd. Department of Aquatic Zoology, Western Australian Museum, Perth, Western Australia.

Jones, D (ed.) 2004, Report on the results of the Western Australian Museum/Woodside Energy Ltd. partnership to explore the marine biodiversity of the Dampier Archipelago Western Australia 1998–2002. Western Australian Museum Supplement No. 66, Perth, Western Australia.

Jones, R, Ricardo, G, Negri, A 2015a, Effects of sediments on the reproductive cycle of corals. *Marine Pollution Bulletin*. 100 (2015) 13–33 http://dx.doi.org/10.1016/j.marpolbul.2015.08.021.

Jones, R, Bessell-Browne, P, Fisher, R, et al., 2015b, Assessing the impacts of sediments from dredging on corals. *Marine Pollution Bulletin* 102:9–29. doi: 10.1016/j.marpolbul.2015.10.049.

Jones, R, Bessell-Browne, P, Fisher, R, Klonowski, W, Slivkoff, M 2017, Assessing the impacts of sediments from dredging on corals. Report of Theme 4 – Project 4.1 Dredging Science Node, Western Australian Marine Science Institution (WAMSI). Perth, Western Australia, 33pp.

Kogi, K, Toru, H, Imamura, A, Iwatani, T and Dudzinski, KM 2004, Demographic parameters of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) around Mikura Island, Japan. *Marine Mammal Science*. 20:510-526.

Last, PR and Stevens, JD 1994, Sharks and Rays of Australia. Melbourne, Victoria: CSIRO.

Laughlin Jr, RB, French, W and Guard, HE 1986, Accumulation of Bis (tributyltin) Oxide by the Marine Mussel Mytilus edulis. Naval Biosciences Laboratory, Naval Supply Center, University of California, Oakland, California 94625.

Lowe, R and Ghisalberti, M 2016, Sediment transport processes within coral reef and vegetated coastal ecosystems: a review. Report of Theme 3 - Project 3.1.2, prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 27 pp.

Marshall, AD, Compagno, LJV and Bennett, MB 2009, Redescription of the genus Manta with resurrection of Manta alfredi (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae). Zootaxa 2301: 1-28. (PDF) Manta alfredi. Available from: https://www.researchgate.net/publication/263974440_Manta_alfredi [accessed Nov 08 2018].

McAlpine, KW, Wenziker, KJ, Apte, SC and Masini, RJ 2004, Background quality for coastal marine waters of the North West Shelf, Western Australia. Technical Series 118, Department of Environment, Perth, Western Australia.

McArthur, C, Ferry, R and Proni J 2002, Development of guidelines for dredged material disposal based on abiotic determinants of coral reef community structure. In: Dredging '02. Key technologies for global prosperity. (ed.) Garbaciak, S Jr, Proceedings of the Third Specialty Conference on Dredging and Dredged Material Disposal, Orlando, Florida.

McCauley, RD 2011, Fugro Scarborough Sea Noise Logger Program: January 2010 to January 2011. Report prepared for Fugro Survey and Exxon Mobil, by Centre for Marine Science and Technology, Curtin University. Project CMST 874, Report R2011-50.

McMahon K, Statton, J and Lavery, P 2017, Seagrasses of the north west of Western Australia: biogeography and considerations for dredging-related research. Report of Theme 5 - Project 5.1.2 prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia. 39 pp.

Möller, LM, Beheregaray, LB, Harcourt, RG and Kruetzen, M 2001, Alliance membership and kinship in wild male bottlenose dolphins (*Tursiops aduncus*) of southeastern Australia. *Proceedings of the Royal Society of London: Series B Biological Sciences*. 268 (1479):1941-1947.

MScience, 2004, Dampier Harbour Port Upgrade – Extended Dredging Program: Sediment Quality Assessment; MSA17R3. Report prepared for Hamersley Iron Pty Ltd.

MScience, 2009, Water Quality Impacts for the Pluto program in an area of intensive dredging. Dampier Marine Services facility – MSA142R2.

MScience, 2010, Pluto LNG Development: Final Report on Coral and Water Quality Monitoring MSA93R160. Report prepared for Woodside Burrup Pty Ltd.

MScience, 2014, Dampier Port Authority Marine Environment: Distribution of Benthic Primary Producer Habitats within Port Waters. Report prepared for Dampier Port Authority.

MScience, 2018a, Marine Habitat Mapping: Dampier and Cape Lambert 2017. Unpublished report MSA264R01 to Rio Tinto, Perth Western Australia, pp13.

MScience, 2018b, Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program 2009. Unpublished report MSA271R01 to Worley Parsons, Perth Western Australia, pp31.

Murrell, MC, Campbell JC, et al., 2009, Effects of irradiance on benthic and water column processes in a Gulf of Mexico estuary: Pensacola Bay, Florida, USA. *Estuarine, Coastal and Shelf Science* 81: 501-512.

Paling EI 1986, The ecological significance of blue-green algal mats in the Dampier mangrove ecosystem. Department of Conservation and Environment. Perth, Western Australia

Paling, EI, and McComb, AJ 1994, Cyanobacterial mats: a possible nitrogen source to arid coast mangroves. *International Journal of Ecology and Environmental Science,* 20: 47-54.

Parra, GJ, and Cagnazzi, D 2016, Conservation Status of the Australian Humpback Dolphin (Sousa sahulensis) Using the IUCN Red List Criteria. Advances in *Marine Biology*. 73:157-192.

Paterson, RA 1990, Effects of long-term anti-shark measures on target and non-target species in Queensland, Australia. *Biological Conservation*. 52:147-159.

Pearce, A, Buchan, S, Chiffings, T, D'Adamo, N, Fandry, C, Fearns, P, Mills, D, Phillips, R and Simpson, C 2003, A review of the oceanography of the Dampier Archipelago, Western Australia. In: (ed.) Wells, FE, Walker, DI, and Jones, DS, The Marine Flora and Fauna of Dampier, Western Australia. Western Australian Museum, Perth, pp.13–50.

Pendoley K 2005, Agrium Pilbara Nitrogen Project. Sea turtle survey – Holden Beach 10 December 2005. Report prepared for URS.

Pendoley, K 2006, Pluto LNG Development Holden Beach – Beach Sea Turtle Habitat Use Survey. Pendoley Environmental Pty Ltd.

Penn, JW, Fletcher, WJ and Head, F (ed) 2005, State of the Fisheries Report 2003/04. Department of Fisheries, Western Australia.

Pogonoski, JJ, Pollard, DA and Paxton, JR 2002, Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes. Canberra, ACT: Environment Australia. Available from: http://www.environment.gov.au/coasts/publications/marine-fish-action/pubs/marine-fish.pdf.

Ross, GJB and Cockcroft, VG 1990, Comments on Australian Bottlenose Dolphins and Taxonomic Status of *Tursiops aduncus* (Ehrenberg, 1832). In: Leatherwood, S. & R.R. Reeves, (eds). The Bottlenose Dolphin. Page(s) 101-128. San Diego: Academic Press.

Schönberg CHL 2016, Effects of dredging on filter feeder communities, with a focus on sponges. Report of Theme 6 – Project 6.1 prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia. 139 pp.

Semeniuk, V, Chalmer PN, et al., 1982, The marine environments of the Dampier Archipelago. *Journal of the Royal Society of Western Australia*, 65 (3): 97-114.

Simpson, CJ 1985a, Environmental factors affecting coral growth in the Dampier Archipelago, Western Australia. Department of Conservation and Environment. Perth, Western Australia.

Simpson, CJ 1985b, Mass Spawning of Scleractinian Corals in the Dampier Archipelago and the Implications for Management of Coral Reefs in Western Australia. Perth, WA, Department of Environment and Conservation.

Simpson, CJ 1988, Ecology of scleractinian corals in the Dampier Archipelago, Western Australia. Technical Series, Western Australian Environmental Protection Authority. 23: 238.

Sinclair Knight Merz 2004), Dampier Port Upgrade Dredging and Disposal Management Plan. Final Revision. Report to Hamersley iron by Sinclair Knight Merz.

Stevens, JD 1999, Management of shark fisheries in northern Australia; Part 1. Shotton, R, (ed.) Case studies of the management of elasmobranch fisheries. FAO Fisheries Technical Paper. 378:456-479. FAO, Rome.

Stoddart, JA, and Gilmour, JP 2005, Patterns of reproduction of in-shore corals of the Dampier Harbour, Western Australia, and comparisons with other reefs. Corals of the Dampier Harbour: Their Survival and Reproduction during the Dredging Programs of 2004. Stoddart JA, and Stoddart SE. Perth, WA, MScience Pty Ltd: 53-64.

Talbot, V, and Creagh, S 1985, Mineralogical variation within the marine sediments of the Dampier region: a dynamic approach. Department of Conservation and Environment Western Australia.

Tzioumis, V, and Keable, S (Eds) 2007, Description of key species groups in the East Marine Region, final report to the Australian Government Department of the Environment, Water, Heritage and the Arts, Australian Museum, Sydney.

UNEP – see United Nations Environment Program.

United Nations Environment Program 2002, Dugong Status Report and Action Plans for Countries and Territories.

URS Australia Pty Ltd 2000, Values and Threats Proposed Dampier Archipelago Multiple Use Conservation Reserve and Dampier Port Limits. Report prepared for Woodside.

URS Australia Pty Ltd 2003, Review of Coral Surveillance Monitoring for the ChEMMS Programme. Report prepared for Woodside.

URS Australia Pty Ltd 2004, Preliminary Estimate of Cumulative Coral Habitat Loss within Dampier Port Limits, Report prepared for Dampier Port Authority.

Wang, JJY, Chou, LS and White, BN 1999, Mitochondrial DNA analysis of sympatric morphotypes of bottlenose dolphins (genus: *Tursiops*) in Chinese waters. *Molecular Ecology*. 8:1603-1612.

Water Corporation 2000. Environmental Information for Burrup Peninsula Desalinated and Seawater Supplies.

Wells, FE, and Walker, DI 2003, The Marine Flora and Fauna of Dampier; Western Australia. Proceedings of the Eleventh International Marine Biological Workshop: The Marine Flora and Fauna of Dampier, Western Australia.

Woodside 2005, The Vincent Development Draft Environmental Impact Statement. Woodside Energy Limited. Perth, Australia.

Woodside, 2006, Pluto LNG Development: Draft Public Environment Report/Public Environment Review, EPBC Referral 2006/2968. Woodside Energy Limited. Perth, Australia.

Woodside, 2012, Cultural Heritage Management Plan – Commissioning and Operations Phase.

Woodside 2013, Goodwyn Alpha (GWA) Facility Operations Environment Plan Summary. Woodside Energy Limited. Perth, Australia.

WorleyParsons 2009, Benthic Habitat Report: Dampier Marine Service Facility. WorleyParsons Pty Ltd, Perth, WA.

WorleyParsons 2011, Dampier Marine Service Facility: Assessment on Proponent Information. WorleyParsons Pty Ltd, Perth, WA.

APPENDIX A
Protected Matters Search Tool results

Australian Government
Department of the Environment and Energy

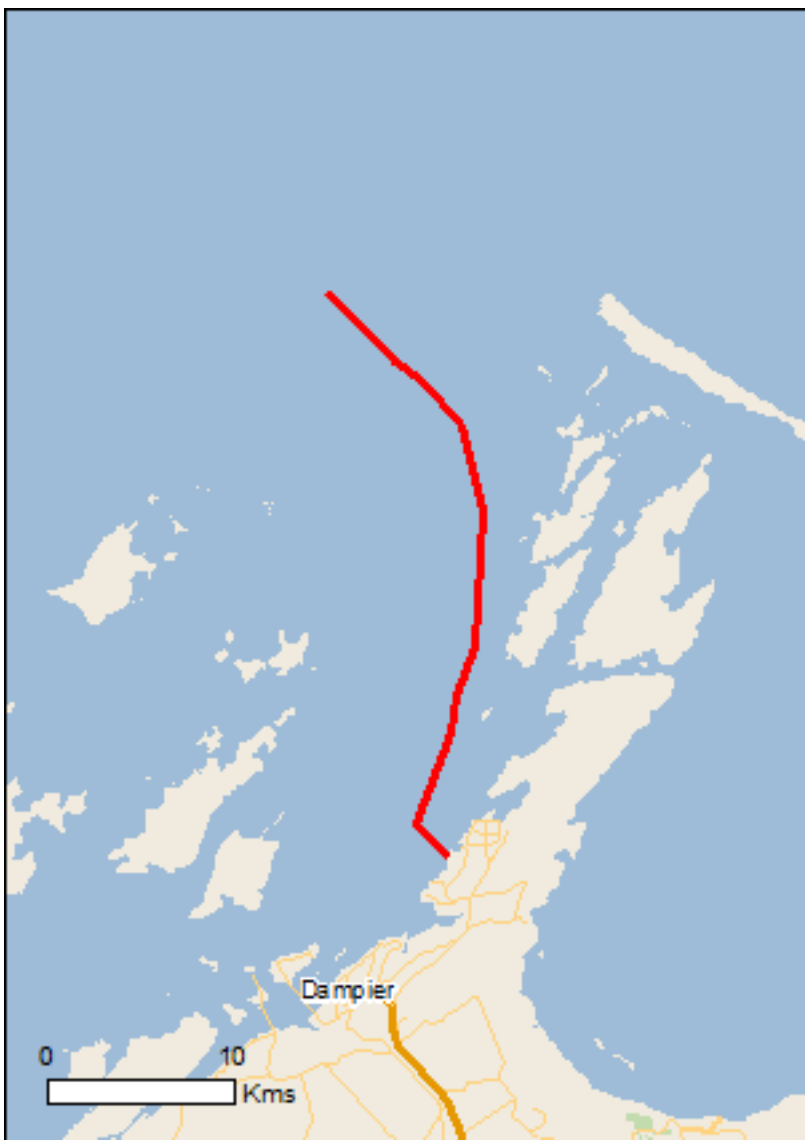
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

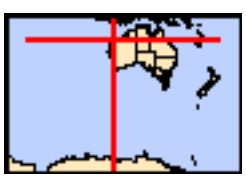
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 01/10/18 16:31:20



Coordinates
Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	31
Listed Migratory Species:	60

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	108
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	17
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties [Resource Information]

Name	State	Status
Indigenous		
Dampier Archipelago (including Burrup Peninsula)	WA	Listed place

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis		
Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Rostratula australis		
Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Mammals		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus angusticeps		
Northwestern Coastal Ctenotus, Airlie Island Ctenotus [25937]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Liasis olivaceus barroni		
Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharias taurus (west coast population)		
Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna pacifica		
Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Hydroprogne caspia		
Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Onychoprion anaethetus		
Bridled Tern [82845]		Breeding known to occur within area
Sterna dougallii		
Roseate Tern [817]		Breeding likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata		
Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Pandion haliaetus		
Osprey [952]		Breeding known to occur within area
Phalaropus lobatus		
Red-necked Phalarope [838]		Species or species habitat known to occur within area
Pluvialis fulva		
Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Pluvialis squatarola		
Grey Plover [865]		Species or species habitat known to occur within area
Thalasseus bergii		
Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes		
Grey-tailed Tattler [851]		Species or species habitat known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Tringa totanus		
Common Redshank, Redshank [835]		Species or species habitat known to occur within area
Xenus cinereus		
Terek Sandpiper [59300]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
[Ardea ibis](#) Cattle Egret [59542]		Species or species habitat may occur within area
[Arenaria interpres](#) Ruddy Turnstone [872]		Species or species habitat known to occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
[Calidris alba](#) Sanderling [875]		Species or species habitat known to occur within area
[Calidris canutus](#) Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area
[Calidris ruficollis](#) Red-necked Stint [860]		Species or species habitat known to occur within area
[Calidris subminuta](#) Long-toed Stint [861]		Species or species habitat known to occur within area
[Calidris tenuirostris](#) Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
[Calonectris leucomelas](#) Streaked Shearwater [1077]		Species or species habitat likely to occur within area
[Charadrius leschenaultii](#) Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
[Charadrius mongolus](#) Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
[Charadrius ruficapillus](#) Red-capped Plover [881]		Species or species habitat known to occur within area
[Charadrius veredus](#) Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
[Chrysococcyx osculans](#) Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
[Fregata ariel](#) Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
[Glareola maldivarum](#) Oriental Pratincole [840]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Breeding known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Pluvialis squatarola Grey Plover [865]		Species or species habitat known to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area

Name	Threatened	Type of Presence
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding likely to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Stiltia isabella Australian Pratincole [818]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Species or species habitat known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Species or species habitat known to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
[Doryrhamphus janssi](#) Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
[Doryrhamphus multiannulatus](#) Many-banded Pipefish [66717]		Species or species habitat may occur within area
[Doryrhamphus negrosensis](#) Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
[Festucalex scalaris](#) Ladder Pipefish [66216]		Species or species habitat may occur within area
[Filicampus tigris](#) Tiger Pipefish [66217]		Species or species habitat may occur within area
[Halicampus brocki](#) Brock's Pipefish [66219]		Species or species habitat may occur within area
[Halicampus grayi](#) Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
[Halicampus nitidus](#) Glittering Pipefish [66224]		Species or species habitat may occur within area
[Halicampus spinirostris](#) Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
[Haliichthys taeniophorus](#) Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
[Hippichthys penicillus](#) Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
[Hippocampus angustus](#) Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
[Hippocampus histrix](#) Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
[Hippocampus kuda](#) Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
[Hippocampus planifrons](#) Flat-face Seahorse [66238]		Species or species habitat may occur within area
[Hippocampus trimaculatus](#) Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
[Micrognathus micronotopterus](#) Tidepool Pipefish [66255]		Species or species habitat may occur within area
[Phoxocampus belcheri](#) Black Rock Pipefish [66719]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within

Name	Status	Type of Presence
		area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Murujuga	WA
Unnamed WA36907	WA
Unnamed WA36909	WA
Unnamed WA36910	WA
Unnamed WA36915	WA

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Mammals		
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-20.60512 116.75796,-20.58961 116.7435,-20.54898 116.76019,-20.53229 116.76177,-20.51014 116.77085,-20.44929 116.77462,-20.41055 116.76526,-20.39033 116.74514,-20.38184 116.73316,-20.35103 116.70154

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

APPENDIX B

MNES likelihood of occurrence

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Birds				
Actitis hypoleucos Common Sandpiper	Migratory		Found along all coastlines of Australia and in many areas inland, the Common Sandpiper is widespread in small numbers. The population when in Australia is concentrated in northern and western Australia (Blakers et al., 1984; Higgins & Davies, 1996). Areas of national importance and maximum counts (Watkins, 1993) include: Nuytsland Nature Reserve, Western Australia (52), Roebuck Bay, Western Australia (40). The species uses a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats. The Common Sandpiper has been recorded in estuaries and deltas of streams, as well as on banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans, and occasionally piers and jetties. The species is often associated with mangroves, and sometimes found in areas of mud littered with rocks or snags (Geering et al., 2007; Higgins & Davies, 1996).	Development envelope: Moderate Zone of influence: Moderate
Anous stolidus Common Noddy	Migratory		The species occurs off the north-west and central Western Australia coast. During the breeding season (peaks in Spring and Autumn), the Common Noddy usually occurs on or near islands, on rocky islets and stacks with precipitous cliffs, or on shoals or cays of coral or sand. When not at the nest, individuals will remain close to the nest, foraging in the surrounding waters. Birds may nest in bushes, saltbush, or other low vegetation. During the non-breeding period, the species occurs in groups throughout the pelagic zone (open ocean) (Higgins & Davies, 1996).	Development envelope: Moderate Zone of influence: Moderate
Apus pacificus Fork-tailed Swift	Migratory		The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. In Australia, they mostly occur over inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and over islands, and sometimes well out to sea. They mostly occur over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh. They are also found at treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes. They are scattered along the coast from south-west Pilbara to the north and east Kimberley region, near Wyndham. In the Kimberley Division they are present in the Pilbara Region and the Eucla Division from September to late April.	Development envelope: Low Zone of influence: Low

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Ardenna pacifica Wedge-tailed Shearwater	Migratory		The Wedge-tailed Shearwater breeds on the east and west coasts of Australia and on off-shore islands. Areas where breeding occurs include (Lindsey, 1986), Cocos-Keeling Island (Western Australia (WA), islands off the west coast of WA. The Wedge-tailed Shearwater is a pelagic, marine bird known from tropical and subtropical waters. The species has been recorded off the continental shelf in north-west Australia (Collins & Jessop, 1997; Marchant & Higgins, 1990). Movement patterns of the Wedge-tailed Shearwater are poorly known but populations at the northern and southern extremities of the known range are migratory, departing nests in early April to early May and spending the non-breeding season in the tropics. The development envelope intersects the wedge-tailed shearwater foraging and breeding BIA which extends north off the coast between Turner River and Locker Point (Figure 4-6).	Development envelope: Moderate Zone of influence: Moderate
Arenaria interpres Ruddy Turnstone	Migratory		The Ruddy Turnstone is widespread within Australia during its non-breeding period of the year (Bamford et al., 2008). It is found in most coastal regions, with occasional records of inland populations (Higgins & Davies, 1996). It strongly prefers rocky shores or beaches where there are large deposits of rotting seaweed (C.D.T. Minton, 2002, pers. comm.). In Australasia, the Ruddy Turnstone is mainly found on coastal regions with exposed rock coast lines or coral reefs. It also lives near platforms and shelves, often with shallow tidal pools and rocky, shingle or gravel beaches. It can, however, be found on sand, coral or shell beaches, shoals, cays and dry ridges of sand or coral. It has occasionally been sighted in estuaries, harbours, bays and coastal lagoons, among low saltmarsh or on exposed beds of seagrass, around sewage ponds and on mudflats. The Ruddy Turnstone does not breed in Australia. Australian sites of international importance that recorded counts of Ruddy Turnstones include: Eighty Mile Beach, Ashmore Reef, Roebuck Bay, Barrow Island, Lacepede islands.	Development envelope: Moderate Zone of influence: Moderate
Calidris acuminata Sharp-tailed Sandpiper	Migratory		The Sharp-tailed Sandpiper spends the non-breeding season in Australia. In Western Australia (WA), they are widespread around coastal and subcoastal plains of Pilbara Region to south-west and east Kimberley Division. In Australasia, the Sharp-tailed Sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline saltlakes inland. They also occur in saltworks and sewage farms. During the non-breeding season, most of the world population of Sharp-tailed Sandpipers occurs in Australia. Small numbers arrive in north-west Australia during mid-August, with large numbers in early September. The Sharp-tailed Sandpiper departs non-breeding grounds in Australia by April.	Development envelope: Low Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Calidris alba Sanderling	Migratory		The Sanderling occurs in coastal areas around Australia. They occur on most of the coast from Eyre to Derby. They are more often recorded on the south and southwest coasts, north to around southern Shark Bay, with more sparsely scattered records further north in Gascoyne and Pilbara Regions and the Kimberley Division. In Australia, the species is almost always found on the coast, mostly on open sandy beaches exposed to open sea-swell, and on exposed sandbars and spits, and shingle banks, where they forage in the wave-wash zone and amongst rotting seaweed. They arrive in Australia during September, mostly occurring in north-western Australia. They move through Roebuck Bay, Darwin and Eyre during September-November. They depart the non-breeding range in Australia during March to May.	Development envelope: Low Zone of influence: Moderate
Calidris canutus Red Knot	Endangered, Migratory	Vulnerable	The Red Knot is common in all the main suitable habitats around the coast of Australia. Very large numbers are regularly recorded in north-west Australia, with 80 Mile Beach and Roebuck Bay being particular strongholds. In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs. They are occasionally seen on terrestrial saline wetlands near the coast, such as lakes, lagoons, pools and pans, and recorded on sewage ponds and saltworks, but rarely use freshwater swamps. They arrive in north-west Australia from late August with rapid increases in weight before migrating further; numbers there decline by 50% in November (Watkins, 1993).	Development envelope: Low Zone of influence: Moderate
Calidris ferruginea Curlew Sandpiper	Critically Endangered, Migratory	Vulnerable	In Australia, Curlew Sandpipers occur around the coasts and are also quite widespread inland, though in smaller numbers. Records occur in all states during the non-breeding period, and also during the breeding season when many non-breeding one year old birds remain in Australia rather than migrating north. In Western Australia, they are widespread around coastal and subcoastal plains from Cape Arid to south-west Kimberley Division, but are more sparsely distributed between Carnarvon and Dampier Archipelago. They occur in large numbers, in thousands to tens of thousands, at Port Hedland Saltworks, 80 Mile Beach, Roebuck Bay and Lake Macleod. Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. This species is gregarious, often occurring in large flocks. This species does not breed in Australia. Curlew Sandpipers usually forage in water, near the shore or on bare wet mud at the edge of wetlands. After a stopover in northern Australia migration continues on a direct route to south-east Australia, the first birds arriving in late August, but the majority not until September. The birds begin to leave in March.	Development envelope: Low Zone of influence: Moderate
Calidris melanotos Pectoral Sandpiper	Migratory		In Western Australia (WA), the species is rarely recorded. It has been observed at the Nullarbor Plain, Reid, Stoke's Inlet, Grassmere Lake, Warden Lake, Dalyup and Yellilup Swamp, Swan River, Benger Swamp, Guraga Lake, Wittecarra, Harding River, coastal Gascoyne, the Pilbara and the Kimberley (Higgins & Davies, 1996). In Australasia, the Pectoral Sandpiper prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.	Development envelope: Low Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Calidris ruficollis Red-necked Stint	Migratory		The Red-necked Stint has been recorded in all coastal regions, and found inland in all states when conditions are suitable. Australian sites of international importance that recorded counts of Red-necked Stints include Eighty Mile Beach, Port Hedland Saltworks, Roebuck Bay. The Red-necked Stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. In north Australia, adults start arriving from the third week of August and most arrive before the end of September. The Red-necked Stint leaves Australia from late February or March through to April.	Development envelope: Low Zone of influence: Moderate
Calidris subminuta Long-toed Stint	Migratory		The Long-toed Stint is a regular summer visitor to Australia, but uncommon in the east. In Western Australia the species is found mainly along the coast, with a few scattered inland records. It is widespread around the Pilbara region and the Kimberley Division between Karratha and Wyndham-Kununurra. The Long-toed Stint occurs in a variety of terrestrial wetlands. They prefer shallow freshwater or brackish wetlands including lakes, swamps, river floodplains, streams, lagoons and sewage ponds. The species is also fond of areas of muddy shoreline, growths of short grass, weeds, sedges, low or floating aquatic vegetation, reeds, rushes and occasionally stunted samphire. The species arrives on the north coast, west of Darwin, Northern Territory, and occupy freshwater wetlands in the west Kimberleys and Pilbara, Western Australia. During summer they disperse across the continent, mainly between Pilbara and the coast of South Australia.	Development envelope: Low Zone of influence: Moderate
Calidris tenuirostris Great Knot	Critically Endangered, Migratory	Vulnerable	The Great Knot has been recorded around the entirety of the Australian coast. The greatest numbers are found in northern Australia; where the species is common on the coasts of the Pilbara and Kimberley, from the Dampier Archipelago to the Northern Territory border. In Australasia, the species typically prefers sheltered coastal habitats, with large intertidal mudflats or sandflats. This includes inlets, bays, harbours, estuaries and lagoons. They are occasionally found on exposed reefs or rock platforms, shorelines with mangrove vegetation, ponds in saltworks, at swamps near the coast, saltlakes and non-tidal lagoons. Typically, the Great Knot roosts in large groups in open areas, often at the waters edge or in shallow water close to feeding grounds (Higgins & Davies, 1996; Rogers, 2001). A group of about 8610 birds have been recorded roosting at an inland claypan near Roebuck Bay in north-west Western Australia (Collins et al., 2001). In Australia, large numbers arrive in the north-west in late August–early September (Lane, 1987), though juveniles and many males may not arrive till October–November (Barter, 1986). Most birds leave Australia directly from the north coast in March–April (Lane, 1987).	Development envelope: Low Zone of influence: Moderate
Calonectris leucomelas Streaked Shearwater	Migratory		The streaked shearwater is a migratory seabird with a broad distribution in the western Pacific Ocean. The species nests on offshore islands in temperate East Asia, including Japan and the Korean peninsula. During winter months the species migrates south, as far as northern Australia, where it occurs around islands and inshore waters.	Development envelope: Moderate Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover	Vulnerable, Migratory	Vulnerable	In Australia, the Greater Sand Plover occurs in coastal areas in all states, though the greatest numbers occur in northern Australia. In northern Australia, the species is especially widespread between North West Cape and Roebuck Bay in Western Australia (Barrett et al., 2003; Blakers et al., 1984; Lane, 1987; Storr, 1980, 1987); there are sparsely scattered records from the largely inaccessible area between Roebuck Bay and Darwin. The species does not breed in Australia. During the non-breeding season, the species is recorded in many coastal areas of Australia (Marchant & Higgins, 1993), especially in the north. In the non-breeding grounds in Australasia, the species is almost entirely coastal, inhabiting littoral and estuarine habitats. They mainly occur on sheltered sandy, shelly or muddy beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons (Bamford, 1988; Blakers et al., 1984; Lane, 1987; Sibson 1948; Stewart et al., 2007), and inshore reefs, rock platforms, small rocky islands or sand cays on coral reefs (Abbott, 1982; Morris, 1989; Sedgwick, 1978).	Development envelope: Low Zone of influence: Moderate
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	Endangered, Migratory	Endangered	Within Australia, the Lesser Sand-Plover is widespread in coastal regions, and has been recorded in all states. It mainly occurs in northern and eastern Australia. Maximum counts include: Eighty Mile Beach, 1575; Roebuck Bay, 1057; Broome, 745; Port Hedland Saltworks, 668. In non-breeding grounds in Australia, this species usually occurs in coastal littoral and estuarine environments. It inhabits large intertidal sandflats or mudflats in sheltered bays, harbours and estuaries, and occasionally sandy ocean beaches, coral reefs, wave-cut rock platforms and rocky outcrops. It also sometime occurs in short saltmarsh or among mangroves. In north-western Australia, the species appears to use the Port Hedland saltworks in preference to nearby beaches (C. Minton, 2002, pers. comm.). The species does not breed in Australia. The species feeds mostly on extensive, freshly-exposed areas of intertidal sandflats and mudflats in estuaries or beaches, or in shallow ponds in saltworks (Evans, 1975; Hindwood & Hoskin, 1954; Johnstone & Storr, 1998; McGill & Keast, 1945; Thomas, 1968). The species is present at non-breeding grounds in Australasia mostly between September and April or May, with greatest numbers in northern Australia (Alcorn et al., 1994; Lane, 1987; Marchant & Higgins, 1993).	Development envelope: Low Zone of influence: Moderate
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory		The Oriental Plover is a non-breeding visitor to Australia, where the species occurs in both coastal and inland areas, mostly in northern Australia. Most records are along the north-western coast, between Exmouth Gulf and Derby in Western Australia. Immediately after arriving in non-breeding grounds in northern Australia, Oriental Plovers spend a few weeks in coastal habitats such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands, before dispersing further inland (Bigg, 1981; Bransbury, 1985; Crawford, 1972; Murlis et al., 1988; Serventy & Whittell, 1976; Storr, 1977, 1980, 1984b). Oriental Plovers arrive in north-western Australia in early to mid-September, with numbers increasing during October (Branson & Minton, 2006; Collins, 1995; Lane, 1987; Marchant & Higgins, 1993). By late April at least some birds are near their breeding grounds in Mongolia (Kitson, 1979).	Development envelope: Moderate Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Fregata ariel Lesser Frigatebird, Least Frigatebird	Migratory		The lesser frigatebird is usually seen in tropical or warmer waters around the coast of north Western Australia, the Northern Territory, Queensland and northern New South Wales (DSEWPaC, 2012d). Within the NWMR, the lesser frigatebird is known to breed on Adele, Bedout and West Lacepede islands, Ashmore Reef and Cartier Islands (outside the ZoC) (DSEWPaC, 2012d). The lesser frigatebird feeds mostly on fish and sometimes cephalopods, and all food is taken while the bird is flying. Lesser frigate birds generally forage close to breeding colonies.	Development envelope: Moderate Zone of influence: Moderate
Glareola maldivarum Oriental Pratincole	Migratory		Within Australia the Oriental Pratincole is widespread in northern areas, especially along the coasts of the Pilbara Region and the Kimberley Division in Western Australia. Nationally important sites and maximum counts (in brackets) include: Eighty Mile Beach (2.88 million birds), Roebuck Plains (50,000), Port Hedland Saltworks (10,000). In non-breeding grounds in Australia, the Oriental Pratincole usually inhabits open plains, floodplains or short grassland (including farmland or airstrips). The species also occurs along the coast, inhabiting beaches, mudflats and islands, or around coastal lagoons (Corben, 1972b; Finch & Cox, 1974; Garstone, 1978; Hobbs & McGill, 1973). Most birds are thought to spend the non-breeding season in Australia the species arrives in northern Australia in late October and early November (Berney, 1904; Collins, 1995; Kilgour, 1904; Storr, 1980), The species usually remains until mid-March or the first week of April (Collins, 1995; Crawford, 1972; Lane, 1987).	Development envelope: Low Zone of influence: Moderate
Hirundo rustica Barn Swallow	Migratory		Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low
Hydroprogne caspia Caspian Tern	Migratory		Within Australia, the Caspian Tern has a widespread occurrence and can be found in both coastal and inland habitat (Higgins & Davies, 1996). In Western Australia the species is widespread in coastal regions, from the Great Australian Bight to the Dampier Peninsula. Breeding can occur in the Pilbara region from around Point Cloates to North Turtle Island, and more rarely, in the Kimberley (Chatto, 2001; Higgins & Davies, 1996). The Caspian Tern is mostly found in sheltered coastal embayments (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins are preferred. They also occur on near-coastal or inland terrestrial wetlands that are either fresh or saline, especially lakes (including ephemeral lakes), waterholes, reservoirs, rivers and creeks. In Australia, the Caspian Tern is a resident and present throughout the year at sites where breeding occurs year round and also at some sites where breeding is protracted (e.g. Darwin and WA).	Development envelope: Low Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Limicola falcinellus Broad-billed Sandpiper	Migratory		In Australia, the Broad-billed Sandpiper is most common on the north and north-west coasts. In Western Australia they mostly occur on the coasts of the Pilbara and Kimberley between Onslow and Broome. The Broad-billed Sandpiper occurs in sheltered parts of the coast, favouring estuarine mudflats but also occasionally occur on saltmarshes, shallow freshwater lagoons, saltworks and sewage farms, and in areas with large soft intertidal mudflats, which may have shell or sandbanks nearby. Occasionally they occur on reefs or rocky platforms. In north-west Australia by late October both adults and first-year birds have arrived, leaving about mid-April.	Development envelope: Low Zone of influence: Moderate
Limosa lapponica Bar-tailed Godwit	Migratory	Vulnerable	The Bar-tailed Godwit has been recorded in the coastal areas of all Australian states. In Western Australia it is widespread around the coast, from Eyre to Derby, with a few scattered records elsewhere in the Kimberley Division. Australian sites of international importance and their populations include (Bamford et al., 2008): Eighty Mile Beach (110,290), Roebuck Bay (65,000). The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It is found often around beds of seagrass and, sometimes, in nearby saltmarsh. The Bar-tailed Godwit begins to arrive in north-west Australia from August with numbers increasing until mid-November and typically depart early to mid-April.	Development envelope: Low Zone of influence: Moderate
Limosa lapponica baueri Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	Vulnerable	Vulnerable	Bar-tailed Godwits (Limosa lapponica) are long-distance migratory shorebirds. About a third of the global population migrate to Australia during the non-breeding season where they occur mainly in the north-west and east. Limosa lapponica bauera is a subspecies that spends the non-breeding season in South-east Australia. The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. Less frequently it occurs in salt lakes and brackish wetlands, sandy ocean beaches and rock platforms. It often occurs around beds of seagrass, and sometimes in nearby saltmarsh or the outer margins of mangrove areas. It forages at low to mid tide in shallow water or along the water's edge on sandy substrates on intertidal flats, banks and beaches or on soft mud substrates.	Development envelope: Low Zone of influence: Moderate
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit	Critically Endangered	Vulnerable	Bar-tailed Godwits (Limosa lapponica) are long-distance migratory shorebirds. About a third of the global population migrate to Australia during the non-breeding season where they occur mainly in the north-west and east. Limosa lapponica menzbieri is a subspecies that spends the non-breeding season in north-west Australia. The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It has also been recorded in coastal sewage farms and saltworks, saltlakes and brackish wetlands near coasts, sandy ocean beaches, rock platforms, and coral reef-flats (Higgins & Davies, 1996). The bar-tailed godwit (northern Siberian) usually forages near the edge of water or in shallow water, mainly in tidal estuaries and harbours. They prefer exposed sandy or soft mud substrates on intertidal flats, banks and beaches.	Development envelope: Low Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Limosa limosa Black-tailed Godwit	Migratory		The Black-tailed Godwit is found in all states and territories of Australia. However, it prefers coastal regions and the largest populations are found on the north coast between Darwin and Weipa, it is generally found in small numbers elsewhere. The Black-tailed Godwit has a primarily coastal habitat environment. The species is commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit; occasionally recorded on rocky coasts or coral islets. The Black-tailed Godwit does not breed in Australia. The Black-tailed Godwit first arrives in north-west Australia from late August (Lane, 1987) with numbers falling from September to mid-November (Blakers et al., 1984).	Development envelope: Low Zone of influence: Moderate
Macronectes giganteus Southern Giant-Petrel	Endangered		The Southern Giant-Petrel is marine bird that occurs in Antarctic to subtropical waters. In summer, it mainly occurs over Antarctic waters, and it is widespread south as far as the pack-ice and onto the Antarctic continent (Marchant & Higgins, 1990). Throughout the colder months, immatures and most adults disperse widely, with Antarctic colonies becoming completely deserted during winter. Thus, in winter they are rare in the southern waters of the Indian Ocean, and more common off South America, South Africa, Australia and New Zealand. It is an opportunistic scavenger and predator, and scavenges from fishing vessels and animal carcasses on land. It is also an active predator of cephalopods and euphausiids, as well as smaller birds (particularly penguins) both at land and at sea.	Development envelope: Moderate Zone of influence: Moderate
Motacilla cinerea Grey Wagtail	Migratory		Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low
Motacilla flava Yellow Wagtail	Migratory		Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew	Critically Endangered, Migratory	Vulnerable	Within Australia, the eastern curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions. Eastern curlews are rarely recorded inland. They have a continuous distribution from Barrow Island and Dampier Archipelago, Western Australia, through the Kimberley. The eastern curlew does not breed in Australia. During the non-breeding season in Australia, the eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass (Zosteraceae). Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. The birds are often recorded among saltmarsh and on mudflats fringed by mangroves, and sometimes within the mangroves. The birds are also found in coastal saltworks and sewage farms (Marchant & Higgins, 1993). Most of the eastern curlew population is found in Australia during the non-breeding season (Bamford et al., 2008), mostly at a few sites on the east and south coasts and in north-western Australia (Lane, 1987). Population numbers are stable at most sites in November or between December to February, indicating little movement during this period (Lane, 1987; Alcorn, 1988).	Development envelope: Low Zone of influence: Moderate
Numenius phaeopus Whimbrel	Migratory		The Whimbrel is a regular migrant to Australia and New Zealand, with a primarily coastal distribution. It is common and widespread from Carnarvon to the north-east Kimberley Division, Western Australia. The Whimbrel is often found on the intertidal mudflats of sheltered coasts. It is also found in harbours, lagoons, estuaries and river deltas, often those with mangroves, but also open, unvegetated mudflats. It is occasionally found on sandy or rocky beaches, on coral or rocky islets, or on intertidal reefs and platforms. The Whimbrel does not breed in Australia. Within Australia, Whimbrels move south through Roebuck Bay, Western Australia, from August and September (Lane, 1987). Whimbrels begin migrating from February onwards (Higgins & Davies, 1996).	Development envelope: Low Zone of influence: Moderate
Onychoprion anaethetus Bridled Tern	Migratory		In Australia, Bridled Terns are widespread, breeding on offshore islands in western, northern and north-eastern Australia, extending from Cape Leeuwin in the south-west, around northern Australia. The species forages in offshore, continental shelf waters and is only rarely recorded along mainland coasts, even those adjacent or close to breeding colonies. In Western Australia, breeding is widespread from islands off Cape Leeuwin (extending round the southern coast to Seal Rocks) north to Shark Bay and in Pilbara region and Kimberley Division. At sea, distribution extends from Cape Leeuwin north to Dirk Hartog Island, with isolated mainland coastal records at Point Maud and Ningaloo, and from Barrow Island to the Dampier Archipelago, and at sea off the Kimberley coast from waters west of the Dampier Peninsula to Ashmore Reef and Joseph Bonaparte Gulf (Barrett et al., 2003; Blakers et al., 1984; Higgins & Davies, 1996; Johnstone & Storr, 1998). Bridled Terns occupy tropical and subtropical seas, breeding on islands, including vegetated coral cays, rocky continental islands and rock stacks (Chatto, 2001; Dunlop & Jenkins, 1992; Dunlop, J.N in Higgins & Davies, 1996). Bridled Terns are migratory or partly migratory in Australia. In Western Australia, almost all Bridled Terns return to breeding colonies between late September and mid-October and normally leave from early to mid-April, although they leave some colonies in some years as late as mid-May. Birds are usually absent from breeding colonies and adjacent seas from early May to mid-September.	Development envelope: Low Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Pandion haliaetus Osprey	Migratory		The osprey is a medium-sized raptor that is widely distributed around Australia in coastal and wetland habitats (DoEE, 2016). The breeding range extends around the northern coast of Australia (including many offshore islands) from Albany in Western Australia to Lake Macquarie in New South Wales. While listed as migratory, adults are generally restricted to a foraging area surrounding their nests. Egg laying in Australia is protracted between April and February (Olsen and Marples, 1993).	Development envelope: Low Zone of influence: Moderate
Pezoporus occidentalis Night Parrot	Endangered	Critically Endangered	Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Moderate
Phalaropus lobatus Red-necked Phalarope	Migratory		In Western Australia the species has been seen on Rottnest Island, Pelican Point, the Swan River, the Port Hedland Saltworks, the Eyre Bird Observatory and Hinds Lake Nature Reserve (Higgins & Davies, 1996). During non-breeding period the Red-necked Phalarope occurs mainly at sea. In Australia it is recorded at both inland and coastal lakes/swamps, including highly saline waters and artificial wetlands notably saltfields (Higgins & Davies, 1996). The Red-necked Phalarope is commonly sighted in Australia from mid-October to early-April (Higgins & Davies, 1996).	Development envelope: Low Zone of influence: Moderate
Pluvialis fulva Pacific Golden Plover	Migratory		Within Australia, the Pacific Golden Plover is widespread in coastal regions. In Western Australia, the species is more widespread along the Pilbara and Kimberley coasts between North-West Cape and the Northern Territory border. Nationally important sites in Western Australia include Eighty Mile Beach. In non-breeding grounds in Australia this species usually inhabits coastal habitats, though it occasionally occurs around inland wetlands. Pacific Golden Plovers usually occur on beaches, mudflats and sandflats (sometimes in vegetation such as mangroves, low saltmarsh such as Sarcocornia, or beds of seagrass) in sheltered areas including harbours, estuaries and lagoons, and also in evaporation ponds in saltworks. Breeding occurs in dry areas of tundra away from the coast. Those arriving in the Kimberley Division of Western Australia occur on passage in October (Storr, 1980). In northern Western Australia, Plovers occur on passage in February and March (Storr, 1980) and leave the Kimberley Division in late April (Collins, 1995).	Development envelope: Low Zone of influence: Moderate
Pluvialis squatarola Grey Plover	Migratory		In Australia, the Grey Plover has been recorded in all states, where it is found along the coasts, and it especially abundant on the western and southern coastlines, mainly between the coast of Western Australia between Albany and the northern Kimberley coast (Barrett et al., 2003; Blakers et al., 1984; Lane, 1987). In non-breeding grounds in Australia, Grey Plovers occur almost entirely in coastal areas, where they usually inhabit sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons.	Development envelope: Low Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Rostratula australis Australian Painted Snipe	Endangered	Endangered	The Australian Painted Snipe has been recorded at wetlands in all states of Australia (Barrett et al., 2003; Blakers et al., 1984; Hall, 1910b). It has been recorded less frequently at a smaller number of more scattered locations farther west in South Australia, the Northern Territory and Western Australia (Barrett et al., 2003; Blakers et al., 1984; Marchant & Higgins, 1993; Rogers et al., 2005). The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia or canegrass or sometimes tea-tree (Melaleuca). Nest records are all, or nearly all, from or near small islands in freshwater wetlands (D. Rogers, 2002, pers. comm.), provided that these islands are a combination of very shallow water, exposed mud, dense low cover and sometimes some tall dense cover (Rogers et al., 2005).	Development envelope: Low Zone of influence: Low
Sterna dougallii Roseate Tern	Migratory		The roseate tern is found across the western and northern coasts of Australia. The species inhabits mostly areas around offshore islands, and are rarely encountered in inshore waters or near the mainland (DotE, 2018). Adult roseate terns have been observed across the north-west of Australia in areas such as Bedout Island, Dampier Archipelago, Lowendal Island and Mary Anne Island. Throughout the year the species often rests and forages in sheltered estuaries, creeks, inshore waters. The development envelope intersects the Roseate Tern foraging BIA which occurs North off the coast between Delambre Island and Eaglehawk Island (Figure 4-6).	Development envelope: Low Zone of influence: Moderate
Sternula nereis nereis Australian Fairy Tern	Vulnerable	Vulnerable	The Australian fairy tern is a widely distributed shorebird occurring along the coasts of New South Wales, Victoria, Tasmania, South Australia and Western Australia (Threatened Species Scientific Committee, 2011). In Western Australia, the species occurs along the coast as far north as the Dampier Archipelago and offshore islands of Barrow, Montebello, and the Lowendal Islands Group (Threatened Species Scientific Committee, 2011). The species occurs mainly on sandy beaches within sheltered coasts. The development envelope intersects the Australian Fairy Tern breeding and foraging BIA which occurs between Hauy Island and Eaglehawk Island (Figure 4-6).	Development envelope: Low Zone of influence: Moderate
Thalasseus bergii Crested Tern	Migratory		Greater Crested Terns are widespread around the coasts of the Indian Ocean, Southern Ocean and west-central Pacific Ocean. They may rest on the surface of the sea in calm weather. Crested Terns occur singularly or in flocks in coastal areas, estuaries, inlets, islands and occasionally on large inland lakes or rivers. They are often seen perching with gulls on beaches, sand spits or jetties (Parks & Wildlife Service 2012). These birds dive from heights of five to eight metres when foraging but only penetrate a few centimetres below the surface of the water.	Development envelope: Moderate Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Tringa brevipes Grey-tailed Tattler	Migratory		Within Australia, the Grey-tailed Tattler has a primarily northern coastal distribution and is found in most coastal regions (Higgins & Davies, 1996). The Grey-tailed Tattler is widespread from Houtman Abrolhos and the mainland adjacent to the Kimberley Division. It is often found on sheltered coasts with reefs and rock platforms or with intertidal mudflats. It can also be found at intertidal rocky, coral or stony reefs as well as platforms and islets that are exposed at low tide. The Grey-tailed Tattler arrives in Australia mostly in August and generally leaves Australia to return to breeding areas by early or mid-April.	Development envelope: Moderate Zone of influence: Moderate
Tringa nebularia Common Greenshank, Greenshank	Migratory		The Common Greenshank does not breed in Australia. However, the species occurs in all types of wetlands and has the widest distribution of any shorebird in Australia (Higgins & Davies, 1996). The Common Greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. Habitats include embayments, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms. The species arrives in Australia from August, possibly mainly in the west (Lane, 1987). Northward migration occurs from March, but mostly in April when numbers decline at sites throughout Australia.	Development envelope: Low Zone of influence: Moderate
Tringa stagnatilis Marsh Sandpiper, Little Greenshank	Migratory		The Marsh Sandpiper is found on coastal and inland wetlands throughout Australia. There are scattered records in Western Australia where they are mainly found around the coast. The Marsh Sandpiper lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes. In Western Australia they prefer freshwater to marine environments. The Marsh Sandpiper does not breed in Australia. Birds arrive in Australia from September and begins to migrate north in March–April.	Development envelope: Low Zone of influence: Low
Tringa totanus Common Redshank, Redshank	Migratory		In Australia, the Common Redshank has been recorded at scattered locations. In Western Australia (WA), the species is vagrant to the south-west with records from the Dampier Saltfields to Roebuck Bay and Broome. The Common Redshank is found at sheltered coastal wetlands such as bays, river estuaries, lagoons, inlets and saltmarsh (with bare open flats and banks of mud or sand). They are also found around saltlakes, freshwater lagoons, artificial wetlands and saltworks and sewage farms (Higgins & Davies, 1996).	Development envelope: Low Zone of influence: Moderate
Xenus cinereus Terek Sandpiper	Migratory		In Australia, the Terek Sandpiper has a primarily coastal distribution, with occasional records inland. It is more widespread and common in northern and eastern Australia than southern Australia. The species is widespread in the Pilbara region and Kimberley Division, from Dampier to Wyndham, with occasional records around Shark Bay. The Terek Sandpiper mostly forages in the open, on soft wet intertidal mudflats or in sheltered estuaries, embayments, harbours or lagoons. The species has also been recorded on islets, mudbanks, sandbanks and spits, and near mangroves and occasionally in samphire (Halosarcia spp.). Birds are seldom near the edge of water. However, birds may wade into the water (Marchant & Higgins, 1993). This species does not breed in Australia. The Terek Sandpiper arrives in north-western Australia in the first week of September (Lane, 1987), and leaves in late April.	Development envelope: Low Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Mammals				
Balaenoptera edeni Bryde's Whale	Migratory		Bryde's Whales occur in temperate to tropical waters, both oceanic and inshore, bounded by latitudes 40° N and 40° S, or the 20°C isotherm (Bannister et al., 1996). Bryde's Whales have been recorded from all Australian states except the Northern Territory (Bannister et al., 1996). there has been some doubt over the exact identity of some of the specimens, with three individuals from Western Australia and two from the east coast reportedly intermediate between Bryde's Whale and the Sei Whale. Bryde's Whales are found year-round in waters between 40° S and 40° N, primarily in temperatures exceeding 16.3°C (Kato, 2002). The coastal from of Bryde's Whale appears to be limited to the 200 m depth isobar, moving along the coast in response to availability of suitable prey (Best et al., 1984). The offshore form is found in deeper water (500 m to 1000 m). This suggests that Bryde's Whales use the upper layers of the ocean, and can therefore be considered pelagic.	Development envelope: Low Zone of influence: Low
Balaenoptera musculus Blue Whale	Endangered, Migratory	Endangered	When considering blue whales more broadly, there are two recognised subspecies of blue whale in the Southern Hemisphere, which are both recorded in Australian waters. These are the southern (or 'true') blue whale (Balaenoptera musculus intermedia) and the 'pygmy' blue whale (Balaenoptera musculus brevicauda) (DSEWPaC, 2012f). In general, southern blue whales occur in waters south of 60° S and pygmy blue whales occur in waters north of 55° S (ie not in the Antarctic) (DEH, 2005). Satellite tagging conducted in 2011 confirmed the Perth Canyon/Naturaliste Plateau and North West Cape/Ningaloo Reef as areas of activity off the WA coast where pygmy blue whales aggregate with some predictability (Double et al., 2011). The most recent satellite tagging confirmed pygmy blue whales general distribution was offshore in water depths over 200 m and commonly over 1000 m (Double et al., 2012b**).** In the NWMR, pygmy blue whales migrate along the 500 m to 1000 m depth contour on the edge of the slope, and are likely to feed opportunistically on ephemeral krill aggregations (DEWHA, 2008b). Satellite tracking has confirmed north-bound animals off Exmouth and the Montebello Islands between April and August, and south-bound animals passing the same areas from October to the end of January, peaking in late November to early December (Double et al., 2012b).	Development envelope: Low Zone of influence: Low
Dasyurus hallucatus Northern Quoll, Digul, Wijingadda, Wiminji	Endangered	Endangered	Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Dugong dugon Dugong	Migratory	Other Protected Fauna	Dugongs occur in coastal and island waters from Shark Bay in Western Australia (25° S) across the northern coastline to Moreton Bay in Queensland (27° S) (Marsh et al., 2002, 2011a). Specific areas supporting dugongs in Western Australia include: Shark Bay; Ningaloo and Exmouth Gulf; the Pilbara coast (Exmouth Gulf to De Grey River (Marsh et al., 2002)); and Eighty Mile Beach and Kimberley Coast Region, including Roebuck Bay (Brown et al., 2014). Within the Dampier Archipelago, dugongs have been recorded near various islands including Rosemary Island, East and West Lewis Islands, Keast Island, Legendre Island and Little Rocky Island (CALM, 2005; URS, 2001 cited in Woodside, 2006). Dugongs have also been sighted in shallow sheltered bays of the Burrup Peninsula and mainland coast such as Regnard Bay and Nickol Bay, and the seaward side of the Hamersley Shoal at the entrance of the Mermaid Sound (Woodside, 2006). Dugongs are seagrass community specialists and the range of the dugong is broadly coincident with the distribution of seagrasses in the tropical and sub-tropical waters in their Australian range.	Development envelope: Moderate Zone of influence: High
Macroderma gigas Ghost Bat	Vulnerable	Vulnerable	Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low
Macrotis lagotis Greater Bilby	Vulnerable	Vulnerable	Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Megaptera novaeangliae Humpback Whale	Vulnerable, Migratory	Conservation Dependent	The humpback whale (Megaptera novaeangliae) is the most commonly sighted whale along the Western Australian coastline. The species is observed annually completing their seasonal northern and southern migrations to and from the Camden Sound area of the west Kimberley (Jenner et al., 2001) in winter and spring, after feeding in Antarctic waters during summer (Bannister and Hedley, 2001). Between the Dampier Archipelago and Montebello Islands, the migratory route the north-bound and south-bound whales follow is a relatively narrow track (Double et al., 2010). Although the north and south-bound migratory routes for most whales are further offshore than the Dampier Archipelago waters (up to 70 nm from the coast), during the south-bound migration it is likely that most individuals, particularly cow/calf pairs, stay closer to the coast, than the northern migratory path (Double et al., 2010). During the south-bound migration, it is likely some whales may travel through Dampier Archipelago waters, either passing the open outer waters, or travelling into the Mermaid Sound proper and continuing westwards, likely through the channel bounded by West Lewis Island and Enderby Island to the south and Rosemary Island to the north (with reference to Jenner et al., 2001). The peak of the northward migration in Dampier Archipelago waters is during July, while the southern migration peaks in late August/early September. The development envelope intersects the humpback whale migration corridor (north and south) BIA which extends from the Kimberley to near Esperance in the south of Western Australia (Figure 4-7)	Development envelope: High Zone of influence: High
Orcinus orca Killer Whale, Orca	Migratory		In Australia, Killer Whales are recorded from all states, with concentrations reported around Tasmania. The preferred habitat of Killer Whales includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters. They may be more common in cold, deep waters, but off Australia, Killer Whales are most often seen along the continental slope and on the shelf, particularly near seal colonies. Killer Whales have regularly been observed within the Australian territorial waters along the ice edge in summer (Thiele & Gill, 1999).	Development envelope: Low Zone of influence: Low
Rhinonicteris aurantia Pilbara Leaf-nosed Bat	Vulnerable	Vulnerable	Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Sousa chinensis Indo-Pacific Humpback Dolphin	Migratory		In Australia, humpback dolphins are thought to be widely distributed along the northern Australian coastline from approximately the Queensland–New South Wales border to western Shark Bay, Western Australia (Parra & Cagnazzi, 2016). While coastal waters are arguably the primary habitat of Australian humpback dolphins, most survey work has been conducted close to the coast; thus, the extent to which humpback dolphins use offshore waters is not yet fully understood. No studies on habitat use have been conducted in Western Australia. Preliminary surveys and ongoing studies in a few locations indicate that Australian humpback dolphins appear to utilise a wide range of near-shore habitats. For example, around the North West Cape, dolphins have been sighted in clear waters over Ningaloo Reef, and in turbid waters in Exmouth Gulf and in depths ranging from 1 to 40 m deep (T. Hunt, personal communication, 19 February 2015, cited in Parra & Cagnazzi, 2016).	Development envelope: High Zone of influence: High
Tursiops aduncus Spotted Bottlenose Dolphin	Migratory		Bottlenose dolphins are distributed continuously around the Australian mainland. Indian Ocean Bottlenose Dolphins have been confirmed to occur in estuarine and coastal waters of eastern, western and northern Australia (Hale et al., 2000; Möller & Beheregaray, 2001; Ross & Cockcroft, 1990). In Australia, the Indian Ocean Bottlenose Dolphin is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters including coastal areas around oceanic islands (Hale et al., 2000; Kogi et al., 2004; Möller & Beheregaray, 2001; Wang et al., 1999).	Development envelope: High Zone of influence: High
Reptiles				
Aipysurus apraefrontalis Short-nosed Seasnake	Critically Endangered	Critically Endangered	The Short-nosed Seasnake is endemic to Western Australia, and has been recorded from Exmouth Gulf, Western Australia (Storr et al., 2002) to the reefs of the Sahul Shelf, in the eastern Indian Ocean. The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m (Cogger, 2000; Guinea, 1993, 1995; McCosker, 1975). Guinea and Whiting (2005) reported that very few Short-nosed Seasnakes moved even as far as 50 m away from the reef flat. All phases of the reproductive cycle of seasnakes takes place in the sea and reproductive seasonality varies among the species.	Development envelope: Moderate Zone of influence: Moderate
Caretta caretta Loggerhead Turtle	Endangered, Migratory	Endangered	The Loggerhead Turtle is distributed between Shark Bay to North West Cape and as far north as Muiron Islands and Dampier Archipelago. The species is found nearshore and in island coral reefs, bays and estuaries in tropical and warm temperate latitudes. The species nests principally from Dirk Hartog Island, along the Gnarloo and Ningaloo Coast to North West Cape and the Muiron Islands. There have been occasional records from Varanus and Rosemary Islands in the Pilbara. Late summer nesting recorded for Barrow Island, Lowendal Islands and Dampier Archipelago. There is limited data on Australian loggerhead turtles; however, literature indicates internesting habitat for this species is generally within 20 km of nesting beaches. The development envelope intersects the Loggerhead Turtle internesting buffer BIA which occurs within a 23 km radius around Rosemary Island (Figure 4-8).	Development envelope: Moderate Zone of influence: High

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Chelonia mydas Green Turtle	Vulnerable, Migratory	Vulnerable	The Green Turtle is distributed between the Ningaloo Coast to Lacepede islands. The species' major nesting sites are the Islands of the Dampier Archipelago including Rosemary, Legendre and Delambre. Internesting habitat is generally within 10 km of nesting beaches. They can be found in nearshore reefs in the photic zone. The development envelope intersects the Green Turtle nesting and internesting buffer BIA which occurs between Delambre Island and Cod Bank (Figure 4-8).	Development envelope: Moderate Zone of influence: High
Ctenotus angusticeps Northwestern Coastal Ctenotus, Airlie Island Ctenotus	Vulnerable		The Airlie Island Ctenotus is known from about 12 locations in north-west WA: Airlie Island (offshore from Onslow), Thangoo Station (Roebuck Bay), Pretty Pool and Wedgefield (Port Hedland), Redbank (Port Hedland), Finucane Island (Port Hedland), Beebingarra Creek, Roebuck (Crab Creek), Cape Keraudren (Pardoo), Port Smith (Lagrange), Willie Creek (Broome), Boodarie Station and Karratha (Biologic, 2012; Sadlier, 1993; Storr, 1988). On the mainland, the Airlie Island Ctenotus generally inhabits the landward fringe of salt marsh communities in samphire shrubland or marine couch grassland (Maryan et al., 2013) in the intertidal zone along mangrove (Grey Mangrove (Avicennia marina) with occasional Red Mangrove (Rhizophora stylosa)) margins. However, subtle differences in vegetation/topography exist among sites where the species has been recorded (Biologic, 2012).	Development envelope: Low Zone of influence: Moderate
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered, Migratory	Vulnerable	The Leatherback Turtle is a pelagic feeder, found in tropical, subtropical and temperate waters throughout the world (Marquez 1990). This species is regularly found in the high latitudes of all oceans including the South Pacific Ocean in the waters offshore from NSW, Victoria, Tasmania and Western Australia (Benson et al., 2011; Limpus & MacLachlan, 1979, 1994). The Leatherback Turtles is a highly pelagic species, venturing close to shore mainly during the nesting season (Sarti Martinez, 2000). There is no confirmed nesting activity in Western Australia. It is known from waters all around Australia (Robins et al., 2002) and can be found foraging year-round in Australian waters (Limpus in Hamann et al., 2006) over Australian continental shelf waters. There are no BIAs for this species.	Development envelope: Moderate Zone of influence: High
Eretmochelys imbricata Hawksbill Turtle	Vulnerable, Migratory	Vulnerable	Major nesting of Hawksbill Turtles in Australia occurs at Varanus Island and Rosemary Island in Western Australia (Pendoley, 2005). The key nesting areas in Australia include the Dampier Archipelago, Barrow, Lowendal and Montebello Island. Hawksbill Turtles spend their first five to ten years drifting on ocean currents (Carr, 1987a; Limpus et al., 1994e). During this pelagic (ocean-going) phase, they are often found in association with rafts of Sargassum (a floating marine plant that is also carried by currents) (Carr, 1987a). Once Hawksbill Turtles reach 30 to 40 cm curved carapace length, they settle and forage in tropical tidal and sub-tidal coral and rocky reef habitat. Satellite tracking has shown that Hawksbill Turtles nesting on Varanus Island and Rosemary Island in Western Australia feed between 50 km and 450 km from their nesting beaches. The development envelope intersects the Hawksbill Turtle nesting and internesting buffer BIA which occurs between Delambre Reed and Cod Bank (Figure 4-8).	Development envelope: Moderate Zone of influence: High

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Liasis olivaceus barroni Olive Python	Vulnerable	Vulnerable	Terrestrial species unlikely to use the tidal area for any part of its lifecycle.	Development envelope: Low Zone of influence: Low
Natator depressus Flatback Turtle	Vulnerable, Migratory	Vulnerable	The Flatback Turtle is found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya (Spring, 1982; Zangerl et al., 1988) and is one of only two species of sea turtle without a global distribution. The Kimberley Region of Western Australia, Cape Dommett (Bowlay & Whiting, 2007) and Lacrosse Island are important nesting areas. The largest nesting sites of the Pilbara region are Barrow Island and the mainland coast (Mundabullangana Station near Cape Thouin and smaller nesting sites at Cemetery Beach in Port Hedland and Bell's Beach near Wickham). Other significant rookeries include Thevenard Island, the Montebello Islands, Varanus Island, the Lowendal Islands, and islands of the Dampier Archipelago. Internesting habitat are up to 70 km from nesting beaches (Waayers et al., 2011; Whittock et al., 2014). Satellite tracking of flatback turtle nesting populations at Barrow Island indicates this species travels to the east of Barrow Island, towards WA mainland coastal waters, between nesting events. Capture locations from trawlers indicate that Flatback Turtles feed in turbid, shallow inshore waters north of latitude 25° S in depths from less than 10 m to depths of over 40 m (Robins, 1995). The development envelope intersects the Flatback Turtle mating, nesting and internesting buffer BIA which occurs North off the coast between Ronsard Island and Long Island (Figure 4-8).	Development envelope: High Zone of influence: High
Fish				
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish	Migratory		The narrow sawfish occurs from the northern Arabian Gulf to Australia, and north to Japan. The species inhabits inshore and estuarine waters and offshore waters up to 100 m deep (International Union for Conservation of Nature (IUCN), 2015), and is most commonly found in sheltered bays with sandy bottoms.	Development envelope: Moderate Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Carcharias taurus Grey Nurse Shark	Vulnerable	Vulnerable	The Grey Nurse Shark (west coast population) has a broad inshore distribution, primarily in sub-tropical to cool temperate waters (Last & Stevens, 1994). The population of Grey Nurse Shark (west coast population) is predominantly found in the south-west coastal waters of Western Australia (Environment Australia, 2002a) and has been recorded as far north as the North West Shelf (Stevens, 1999; Pogonoski et al., 2002). Grey Nurse Sharks are often observed hovering motionless just above the seabed, in or near deep sandy-bottomed gutters or rocky caves, and in the vicinity of inshore rocky reefs and islands (Pollard et al., 1996). The species has been recorded at varying depths, but is generally found between 15–40 m (Otway & Parker, 2000). Grey Nurse Sharks have also been recorded in the surf zone, around coral reefs, and to depths of around 200 m on the continental shelf (Pollard et al., 1996). They generally occur either alone or in small to medium sized groups, usually of fewer than 20 sharks (Pollard et al., 1996).	Development envelope: Low Zone of influence: Moderate
Carcharodon carcharias White Shark, Great White Shark	Vulnerable, Migratory	Vulnerable	In Australia, Great White Sharks have has been sighted in all coastal areas except in the Northern Territory. The majority of recorded great white shark movements occur between the coast and the 100 metre depth contour. Both adults and juveniles have been recorded diving to depths of 1000 metres (Bruce et al., 2006; Bruce & Bradford, 2008). Great White Sharks can be found from close inshore around rocky reefs, surf beaches and shallow coastal bays to outer continental shelf and slope areas (Pogonoski et al., 2002 in DEWHA, 2009). They also make open ocean excursions and can cross ocean basins (for instance from South Africa to the western coast of Australia and from the eastern coast of Australia to New Zealand). Great White Sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA, 2009). White sharks were identified as potentially occurring within the development envelope/zone of influence but given the migratory nature of the species, its low abundance, broad distribution in temperate waters across southern Australia and absence of preferred prey (pinnipeds), white sharks are unlikely to occur in large numbers.	Development envelope: Moderate Zone of influence: Moderate
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	Migratory		The species is commonly sighted inshore, but also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al., 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest this species is more resident in tropical waters and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations (Deakos et al., 2011; Marshall et al., 2009).	Development envelope: Moderate Zone of influence: Moderate
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	Migratory		The Giant Manta Ray is broadly distributed in tropical waters of Australia. The species primarily inhabits nearshore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al., 2011).	Development envelope: Moderate Zone of influence: Moderate

Species	Status under EPBC Act	Status under WC Act	Ecology/habitat requirements	Likelihood of presence
Pristis clavata Dwarf Sawfish, Queensland Sawfish	Vulnerable, Migratory		The species' Australian distribution has been considered to extend north from Cairns around the Cape York Peninsula in Queensland, across northern Australian waters to the Pilbara coast in Western Australia (Last & Stevens, 1994; McAuley et al., 2005; Stevens et al., 2008). The Dwarf Sawfish usually inhabits shallow (2–3 m) coastal waters and estuarine habitats. Unlike the Freshwater Sawfish (P. microdon), the Dwarf Sawfish does not utilise any purely freshwater areas, as the species' range is restricted to brackish and salt water (Thorburn et al., 2007a).	Development envelope: Moderate Zone of influence: Moderate
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable, Migratory	Vulnerable	In Australian waters, Green Sawfish have historically been recorded in the coastal waters off Broome, Western Australia. Green sawfish are currently distributed from about the Whitsundays (Harry et al., 2011) in Queensland across northern Australian waters to Shark Bay in Western Australia. Individuals have been recorded in inshore coastal environments and estuaries but the species does not penetrate into freshwater. There are also records of green sawfish hundreds of kilometres offshore in relatively deep water (Stevens et al., 2005). The Green Sawfish inhabits muddy bottom habitats and enters estuaries (Allen, 1997; Stead, 1963). It has been recorded in inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches (Peverell et al., 2004; Stevens et al., 2005; Thorburn et al., 2004). Stead (1963) reported that this species was frequently found in shallow water. Its habitat is heavily fished and often subject to pollution, habitat loss and degradation from coastal, riverine and catchment developments.	Development envelope: Moderate Zone of influence: Moderate
Rhincodon typus Whale Shark	Vulnerable, Migratory		Whale sharks aggregate annually to feed in the waters around Ningaloo Reef from March to November, with the largest numbers recorded in April and May (CALM, 2005; DSEWPaC, 2012a; Environment Australia, 2002; Sleeman et al., 2010). However, seasonal aggregation can be variable, with individual whale sharks recorded at other times of the year. DoEE has defined an additional BIA for foraging whale sharks (post-aggregation at Ningaloo) centred on the 200 m isobath from July to November. This area extends northward from the Ningaloo aggregation area to near Troughton Island in the east Kimberley but it does not cross the development envelope.	Development envelope: Low Zone of influence: Low

APPENDIX C

MNES impact risk assessment

Species	Impact assessment	Likelihood (environment risk consequence only)	Magnitude	Impact significance level/environment risk consequence
Birds				
Anous stolidus Common Noddy (EPBC – Migratory)	Construction impacts *Planned events* The species is pelagic and forages in open waters which will be temporarily impacted during the Proposal in the development envelope/zone of influence from dredging activities (e.g. increased turbidity). However, the Proposal would not affect important/critical habitat and the species is highly mobile and would be able to forage in non-impacted waters. Breeding habitat is unlikely to be impacted.	N/A	Slight	Minor
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	Operational impacts *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3). Migratory birds are unlikely to be impacted by a gas release as no hydrocarbons are expected to accumulate at the sea surface.	Remote	No lasting effect	Low
Fregata ariel Lesser Frigatebird, Least Frigatebird (EPBC – Migratory) *Macronectes giganteus* Southern Giant-Petrel (EPBC – Endangered)	Construction impacts *Planned events* The species is pelagic and forages in open waters which will be temporarily impacted during the Proposal in the development envelope/zone of influence from dredging activities (e.g. increased turbidity). However, the Proposal would not substantially affect important/critical habitat and the species is highly mobile and would be able to forage in non-impacted waters. Impacts are therefore considered temporary and minor. Breeding is not known to occur in the Dampier Archipelago.	N/A	Slight	Minor
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	Operational impacts *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3). Migratory birds are unlikely to be impacted by a gas release as no hydrocarbons are expected to accumulate at the sea surface.	Remote	No lasting effect	Low
Phalaropus lobatus Red-necked Phalarope (EPBC – Migratory)	Construction impacts *Planned events* During the non-breeding seasons the species occurs and forages in open waters which may be temporarily impacted during the Proposal in the development envelope/zone of influence from dredging activities (e.g. increased turbidity). However, the Proposal would not affect important/critical habitat and the species is highly mobile and would be able to forage in non impacted waters. Impacts are therefore considered temporary and minor.	N/A	Slight	Minor

Species	Impact assessment	Likelihood (environment risk consequence only)	Magnitude	Impact significance level/environment risk consequence
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3). Migratory birds are unlikely to be impacted by a gas release as no hydrocarbons are expected to accumulate at the sea surface.	Remote	No lasting effect	Low
Ardenna pacifica Wedge-tailed Shearwater (EPBC – Migratory) *Calonectris leucomelas* Streaked Shearwater (EPBC – Migratory) *Onychoprion anaethetus* Bridled Tern (EPBC – Migratory) *Pandion haliaetus* Osprey (EPBC – Migratory) *Thalasseus bergii* Crested Tern (EPBC – Migratory)	<u>Construction impacts</u> *Planned events* The species is pelagic and forages in open waters which will be temporarily impacted during the Proposal in the development envelope/zone of influence from dredging activities (e.g. increased turbidity). However, the Proposal would not substantially affect important/critical habitat and the species is highly mobile and would be able to forage in non-impacted waters. Impacts are therefore considered temporary and minor.	N/A	Slight	Minor
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3). Migratory birds are unlikely to be impacted by a gas release as no hydrocarbons are expected to accumulate at the sea surface.	Remote	No lasting effect	Low
Actitis hypoleucos Common Sandpiper (EPBC – Migratory) *Arenaria interpres* Ruddy Turnstone (EPBC – Migratory) *Tringa brevipes* Grey-tailed Tattler (EPBC – Migratory)	<u>Construction impacts</u> *Planned events* The onshore crossing site and immediate adjacent shoreline areas provides some marginal habitat for the species. However, it is highly disturbed habitat due to surrounding industrial developments resulting in noise and light emissions and physical disturbances. Higher quality habitats are present throughout the Dampier Archipelago islands and mainland and these are located at least 1.5 km from the development envelope. Dredging may impact some shoreline habitats in the zone of influence from sedimentation, but impacts are unlikely to substantially affect important/critical habitat or foraging behaviour. Impacts would be temporary and minor.	N/A	Minor	Low
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight

Species	Impact assessment	Likelihood (environment risk consequence only)	Magnitude	Impact significance level/environment risk consequence
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3). Migratory birds are unlikely to be impacted by a gas release as no hydrocarbons are expected to accumulate at the sea surface.	Remote	No lasting effect	Low
Hydroprogne caspia Caspian Tern (EPBC – Migratory) *Limicola falcinellus* Broad-billed Sandpiper (EPBC – Migratory) *Limosa lapponica* Bar-tailed Godwit (EPBC – Migratory; WC – Vulnerable) *Numenius madagascariensis* Eastern Curlew, Far Eastern Curlew (EPBC – Critically Endangered, Migratory; WC – Vulnerable) *Numenius phaeopus* Whimbrel (EPBC – Migratory) *Pluvialis fulva* Pacific Golden Plover (EPBC – Migratory) *Pluvialis squatarola* Grey Plover (EPBC – Migratory) *Sterna dougallii* Roseate Tern (EPBC – Migratory) *Sternula nereis nereis* Australian Fairy Tern (EPBC – Vulnerable; WC – Vulnerable) *Tringa totanus* Common Redshank, Redshank (EPBC – Migratory)	<u>Construction impacts</u> *Planned events* The species is unlikely to be found at the shore crossing site due to lack of preferred habitat but may be found foraging in the wider zone of influence. These habitats are present throughout the Dampier Archipelago islands and mainland and are located at least 1.5 km from the development envelope. Dredging may impact some shoreline habitats in the zone of influence as a result of sedimentation but impacts are unlikely to substantially affect important/critical habitat or foraging behaviour. Impacts would be temporary and minor.	N/A	Slight	Minor
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3). Migratory birds are unlikely to be impacted by a gas release as no hydrocarbons are expected to accumulate at the sea surface.	Remote	No lasting effect	Low
Calidris acuminate Sharp-tailed Sandpiper (EPBC – Migratory) *Calidris alba* Sanderling (EPBC – Migratory) *Calidris canutus* Red Knot (EPBC – Endangered, Migratory; WC – Vulnerable) *Calidris ferruginea* Curlew Sandpiper (EPBC – Critically Endangered, Migratory; WC – Vulnerable) *Calidris melanotos* Pectoral Sandpiper (EPBC – Migratory) *Calidris subminuta* Long-toed Stint (EPBC – Migratory) *Calidris tenuirostris* Great Knot (EPBC – Critically Endangered, Migratory; WC – Vulnerable) *Charadrius leschenaultii* Greater Sand Plover, Large Sand Plover (EPBC – Vulnerable, Migratory; WC – Vulnerable) *Charadrius mongolus* Lesser Sand Plover, Mongolian Plover (EPBC – Endangered, Migratory) *Charadrius veredus* Oriental Plover, Oriental Dotterel (EPBC – Migratory) *Glareola maldivarum* Oriental Pratincole (EPBC – Migratory) *Limosa lapponica baueri* Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit (EPBC – Vulnerable; WC – Vulnerable) *Limosa lapponica menzbieri* Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (EPBC – Critically Endangered; WC – Vulnerable) *Limosa limosa* Black-tailed Godwit (EPBC – Migratory) *Tringa nebularia* Common Greenshank, Greenshank (EPBC – Migratory) *Xenus cinereus* Terek Sandpiper	<u>Construction impacts</u> *Planned events* The species is unlikely to be found at the shore crossing site due to lack of preferred habitat but may be found foraging in the wider zone of influence. These habitats are present throughout the Dampier Archipelago islands and mainland and are located at least 1.5 km from the development envelope. Dredging may impact some shoreline habitats in the zone of influence as a result of sedimentation but impacts are unlikely to substantially affect important/critical habitat or foraging behaviour. Impacts would be temporary and minor. The species does not breed in Australia.	N/A	Slight	Minor
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3). Migratory birds are unlikely to be impacted by a gas release as no hydrocarbons are expected to accumulate at the sea surface.	Remote	No lasting effect	Low

Species	Impact assessment	Likelihood (environment risk consequence only)	Magnitude	Impact significance level/environment risk consequence
Mammals				
Dugong dugon Dugong (EPBC – Migratory; WC – Other protected fauna)	<u>Construction impacts</u> *Planned events* The species has been previously recorded in the waters of the Dampier Archipelago where it forages among seagrass habitats. It has the potential to be indirectly impacted from habitat disturbances and construction noise. Impacts would be temporary.	N/A	Minor	Moderate
	Unplanned events While highly unlikely, the species has the potential to be directly impacted during construction (vessel collisions). This unlikely to effect the species at a population level.	Highly unlikely	Slight	Low
	An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3).	Remote	Minor	Low
Megaptera novaeangliae Humpback Whale EPBC – Vulnerable, Migratory; WC – Conservation dependent) *Tursiops aduncus* Spotted Bottlenose Dolphin (EPBC – Migratory) *Sousa chinensis* Indo-Pacific Humpback Dolphin (EPBC – Migratory)	<u>Construction impacts</u> *Planned events* The species has been previously recorded in the waters of the Dampier Archipelago. It has the potential to be indirectly impacted from habitat disturbances (water quality impacts) and construction noise. Impacts would be temporary.	N/A	Minor	Moderate
	Unplanned events While highly unlikely, the species has the potential to be directly impacted during construction (vessel collisions). This unlikely to effect the species at a population level.	Highly unlikely	Slight	Low
	Unplanned events An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes but it could impact the habitat and foraging resources of the species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on marine fauna and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3).	Remote	Minor	Low
Reptiles				
Aipysurus apraefrontalis Short-nosed Seasnake (EPBC – Critically endangered)	<u>Construction impacts</u> *Planned events* The species is unlikely to be found at the shore crossing site due to lack of preferred habitat but may be found in the wider zone of influence. Direct impacts are unlikely due to the mobility of the species. Habitats are also unlikely to be directly impacted and removed. Some minor indirect impacts to habitats from sedimentation may occur during dredging. These would be temporary and minor.	N/A	Slight	Minor

Species	Impact assessment	Likelihood (environment risk consequence only)	Magnitude	Impact significance level/environment risk consequence
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes but it could impact the habitat and foraging resources of the species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on reptiles and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3).	Remote	Minor	Low
Natator depressus Flatback Turtle (EPBC – Vulnerable, Migratory; WC – Vulnerable) *Eretmochelys imbricata* Hawksbill Turtle (EPBC – Vulnerable, Migratory; WC – Vulnerable) *Dermochelys coriacea* Leatherback Turtle, Leathery Turtle, Luth (EPBC – Endangered, Migratory; WC – Vulnerable) *Chelonia mydas* Green Turtle (EPBC – Vulnerable, Migratory; WC – Vulnerable) *Caretta caretta* Loggerhead Turtle (EPBC – Endangered, Migratory; WC – Endangered)	<u>Construction impacts</u> *Planned events* The species has been previously recorded in the waters of the Dampier Archipelago. It has the potential to be indirectly impacted from habitat disturbances, construction noise and light emissions. Impacts would be temporary.	N/A	Minor	Moderate
	Unplanned events The species has the potential to be directly impacted during construction (vessel collisions, dredge entrainment). Entrainment, in particular is highly likely to occur considering location of dredging activities within Mermaid Sound.	Highly likely	Slight	High
	Unplanned events An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes. However, some shoreline habitats could potentially be impacted, including some habitat and foraging resources for this species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on reptiles and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3).	Remote	Minor	Low
Fish				
Carcharodon carcharias White Shark, Great White Shark (EPBC – Vulnerable, Migratory; WC – Vulnerable) *Carcharias taurus* Grey Nurse Shark (EPBC – Vulnerable; WC – Vulnerable)	<u>Construction impacts</u> *Planned events* The species has been infrequently recorded in the waters of the Dampier Archipelago and there are no known populations in the area. It has the potential to be indirectly impacted from construction noise and water quality impacts during dredging (increased turbidity). Impacts would be temporary and minor considering its mobility, capacity to avoid impacted areas and extent of similar habitats outside the zone of influence.	N/A	Slight	Minor
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes but it could impact the habitat and foraging resources of the species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight

Species	Impact assessment	Likelihood (environment risk consequence only)	Magnitude	Impact significance level/environment risk consequence
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on fish and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3).	Remote	Minor	Low
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish (EPBC – Vulnerable, migratoy; WC – Vulnerable) *Pristis clavata* Dwarf Sawfish, Queensland Sawfish (EPBC – Vulnerable, Migratory) *Manta birostris* Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray (EPBC – Migratory) *Manta alfredi* Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray (EPBC – Migratory) *Anoxypristis cuspidate* Narrow Sawfish, Knifetooth Sawfish (EPBC – Migratory)	<u>Construction impacts</u> *Planned events* The species has the potential to occur within the waters of the Dampier Archipelago, including within the development envelope and zone of influence. It has the potential to be impacted indirectly from noise impacts and disturbances to its habitat during dredging activities. Impacts would be temporary and considering the extent of habitat in the wider archipelago and the mobility of the species impacts would be minor.	N/A	Slight	Minor
	Unplanned events The species is highly mobile and unlikely to be directly impacted from vessel strikes. An oil spill during construction, has the potential to impact water quality. The risk of such an event occurring is highly unlikely and would involve small volumes but it could impact the habitat and foraging resources of the species.	Highly unlikely	Minor	Moderate
	<u>Operational impacts</u> *Planned events* The proposed trunkline is unlikely to provide new habitat for this species.	N/A	No lasting effect	Slight
	Unplanned events A hydrocarbon spill (gas) from the trunkline has the potential to have a moderate consequence on fish and habitats within the Dampier Archipelago. However, there is only a remote chance of such an event occurring based on the risk assessment and proposed design parameters (refer to Section 5.3.3).	Remote	Minor	Low

APPENDIX D

MNES assessments of significance

An assessment on the significance of the impacts was undertaken for relevant MNES in accordance with the following guidelines:

- Matters of National Environmental Significance. Significant impact guidelines 1.2 Environment Protection and Biodiversity Conservation Act 1999 (Department of the Environment, 2013)
- Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies. Significant impact guidelines 1.2 Environment Protection and Biodiversity Conservation Act 1999 (DSEWPaC, 2013).

The assessment addresses each of the criteria in the relevant guidelines to determine whether the Proposal has the potential to have a significant impact on the MNES.

<table>
<tr><th>MNES Significance criteria</th><th>Significant impact assessment</th></tr>
<tr><td>Endangered species</td><td>Caretta caretta Loggerhead Turtle</td></tr>
<tr><td>An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:
lead to a long-term decrease in the size of a population</td><td>The species nests principally from Dirk Hartog Island, along the Gnarloo and Ningaloo Coast to North West Cape and the Muiron Islands. There have been occasional records from Varanus and Rosemary Islands in the Pilbara. However, these are not identified as a nesting BIA. Furthermore, considering Rosemary Island is located about 17 kilometres west of the Proposal, it is unlikely it would be directly or indirectly impacted. An internesting BIA is, however, present within the waters of the Dampier Archipelago and intersects the development envelope (Figure 4-8).
Potential impacts on turtles may results from the following:
Direct impacts from vessel strikes and/or entrainment during dredging. Dredges can be a direct source of turtle mortality where animals become caught in the dredge (entrainment). Recent technological advances to reduce the impacts of dredge operations on marine turtles include turtle deflecting devices, which have been incorporated on some larger dredging operations to reduce the incidence of turtle injury. Measures to avoid/minimise direct impacts to turtles will be investigated and implemented as part of the Dredge and Spoil Disposal Management Plan (DSDMP).
Generally, elevated underwater noise can affect marine organisms in three main ways (Richardson et al., 1995; Simmonds et al., 2004):
by causing direct physical effects on hearing or other organs (injury), which can include PTS or TTS
by marking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)
through disturbance leading to behavioural changes or displacement of animals from important areas.
Physical effects can occur but only likely at a very short range and high sound intensities. Physical impacts are unlikely to occur in most large marine species, as they will display avoidance behaviour well before they get within the range at which physical effects may occur. Marine turtles have an auditory bandwidth of 100–800 Hz, with the greatest sensitivity between 200–400 Hz (adults) and 600–700 Hz (juveniles). Based on a literature review, the following sound exposure criteria are applicable.
<table>
<tr><th>Criterion</th><th>Effect</th><th>Source</th></tr>
<tr><td>Peak pressure</td><td></td><td></td></tr>
<tr><td>224 dB re 1 µPa</td><td>Onset of TTS and behavioural disturbance in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>230 dB re 1 µPa</td><td>Onset of PTS and organ trauma in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>SEL</td><td></td><td></td></tr>
<tr><td>183 dB re 1 µPa2-s</td><td>TTS and behavioural disturbance in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>198 dB re 1 µPa2-s</td><td>Onset of PTS and organ trauma in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>210 dB re 1 µPa2-s</td><td>Injury in Turtles</td><td>Popper et al. (2014)</td></tr>
<tr><td>RMS pressure</td><td></td><td></td></tr>
<tr><td>166 dB re 1 µPa</td><td>Avoidance response in turtles</td><td>McCauley et al., 2000</td></tr>
</table>
</td></tr>
</table>

MNES Significance criteria	Significant impact assessment

175 dB re 1 µPa	Alarm response by turtles	McCauley et al, 2000

Noise sources from the Proposal would only be emitted during construction from vessel operations including dredging and spoil disposal/rock dumping, piling activities and hydrographic surveys using multibeam echo sounders. Emissions are generally likely to range between 154 dB re 1µPa at 1 m to 198 dB re 1µPa at 1 m. Piling activities, however, may result in maximum Peak Pressure of 240 dB re 1µPa @ 1 m and a maximum SEL of the order of 215 dB re 1µPa2.s @ 1 m for one pulse. These activities, would take 2-3weeks to complete. The proposed construction activities are relatively common in the Dampier Archipelago/Mermaid Sound which is located within the boundary of the Port of Dampier and has high vessel traffic. Sea turtles are expected to avoid areas before sounds reach a level where it can cause them any physical harm. However, there is a risk of potential injury if piling activities start when a turtle is within close proximity of activities. Mitigation measures have been proposed to minimise construction noise impacts, including soft start procedures and stopping activities when turtles are sighted within a certain radius of any activities. While noise impacts also have the potential to impact some foraging resources of the turtles, impacts are unlikely to reduce the availability of this resource to substantially impact foraging behaviour.

- Marine turtles use light as an orientation cue. Artificial light can inhibit nesting by females and can disrupt hatchling orientation and sea finding behaviour. When hatchlings are attracted to light inland they may be exposed to increased mortality from avian and terrestrial predators, trapped in vegetation or killed on roads. If hatchlings do reach the ocean they may have used valuable energy reserves required to reach pelagic feeding areas. Lighting of jetties, vessels or platforms can create pools of light that attract swimming hatchlings and increase their risk of predation. Potential impacts from vessel lighting may include:
  - sea turtle hatchings being attracted to lights onboard dredge vessel(s)
  - adult sea turtle being deterred from nesting/foraging activities.

  Potential consequences may include:
  - hatchlings trapped by the light spill from vessel lights being concentrated within a small area, exposing them to predation.
  - physical exhaustion of hatchlings from maintaining position under dredge lighting, after entering the water.
  - nesting and foraging activity by adult sea turtle being reduced leading to a loss of available habitat.

  Lighting for the Proposal would only be required during construction and be limited to the shore crossing location and construction vessels. The shore crossing location is located within an industrial zone already impacted by lighting impacts. Vessels would be required along the trunkline alignment away from any shoreline and in an area of high vessel traffic where vessel lighting would be common. While impacts are likely to be minor, management measures have been recommended to further reduce potential impacts.
- The species is carnivorous, feeding predominantly on benthic invertebrates in habitats ranging from near shore to water depths of 55 m. During their post-hatchling stage, they feed on algae, pelagic crustaceans and molluscs. Indirect impact to water quality from dredging operations (increased turbidity and sedimentation of benthic habitats) could reduce foraging resources. The impact of the Pluto LNG Facility trunkline located immediately to the east of the proposed Scarborough trunkline was assessed in 2006 and monitored in 2009. MScience (2018) undertook a review of the extent and intensity of turbid plumes around the Pluto LNG Facility trunkline dredging program.

  The Pluto LNG Facility trunkline modelling in 2006 identified that as the dredging activities move along the gas trunkline deposition is predicted to remain elevated but localised, thus following the dredging footprint away from shore. The use

MNES Significance criteria	Significant impact assessment
	of a trailer suction hopper dredge has the potential to increase deposition. However, the plume associated with these combined activities is predicted to remain localised. Furthermore, previous monitoring studies have highlighted the high levels of suspended solids and sedimentation that occur through natural events (for example, swells and storms) and other port operations (such as ship movements) and previous dredge impact modelling studies that examined resuspension by storm events (SKM, 2004) concluded that additional TSS and sedimentation that would be contributed by dredged material would be insignificant in relation to the wider resuspension and sedimentation budget of the area. These pre-dredging assessment conclusions were confirmed during the monitoring. The 2009 study found that turbidity elevation was minimal at the sensitive receptor communities around Conzinc, Angel and Gidley Islands, and below thresholds with a potential to cause a stress to corals, the most sensitive communities to light reduction and sedimentation. Equally, the 2009 trunkline dredging did not cause turbidity around the coral communities to reach levels of 3.2 NTU. Dredge logs examined during the 2009 study demonstrated that trunkline dredging is a relatively rapid process, with the dredge often progressing over 1 km per day along the route. This rapid movement of the source of suspended sediment coupled with the propensity of all dredging to cause relatively short-lived elevations in turbidity (Jones et al., 2015b) means that duration terms exceeding 2–3 days for any material increase in turbidity are extremely unlikely. The only exception to that would be for communities near spoil grounds receiving spoil from the dredging. Monitoring of turbidity around trunkline dredging during the 2009 campaign demonstrated that at distances greater than 500 m from dredging, turbidity elevations were so low as to be below the threshold of a Zone of Moderate Impact (ZOMI). Turbidity levels monitored at coral sites nearest to the spoil ground used in that campaign were also below intensities which could indicate a ZOMI threshold. Overall, the agreement of results from boat-based, satellite-based and in situ monitoring of turbidity with the predictions of a model based on suspended sediment concentrations, provide strong support to the finding that trunkline dredging within this area of Mermaid Sound has a very low potential to cause damage to the local benthic primary producer communities and their habitats. • Indirect impacts to water quality from an oil spill (refuelling accident) resulting in impact to foraging habitat and/or mortality. Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. This assumes no intervention. Management measures have been proposed to further minimise the scale of any oil spill. Based on the above, it is unlikely the Proposal would lead to a long-term decrease in the size of a population of the species.
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • reduce the area of occupancy of the species	The Proposal would not remove any habitat for the species such that the area of occupancy of the species would be reduced.

MNES Significance criteria	Significant impact assessment
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • fragment an existing population into two or more populations.	The Proposal would not create temporary or permanent barriers such that it would fragment an existing population.
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • adversely affect habitat critical to the survival of a species	No "Critical Habitat" as defined under Section 207A of the EPBC Act (Register of Critical Habitat) has been identified and listed for marine turtles. However, the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) has defined habitat critical to the survival of a species for marine turtle stocks by consensus of a panel of experts in marine turtle biology. These are nesting and internesting habitat. There are no nesting BIAs within the Dampier Archipelago for the species. An internesting BIA is, however, present within the waters of the Dampier Archipelago and intersects the development envelope (Figure 4-8). This habitat, along with foraging habitat, has the potential to be impacted indirectly through water quality impacts. However, as assessed above, impacts would be temporary, localised and minor with the implementation of proposed management measures and therefore unlikely to impact on the survival of the species.
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • disrupt the breeding cycle of a population	There are no nesting BIAs within the Dampier Archipelago for the species. However, the species is known to breed on Rosemary Island with the breeding period occurring November and May. Considering Rosemary Island is located around 17 kilometres to the west of the Proposal, it is unlikely it would be directly or indirectly impacted. An internesting BIA is, however, present within the waters of the Dampier Archipelago and intersects the development envelope (Figure 4-8). As detailed above, a number of proposal activities have the potential to impact individuals of the species and/or its habitat. However, this would likely result in minor impacts taking into consideration the proposed management measures and the breeding cycle in the Dampier Archipelago is unlikely to be impacted.
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	As assessed above, habitat for the species has the potential to be impacted indirectly through water quality impacts. However, as detailed above and taking into consideration the proposed management measures, the Proposal is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

MNES Significance criteria	Significant impact assessment
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	The Proposal is unlikely to result in the introduction of an invasive species that would be harmful to the threatened species. Furthermore, management measures would be implemented to avoid the risk of invasive species becoming established in the region as a result of contaminated ballast waters/hulls.
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • introduce disease that may cause the species to decline, or interfere with the recovery of the species	The Proposal is unlikely to result in the introduction of disease and therefore a resulting decline of the species is not anticipated.

.

The long-term recovery objective for marine turtles is to minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list. The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) has been prepared and outlines overarching actions to meet this objective. An assessment of the Proposal against these actions is below.

Action	Assessment
Assessing and addressing threats	
A1 Maintain and improve efficacy of legal and management protection	The Proposal would not interfere or prevent the implementation of this action by others.
A2 Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability	The Proposal would not interfere or prevent the implementation of this action by others.
A3 Reduce the impacts from marine debris	Construction vessels and other activities along the shoreline may result in marine debris (e.g. waste) ending up in the water column if not adequately managed. Waste management measures have been recommended and would be implemented to ensure waste from vessels and other construction activities do not end up in the natural environment. Furthermore, construction personnel would be inducted on the importance of the region for marine turtles and the importance of avoiding pollution of water.
A4 Minimise chemical and terrestrial discharge	The Proposal would not result in planned chemical or terrestrial discharges to the environment.
A5 Address international take within and outside Australia's jurisdiction	The Proposal would not interfere or prevent the implementation of this action by others.
A6 Reduce impacts from terrestrial predation	The Proposal would not interfere or prevent the implementation of this action by others.
A7 Reduce international and domestic fisheries bycatch	The Proposal would not interfere or prevent the implementation of this action by others.
A8 Minimise light pollution	Potential impacts from light pollution have been assessed above. There would be no light pollution during operation of the Proposal. Management measures have been proposed to minimise impacts of light emissions during construction and therefore the Proposal complies with the action of the recovery plan to minimise light pollution.
A9 Address the impacts of coastal development/infrastructure and dredging and trawling	Activities resulting in degradation in nesting, internesting and foraging habitats may directly cause turtle mortality, or indirectly contribute to a decreased stock viability by reducing food availability, reducing growth rates or fecundity, or increasing susceptibility to injury and disease. In particular, management of dredging must take into account the impact of changes to the benthic environment in terms of the flow-on implications for marine turtle stock viability.

MNES Significance criteria	Significant impact assessment	
		The proposed trunkline alignment avoids sensitive benthic habitats, including foraging habitat for the species. As discussed further up, indirect impacts resulting from increased turbidity and/or sedimentation of habitats is likely to be minor and highly localised around the trunkline alignment. The impact of dredges (entrainment) and vessel strikes have also been considered above and are highly unlikely considering the implementation of the proposed management measures.
	A10 Maintain and improve sustainable Indigenous management of marine turtles	The Proposal would not interfere or prevent the implementation of this action by others.
	Enabling and measuring recovery	
	B1 Determine trends at index beaches	The Proposal would not interfere or prevent the implementation of this action by others.
	B2 Understand population demographics at key foraging grounds	The Proposal would not interfere or prevent the implementation of this action by others.
	B3 Address information gaps to better facilitate the recovery of marine turtle stocks	The Proposal would not interfere or prevent the implementation of this action by others.
CONCLUSIONS	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality, construction noise and light pollution as well as potential direct impacts from vessel strikes and/or entrainment during dredging. These impacts are unlikely to be significant with the implementation of the recommended management measures.	
Vulnerable species	*Megaptera novaeangliae* Humpback Whale	
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of an important population of a species	Although the north and south-bound migratory routes for most whales are further offshore than the Dampier Archipelago waters (up to 70 nm from the coast), during the south-bound migration it is likely that most individuals, particularly cow/calf pairs, stay closer to the coast, than the northern migratory path (Double et al., 2010). During the south-bound migration, it is likely some whales may travel through Dampier Archipelago waters, either passing the open outer waters, or travelling into Mermaid Sound and continuing westwards, likely through the channel bounded by West Lewis Island and Enderby Island to the south and Rosemary Island to the north (with reference to Jenner et al., 2001). The peak of the northward migration in Dampier Archipelago waters is during July, while the southern migration peaks in late August/early September. The Proposal has the potential to impact the species through: • Vessel strikes – The risk of vessel strikes is considered highly unlikely. However, management measures have been recommended to avoid any impacts. • Construction noise – Generally, elevated underwater noise can affect marine organisms in three main ways (Richardson et al., 1995; Simmonds et al., 2004): – by causing direct physical effects on hearing or other organs (injury), which can include PTS or TTS	

<table>
<tr><th>MNES Significance criteria</th><th>Significant impact assessment</th></tr>
<tr><td></td><td>

by masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)
through disturbance leading to behavioural changes or displacement of animals from important areas.

Physical effects can occur but are only likely at a very short range and at high sound intensities. Physical impacts are unlikely to occur in the majority of large marine species as species will display avoidance behaviour well before they get within the range at which physical effects may occur. Based on a literature review the following sound exposure criteria are applicable.
<table>
<tr><th>Criterion</th><th>Effect</th><th>Source</th></tr>
<tr><td>Peak pressure</td><td></td><td></td></tr>
<tr><td>224 dB re 1 µPa</td><td>Onset of TTS and behavioural disturbance in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>230 dB re 1 µPa</td><td>Onset of PTS and organ trauma in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>SEL</td><td></td><td></td></tr>
<tr><td>183 dB re 1 µPa2-s</td><td>TTS and behavioural disturbance in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>198 dB re 1 µPa2-s</td><td>Onset of PTS and organ trauma in cetaceans, dugongs</td><td>Southall et al., 2007</td></tr>
<tr><td>210 dB re 1 µPa2-s</td><td>Injury in Turtles</td><td>Popper et al. (2014)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>RMS pressure</td><td></td><td></td></tr>
<tr><td>166 dB re 1 µPa</td><td>Avoidance response in turtles</td><td>McCauley et al., 2000</td></tr>
<tr><td>175 dB re 1 µPa</td><td>Alarm response by turtles</td><td>McCauley et al, 2000</td></tr>
</table>
Noise sources from the Proposal would only be emitted during construction; from vessel operations including dredging and spoil disposal/rock dumping, piling activities and hydrographic surveys using multibeam echo sounders. Emissions are generally likely to range between 154 dB re 1µPa at 1 m to 198 dB re 1µPa at 1 m. Piling activities, however, may result in maximum Peak Pressure of 240 dB re 1µPa @ 1 m and a maximum SEL of the order of 215 dB re 1µPa2.s @ 1 m for one pulse. These activities, would take 2-3 weeks to complete. The proposed construction activities are relatively common in the Dampier Archipelago/Mermaid Sound which is located within the boundary of the Port of Dampier and has high vessel traffic. Humpback whales are expected to avoid areas before sounds reach a level where it can cause them any physical harm. However, there is a risk of potential injury if piling activities start when a whale is within close proximity of activities. Mitigation measures have been proposed to minimise construction noise impacts, including soft start procedures and stopping activities when whales are sighted within a certain radius of any activities.

Indirect impacts to water quality as a result of increased turbidity levels during dredging. The impact of the Pluto LNG Facility trunkline located immediately to the east of the proposed Scarborough trunkline was assessed in 2006 and monitored in 2009. MScience (2018) undertook a review of the extent and intensity of turbid plumes around the Pluto LNG Facility trunkline dredging program.

</td></tr>
</table>

MNES Significance criteria	Significant impact assessment
	The Pluto LNG Facility trunkline modelling in 2006 identified that as the dredging activities move along the gas trunkline deposition is predicted to remain elevated but localised, thus following the dredging footprint away from shore. The use of trailer suction hopper dredge has the potential to increase deposition. However, the plume associated with these combined activities is predicted to remain localised. Furthermore, previous monitoring studies have highlighted the high levels of suspended solids and sedimentation that occur through natural events (for example, swells and storms) and other port operations (such as ship movements) and previous dredge impact modelling studies that examined resuspension by storm events (SKM, 2004) concluded that additional TSS and sedimentation that would be contributed by dredged material would be insignificant in relation to the wider resuspension and sedimentation budget of the area. These pre-dredging assessment conclusions were confirmed during the monitoring. Monitoring of turbidity around trunkline dredging during the 2009 campaign demonstrated that at distances greater than 500 m from dredging, turbidity elevations were so low as to be below the threshold of a Zone of Moderate Impact (ZOMI) for benthic communities. Increased turbidity levels, in an area that is already naturally turbid, is unlikely to impact the Humpback Whale. • Indirect impacts to water quality from an oil spill (refuelling accident) resulting in impact to foraging habitat and/or mortality. Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. This assumes no intervention. Management measures have been proposed to further minimise the scale of any oil spill.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • reduce the area of occupancy of an important population	The Proposal would not remove any habitat for the species such that the area of occupancy of the species would be reduced.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • fragment an existing important population into two or more populations	The Proposal would not create temporary or permanent barriers such that it would fragment an existing population.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • adversely affect habitat critical to the survival of a species	No “Critical Habitat” as defined under Section 207A of the EPBC Act (Register of Critical Habitat) has been identified and listed for the Humpback Whale. However, the Humpback Whale Recovery Plan 2005-2010 no longer in force provides information on habitat important (and potentially critical) to the survival of humpback whales. This includes calving areas, migration, resting and feeding areas. Of these only a migration route is present within the Damper Archipelago, identified as a migration BIA (Figure 4-7). Whales with calves are likely to be observed passing through the islands in August/September during their southern migration. As discussed above, with the implementation of the proposed management measures, the impacts from the Proposal are unlikely to affect habitat to a level that would compromise the survival of the species.

MNES Significance criteria	Significant impact assessment
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • disrupt the breeding cycle of an important population	The humpback whale is highly mobile and the Proposal is unlikely to impact on the migration route of the species. Potential impacts as detailed above are unlikely to disrupt the breeding cycle of an important population.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The Proposal is unlikely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The Proposal is unlikely to result in the introduction of an invasive species that would be harmful to the threatened species. Furthermore, management measures would be implemented to avoid the risk of invasive species becoming established in the region as a result of contaminated ballast waters/hulls.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • introduce disease that may cause the species to decline, or	The Proposal is unlikely to result in the introduction of disease and therefore a resulting decline of the species is not anticipated.

<table>
<tr><th>MNES Significance criteria</th><th>Significant impact assessment</th></tr>
<tr><td>interfere substantially with the recovery of the species.</td><td>
The Humpback Whale Recovery Plan 2005-2010 no longer in force cited a number of threats. Of these, the one relevant to the Proposal was habitat degradation.

Anthropogenic activities have the potential to degrade habitat important to the species. These activities may degrade habitat by operating at times that coincide with the presence of whales, or they may occur when whales are absent, but degrade habitat suitability on a permanent or semi-permanent basis. Habitat degradation may result in reduced occupancy and/or exclusion of individual whales from suitable habitat, compromised reproductive success, and mortality. It is possible that impacts on enough individual whales could lead to broader impacts at the population level, e.g. by reducing recruitment to such an extent that species recovery is impeded. This would be more likely to arise where activities that cause habitat degradation occurred intensively and/or cumulatively, or over a large portion of their range. These activities are discussed below:
<table>
<tr><th>Activity/impact</th><th>Assessment</th></tr>
<tr><td>Acoustic pollution (e.g. commercial and recreational vessel noise, and seismic survey activity)</td><td>As discussed above, the impacts of construction noise have the potential to elicit an avoidance response. Management measures have been proposed to avoid/minimise potential impacts.</td></tr>
<tr><td>entanglement (e.g. in marine debris, fishing and aquaculture equipment)</td><td>The Proposal would not utilise equipment that would increase the risk of entanglement.</td></tr>
<tr><td>physical injury and death from ship strike</td><td>Direct impacts from vessel strikes is a possible though highly unlikely event and management measures have been proposed to avoid impacts.</td></tr>
<tr><td>built structures that impact upon habitat availability and/or use (e.g. marinas, wharves, aquaculture installations, mining or drilling infrastructure)</td><td>The Proposal would not involve the building of structures that would impact habitat availability or use.</td></tr>
<tr><td>changing water quality and pollution (e.g. runoff from land based agriculture, oil spills, outputs from aquaculture)</td><td>As discussed above, the Proposal has the potential to have indirect impacts to water quality through increased localised turbidity levels during dredging activities and from accidental oil spills.</td></tr>
<tr><td>changes to water flow regimes causing extensive sedimentation or erosion or altered currents in near shore habitat (e.g. canals and dredging)</td><td>The Proposal would not change water flow regimes.</td></tr>
</table>
It should be noted that at the time of the writing of the plan, both migratory populations of humpback whales were increasing at the optimum biological rate suggesting that to date habitat degradation has not had a negative impact on population or species recovery.
</td></tr>
</table>

MNES Significance criteria	Significant impact assessment
CONCLUSIONS	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality and construction noise as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Vulnerable species	*Chelonia mydas* Green Turtle*; Dermochelys coriacea* Leatherback Turtle, Leathery Turtle, Luth; *Eretmochelys imbricata* Hawksbill Turtle*; Natator depressus* Flatback Turtle
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of an important population of a species	The Green Turtle is distributed between the Ningaloo Coast to Lacepede islands. The species' major nesting sites are the Islands of the Dampier Archipelago including Rosemary, Legendre and Delambre. Internesting habitat is generally within 10 km of nesting beaches. They can be found in nearshore reefs in the photic zone. The development envelope intersects the Green Turtle nesting and internesting buffer BIAs (Figure 4-8). The Leatherback Turtle is a highly pelagic species, venturing close to shore mainly during the nesting season. There is no confirmed nesting activity in Western Australia. It is known from waters all around Australia and can be found foraging year-round in Australian waters over Australian continental shelf waters. There are no BIAs for this species intersecting the development envelope. The major nesting of Hawksbill Turtles in Australia occurs at Varanus Island and Rosemary Island in Western Australia. The key nesting areas in Australia include the Dampier Archipelago, Barrow, Lowendal and Montebello Island. Hawksbill Turtles spend their first five to ten years drifting on ocean currents. During this pelagic (ocean-going) phase, they are often found in association with rafts of *Sargassum* (a floating marine plant that is also carried by currents). Once Hawksbill Turtles reach 30 to 40 cm curved carapace length, they settle and forage in tropical tidal and sub-tidal coral and rocky reef habitat. Satellite tracking has shown that Hawksbill Turtles nesting on Varanus Island and Rosemary Island in Western Australia feed between 50 km and 450 km from their nesting beaches. The development envelope intersects the Hawksbill Turtle nesting and internesting buffer BIA (Figure 4-8). The Kimberley Region of Western Australia, Cape Dommett and Lacrosse Island are important nesting areas for the Flatback Turtle. The largest nesting sites of the Pilbara region are Barrow Island and the mainland coast (Mundabullangana Station near Cape Thouin and smaller nesting sites at Cemetery Beach in Port Hedland and Bell's Beach near Wickham). Other significant rookeries include Thevenard Island, the Montebello Islands, Varanus Island, the Lowendal Islands, and islands of the Dampier Archipelago including Hauy and Delambre islands. Capture locations from trawlers indicate that Flatback Turtles feed in turbid, shallow inshore waters north of latitude 25° S in depths from less than 10 m to depths of over 40 m. The development envelope intersects the Flatback Turtle mating, nesting and internesting buffer BIA (Figure 4-8). The nearest turtle nesting beach to the Proposal is Holden Beach to the south west of the shore crossing location. This nesting beach is currently impacted by existing external light sources from the industrial zone. Systematic turtle monitoring has been undertaken on Holden Beach adjacent to Site A of the Pluto LNG Plant throughout the construction and operational phases between 2007 and 2017 Pendoley (2017): • Holden Beach is a north-west facing beach, approximately 590 m in length, situated immediately south of the existing Pluto LNG jetty, on the western coast of the Burrup Peninsula. The beach is split into two beaches by a rocky outcrop, which extends into the intertidal zone. Surveys conducted in 2005/2006 and 2006/2007 seasons by Pendoley Environmental (Pendoley 2005b and 2006) suggested body pits observed on Holden Beach were characteristic of flatback and green turtles. • A number of existing and external sources of light are located within close proximity to Holden Beach including lighting from the Pluto LNG Project jetty, Pluto LNG Site A infrastructure and other nearby facilities.

MNES Significance criteria	Significant impact assessment

- A total of 63 turtle tracks have been identified on Holden Beach since monitoring began, creating 73 body pits which resulted in 35 successful nests. Turtle track activity on Holden Beach peaked between November and January during the 2007-2017 seasons.
- A total of 822 hatching tracks were observed between 2007 and 2017 seasons. Incubation time is not presented due to varying frequency of monitoring surveys. Hatchling emergence on Holden Beach peaked between December and February during the 2007-2017 seasons.
- The results indicate that Holden Beach is not a major sea turtle rookery, supporting Pendoley 2010 which proposed that key sea turtle nesting locations are located towards the outer Dampier Archipelago on Rosemary and Legendre Islands.

Considering the main nesting beaches of Rosemary Island are located around 17 kilometres to the west of the Proposal, Legendre Island 11 kilometres to the east, Hauy Island 21 kilometres to the east and Delambre Island 34 kilometres to the east, it is unlikely these would be directly or indirectly impacted.

Potential impacts on turtles may results from the following:

- Direct impacts from vessel strikes and/or entrainment during dredging. Dredges can be a direct source of turtle mortality where animals become caught in the dredge (entrainment). Recent technological advances to reduce the impacts of dredge operations on marine turtles include turtle deflecting devices, which have been incorporated on some larger dredging operations to reduce the incidence of turtle injury. Measures to avoid/minimise direct impacts to turtles will be investigated and implemented as part of the Dredge and Spoil Disposal Management Plan (DSDMP).
- Generally, elevated underwater noise can affect marine organisms in three main ways (Richardson et al., 1995; Simmonds et al., 2004):
  - by causing direct physical effects on hearing or other organs (injury), which can include PTS or TTS
  - by marking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)
  - through disturbance leading to behavioural changes or displacement of animals from important areas.

  Physical effects can occur but only likely at a very short range and high sound intensities. Physical impacts are unlikely to occur in the majority of large marine species as species will display avoidance behaviour well before they get within the range at which physical effects may occur. Marine turtles have an auditory bandwidth of 100–800 Hz, with the greatest sensitivity between 200–400 Hz (adults) and 600–700 Hz (juveniles) (Ketten & Bartol, 2005). Based on a literature review the following sound exposure criteria are applicable.

Criterion	Effect	Source
Peak pressure		
224 dB re 1 µPa	Onset of TTS and behavioural disturbance in cetaceans, dugongs	Southall et al., 2007
230 dB re 1 µPa	Onset of PTS and organ trauma in cetaceans, dugongs	Southall et al., 2007
SEL		
183 dB re 1 µPa2-s	TTS and behavioural disturbance in cetaceans, dugongs	Southall et al., 2007

MNES Significance criteria	Significant impact assessment		
	198 dB re 1 µPa2-s	Onset of PTS and organ trauma in cetaceans, dugongs	Southall et al., 2007
	210 dB re 1 µPa2-s	Injury in Turtles	Popper et al. (2014)
	RMS pressure		
	166 dB re 1 µPa	Avoidance response in turtles	McCauley et al., 2000
	175 dB re 1 µPa	Alarm response by turtles	McCauley et al, 2000

Noise sources from the Proposal would only be emitted during construction from vessel operations including dredging and spoil disposal/rock dumping, piling activities and hydrographic surveys using multibeam echo sounders. Emissions are generally likely to range between 154 dB re 1µPa at 1 m to 198 dB re 1µPa at 1 m. Piling activities, however, may result in maximum Peak Pressure of 240 dB re 1µPa @ 1 m and a maximum SEL of the order of 215 dB re 1µPa2.s @ 1 m for one pulse. These activities, would take 8-10 days to complete. The proposed construction activities are relatively common in the Dampier Archipelago/Mermaid Sound which is located within the boundary of the Port of Dampier and has high vessel traffic. Sea turtles are expected to avoid areas before sounds reach a level where it can cause them any physical harm. However, there is a risk of potential injury if piling activities start when a turtle is within close proximity of activities. Mitigation measures have been proposed to minimise construction noise impacts, including soft start approaches and stopping activities when turtles are sighted within a certain radius of any activities. While noise impacts also have the potential to impact some foraging resources of the turtles, impacts are unlikely to reduce the availability of this resource to substantially impact foraging behaviour.

- Marine turtles use light as an orientation cue. Artificial light can inhibit nesting by females and can disrupt hatchling orientation and sea finding behaviour. When hatchlings are attracted to light inland they may be exposed to increased mortality from avian and terrestrial predators, trapped in vegetation or killed on roads. If hatchlings do reach the ocean they may have used valuable energy reserves required to reach pelagic feeding areas. Lighting of jetties, vessels or platforms can create pools of light that attract swimming hatchlings and increase their risk of predation.

  Potential impacts from vessel lighting may include:

  - sea turtle hatchings being attracted to lights onboard dredge vessel(s)
  - adult sea turtle being deterred from nesting/foraging activities.

  Potential consequences may include:

  - hatchlings trapped by the light spill from vessel lights being concentrated within a small area exposing them to predation
  - physical exhaustion of hatchlings from maintaining position under dredge lighting, after entering the water
  - nesting and foraging activity by adult sea turtle being reduced leading to a loss of available habitat.

  Lighting for the Proposal would only be required during construction and be limited to the shore crossing location and construction vessels. The shore crossing location is located within an industrial zone already impacted by lighting impacts. Vessels would be required along the trunkline alignment away from any shoreline and in an area of high vessel traffic where vessel lighting would be common. While impacts are likely to be minor, management measures have been recommended to further reduce potential impacts.

MNES Significance criteria	Significant impact assessment
	• The Green Turtle is Primarily herbivorous, foraging on algae, seagrass and mangroves. In their pelagic juvenile stage, they feed on algae, pelagic crustaceans and mollusc. The Leatherback Turtle is Oceanic and therefore remain planktivorous throughout their life, feeding on jellyfish and large planktonic ascidians (e.g. sea squirts) in the water column. The Hawksbill Turtle is omnivorous, feeding on algae, sponges, soft corals and other soft-bodied invertebrates. The Flatback Turtle is Primarily carnivorous, feeding on soft-bodied invertebrates. Juveniles eat gastropod molluscs, squid, siphonophores. Limited data indicate that cuttlefish, hydroids, soft corals, crinoids, molluscs and jellyfish are also eaten. Indirect impact to water quality from dredging operations (increased turbidity and sedimentation of benthic habitats) could reduce foraging resources. The impact of the Pluto LNG Facility trunkline located immediately to the east of the proposed Scarborough trunkline was assessed in 2006 and monitored in 2009. MScience (2018) undertook a review of the extent and intensity of turbid plumes around the Pluto LNG Facility trunkline dredging program. The Pluto LNG Facility trunkline modelling in 2006 identified that as the dredging activities move along the gas trunkline deposition is predicted to remain elevated but localised, thus following the dredging footprint away from shore. The use of trailer suction hopper dredge has the potential to increase deposition. However, the plume associated with these combined activities is predicted to remain localised. Furthermore, previous monitoring studies have highlighted the high levels of suspended solids and sedimentation that occur through natural events (for example, swells and storms) and other port operations (such as ship movements) and previous dredge impact modelling studies that examined resuspension by storm events (SKM, 2004) concluded that additional TSS and sedimentation that would be contributed by dredged material would be insignificant in relation to the wider resuspension and sedimentation budget of the area. This pre-dredging assessment conclusions were confirmed during the monitoring. The 2009 study found that turbidity elevation was minimal at the sensitive receptor communities around Conzinc, Angel and Gidley Islands, and below thresholds with a potential to cause a stress to corals. Equally, the 2009 trunkline dredging did not cause turbidity around the coral communities to reach levels of 3.2 NTU. Dredge logs examined during the 2009 study demonstrated that trunkline dredging is a relatively rapid process, with the dredge often progressing over 1 km per day along the route. This rapid movement of the source of suspended sediment coupled with the propensity of all dredging to cause relatively short-lived elevations in turbidity (Jones et al., 2015b) means that duration terms exceeding 2–3 days for any material increase in turbidity are extremely unlikely. The only exception to that would be for communities near spoil grounds receiving spoil from the dredging. Monitoring of turbidity around trunkline dredging during the 2009 campaign demonstrated that at distances greater than 500 m from dredging, turbidity elevations were so low as to be below the threshold of a Zone of Moderate Impact (ZOMI). Turbidity levels monitored at coral sites nearest to the spoil ground used in that campaign were also below intensities which could indicate a ZOMI threshold. Overall, the agreement of results from boat-based, satellite-based and in situ monitoring of turbidity with the predictions of a model based on suspended sediment concentrations, provide strong support to the finding that trunkline dredging within this area of Mermaid Sound has a very low potential to cause damage to the local benthic primary producer communities and their habitats. • Indirect impacts to water quality from an oil spill (refuelling accident) resulting in impact to foraging habitat and/or mortality. Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the

MNES Significance criteria	Significant impact assessment
	overall extent of the area impacted and the limit of exposure to sensitive receptors. This assumes no intervention. Management measures have been proposed to further minimise the scale of any oil spill. Based on the above, it is unlikely the Proposal would lead to a long-term decrease in the size of a population of the species.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • reduce the area of occupancy of an important population	The Proposal would not remove any habitat for the species such that the area of occupancy of the species would be reduced.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • fragment an existing important population into two or more populations	The Proposal would not create temporary or permanent barriers such that it would fragment an existing population.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • adversely affect habitat critical to the survival of a species	No "Critical Habitat" as defined under Section 207A of the EPBC Act (Register of Critical Habitat) has been identified and listed for marine turtles. However, the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) has defined habitat critical to the survival of a species for marine turtle stocks by consensus of a panel of experts in marine turtle biology. These are nesting and internesting habitat. Nesting and internesting BIAs are present within the Dampier Archipelago for all the species except the Leatherback Turtle (Figure 4-8). A mating BIA is also present for the Flatback Turtle. These habitats, along with foraging habitat, has the potential to be impacted indirectly through water quality impacts. However, as assessed above, impacts would be temporary, localised and minor with the implementation of proposed management measures and therefore unlikely to impact on the survival of the species
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • disrupt the breeding cycle of an important population	As stated above, considering the main nesting beaches of Rosemary Island are located around 17 kilometres to the west of the Proposal, Legendre Island 11 kilometres to the east, Hauy Island 21 kilometres to the east and Delambre Island 34 kilometres to the east, it is unlikely these would be directly or indirectly impacted. Except for the Leatherback Turtle, nesting and internesting BIAs, as well as a mating BIA for the Flatback Turtle, are present within the Dampier Archipelago and intersect the development envelope (Figure 4-8). The nesting period is between October and March. As detailed above, a number of proposal activities have the potential to impact individuals of the species and/or its habitat. However, this would likely result in minor impacts taking into consideration the proposed management measures and the breeding cycle in the Dampier Archipelago is unlikely to be impacted.
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	As assessed above, habitat for the species has the potential to be impacted indirectly through water quality impacts. However, as detailed above and taking into consideration the proposed management measures, the Proposal is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

<table>
<tr><th>MNES Significance criteria</th><th>Significant impact assessment</th></tr>
<tr><td>An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat</td><td>The Proposal is unlikely to result in the introduction of an invasive species that would be harmful to the threatened species. Furthermore, management measures would be implemented to avoid the risk of invasive species becoming established in the region as a result of contaminated ballast waters/hulls.</td></tr>
<tr><td>An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:
introduce disease that may cause the species to decline, or</td><td>The Proposal is unlikely to result in the introduction of disease and therefore a resulting decline of the species is not anticipated.</td></tr>
<tr><td>An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:
interfere substantially with the recovery of the species.</td><td>The long-term recovery objective for marine turtles is to minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list. The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) has been prepared and outlines overarching actions to meet this objective. An assessment of the Proposal against these actions is below.
<table>
<tr><th>Action</th><th>Assessment</th></tr>
<tr><td colspan="2">Assessing and addressing threats</td></tr>
<tr><td>A1 Maintain and improve efficacy of legal and management protection</td><td>The Proposal would not interfere or prevent the implementation of this action by others.</td></tr>
<tr><td>A2 Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability</td><td>The Proposal would not interfere or prevent the implementation of this action by others.</td></tr>
<tr><td>A3 Reduce the impacts from marine debris</td><td>Construction vessels and other activities along the shoreline may result in marine debris (e.g. waste) ending up in the water column if not adequately managed. Waste management measures have been recommended and would be implemented to ensure waste from vessels and other construction activities do not end up in the natural environment. Furthermore, construction personnel would be inducted on the importance of region for marine turtles and the importance of avoiding pollution of water.</td></tr>
<tr><td>A4 Minimise chemical and terrestrial discharge</td><td>The Proposal would not result in planned chemical or terrestrial discharges to the environment.</td></tr>
<tr><td>A5 Address international take within and outside Australia's jurisdiction</td><td>The Proposal would not interfere or prevent the implementation of this action by others.</td></tr>
</table></td></tr>
</table>

MNES Significance criteria	Significant impact assessment	
	A6 Reduce impacts from terrestrial predation	The Proposal would not interfere or prevent the implementation of this action by others.
	A7 Reduce international and domestic fisheries bycatch	The Proposal would not interfere or prevent the implementation of this action by others.
	A8 Minimise light pollution	Potential impacts from light pollution have been assessed above. There would be no light pollution during operation of the Proposal. Management measures have been proposed to minimise impacts of light emissions during construction. Therefore, the Proposal complies with the action of the recovery plan to minimise light pollution.
	A9 Address the impacts of coastal development/infrastructure and dredging and trawling	Activities resulting in degradation in nesting, internesting and foraging habitats may directly cause turtle mortality, or indirectly contribute to a decreased stock viability by reducing food availability, reducing growth rates or fecundity, or increasing susceptibility to injury and disease. In particular, management of dredging must take into account the impact of changes to the benthic environment in terms of the flow-on implications for marine turtle stock viability. The proposed trunkline alignment avoids sensitive benthic habitats, including foraging habitat for the species. As discussed further up, indirect impacts resulting from increased turbidity and/or sedimentation of habitats is likely to be minor and highly localised around the trunkline alignment. The impact of dredges (entrainment) and vessel strikes have also been considered above and are highly unlikely considering the implementation of the proposed management measures.
	A10 Maintain and improve sustainable Indigenous management of marine turtles	The Proposal would not interfere or prevent the implementation of this action by others.
	Enabling and measuring recovery	
	B1 Determine trends at index beaches	The Proposal would not interfere or prevent the implementation of this action by others.
	B2 Understand population demographics at key foraging grounds	The Proposal would not interfere or prevent the implementation of this action by others.
	B3 Address information gaps to better facilitate the recovery of marine turtle stocks	The Proposal would not interfere or prevent the implementation of this action by others.

MNES Significance criteria	Significant impact assessment
CONCLUSIONS	The Proposal would not result in permanent or long term impacts to any of the species or their habitats. Impacts would occur during construction and result in temporary localised degradation of water quality, construction noise and light pollution as well as potential direct impacts from vessel strikes and/or entrainment during dredging. These impacts are unlikely to be significant with the implementation of the recommended management measures.

MNES Significance criteria	Significant impact assessment
Migratory species	*Dugong Dugon* Dugong
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	• The Dugong is primarily herbivorous and forages on seagrass. Seagrasses in the Dampier Archipelago are generally sparse, occurring in low abundance on shallow sandy sediments in sheltered areas such as flats and larger bays (CALM, 2005; Jones, 2004). The most significant areas of seagrass in the Dampier Archipelago are found between Keast and Legendre Islands to the north of the Burrup Peninsula, and between West Intercourse Island and Cape Preston. Minor seagrass meadows are also found within macroalgal meadows in shallow sand areas such as West Conzinc Island (URS, 2000) and Withnell Bay (Bertolino 2006). None of these would be directly impacted. The impact of the Pluto LNG Facility trunkline located immediately to the east of the proposed Scarborough trunkline was assessed in 2006 and monitored in 2009. MScience (2018) undertook a review of the extent and intensity of turbid plumes around the Pluto LNG Facility trunkline dredging program. The Pluto LNG Facility trunkline modelling in 2006 identified that as the dredging activities move along the gas trunkline deposition is predicted to remain elevated but localised, thus following the dredging footprint away from shore. The use of trailer suction hopper dredge has the potential to increase deposition. However, the plume associated with these combined activities is predicted to remain localised. Furthermore, previous monitoring studies have highlighted the high levels of suspended solids and sedimentation that occur through natural events (for example, swells and storms) and other port operations (such as ship movements) and previous dredge impact modelling studies that examined resuspension by storm events (SKM, 2004) concluded that additional TSS and sedimentation that would be contributed by dredged material would be insignificant in relation to the wider resuspension and sedimentation budget of the area. This pre-dredging assessment conclusions were confirmed during the monitoring. The 2009 study found that turbidity elevation was minimal at the sensitive receptor communities around Conzinc, Angel and Gidley Islands, areas where sparse seagrass has been recorded in the past. Dredge logs examined during the 2009 study demonstrated that trunkline dredging is a relatively rapid process, with the dredge often progressing over 1 km per day along the route. This rapid movement of the source of suspended sediment coupled with the propensity of all dredging to cause relatively short-lived elevations in turbidity (Jones et al., 2015b) means that duration terms exceeding 2–3 days for any material increase in turbidity are extremely unlikely. The only exception to that would be for communities near spoil grounds receiving spoil from the dredging. Overall, the agreement of results from boat-based, satellite-based and in situ monitoring of turbidity with the predictions of a model based on suspended sediment concentrations, provide strong support to the finding that trunkline dredging within this area of Mermaid Sound has a very low potential to cause damage to the local benthic primary producer communities and their habitats. • Indirect impacts to water quality from an oil spill (refuelling accident) resulting in impact to foraging habitat and/or mortality. Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. • However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. This assumes no intervention. Management measures have been proposed to further minimise the scale of any oil spill..

MNES Significance criteria	Significant impact assessment
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	The Proposal is unlikely to result in the introduction of an invasive species that would be harmful to the threatened species. Furthermore, management measures would be implemented to avoid the risk of invasive species becoming established in the region as a result of contaminated ballast waters/hulls.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

As stated above the Dampier Archipelago does not have extensive areas of seagrass habitat which would provide habitat for an ecologically significant proportion of a population. Furthermore, the most significant areas of seagrass in the Dampier Archipelago are found between Keast and Legendre Islands to the north of the Burrup Peninsula, and between West Intercourse Island and Cape Preston further away from the development envelope. Impacts to foraging habitat (seagrass) is likely to be minor as discussed above. Furthermore, considering the location of seagrass habitats away from the development envelope, the risk of vessel collisions would be reduced. Management measures have, however, been proposed to avoid direct and indirect impacts.

Construction noise has the potential to impact Dugongs. Generally, elevated underwater noise can affect marine organisms in three main ways (Richardson et al., 1995; Simmonds et al., 2004):

- by causing direct physical effects on hearing or other organs (injury), which can include PTS or TTS
- by marking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)
- through disturbance leading to behavioural changes or displacement of animals from important areas.

Physical effects can occur but only likely at a very short range and high sound intensities. Physical impacts are unlikely to occur in the majority of large marine species as species will display avoidance behaviour well before they get within the range at which physical effects may occur. Considering the proposed trunkline alignment would be located away from any prime foraging grounds, the risk of an impact is considered low. Based on a literature review the following sound exposure criteria are applicable.

Criterion	Effect	Source
Peak Pressure		
224 dB re 1 µPa	Onset of TTS and behavioural disturbance in cetaceans. Also applied to dugongs and turtles.	Southall et al., 2007
230 dB re 1 µPa	Onset of PTS and organ trauma in cetaceans. Also applied to dugongs and turtles.	Southall et al., 2007
SEL		
198 dB re 1 µPa2-s	Onset of PTS and organ trauma in cetaceans. Also applied to dugongs and turtles.	Southall et al., 2007
183 dB re 1 µPa2-s	TTS and behavioural disturbance in cetaceans. Also applied to dugongs and turtles.	Southall et al., 2007
RMS pressure		
166 dB re 1 µPa	Behavioural response in Turtles	McCauley et al., 2000
175 dB re 1 µPa	Avoidance behaviours by Turtles	McCauley et al., 2000

Noise sources from the Proposal would only be emitted during construction from vessel operations including dredging and spoil disposal/rock dumping, piling activities and hydrographic surveys using multibeam echo sounders. Emissions are generally likely to range between 154 dB re 1µPa at 1 m to 198 dB re 1µPa at 1 m. Piling activities, however, may result in maximum Peak Pressure of 240 dB re 1µPa @ 1 m and a maximum SEL of the order of 215 dB re 1µPa2.s @ 1 m for one pulse. These activities, would take 2-3 weeks to complete. The proposed construction activities are relatively common in the Dampier

MNES Significance criteria	Significant impact assessment
	Archipelago/Mermaid Sound which is located within the boundary of the Port of Dampier and has high vessel traffic. Dugongs are expected to avoid areas before sounds reach a level where it can cause them any physical harm. However, there is a risk of potential injury if piling activities start when a Dugong is within close proximity of activities. Mitigation measures have been proposed to minimise construction noise impacts, including soft start approaches and stopping activities when Dugongs are sighted within a certain radius of any activities. While noise impacts also have the potential to impact some foraging resources of the Dugong, impacts are unlikely to reduce the availability of this resource to substantially impact foraging behaviour. The Proposal is therefore unlikely to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of this species.
CONCLUSIONS	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Migratory species	*Megaptera novaeangliae* Humpback Whale
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	As detailed further up, with the proposed management measures implemented, the Proposal is unlikely to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for this migratory species.
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	The Proposal is unlikely to result in the introduction of an invasive species that would be harmful to the threatened species. Furthermore, management measures would be implemented to avoid the risk of invasive species becoming established in the region as a result of contaminated ballast waters/hulls.

MNES Significance criteria	Significant impact assessment
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	As detailed further up, with the proposed management measures implemented, the Proposal is unlikely to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of this migratory species.
CONCLUSIONS	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.
Migratory species	*Sousa chinensis* Indo-Pacific Humpback Dolphin*; Tursiops aduncus* Spotted Bottlenose Dolphin
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	Impacts to their habitat would be indirect and temporary and relate to water quality impacts during construction. This includes: • The Pluto LNG Facility trunkline modelling in 2006 identified that as the dredging activities move along the gas trunkline deposition is predicted to remain elevated but localised, thus following the dredging footprint away from shore. The use of trailer suction hopper dredge has the potential to increase deposition. However, the plume associated with these combined activities is predicted to remain localised. Furthermore, previous monitoring studies have highlighted the high levels of suspended solids and sedimentation that occur through natural events (for example, swells and storms) and other port operations (such as ship movements) and previous dredge impact modelling studies that examined resuspension by storm events (SKM, 2004) concluded that additional TSS and sedimentation that would be contributed by dredged material would be insignificant in relation to the wider resuspension and sedimentation budget of the area. This pre-dredging assessment conclusions were confirmed during the monitoring. Indirect impacts to water quality as a result of an increase in turbidity levels in the vicinity to dredging activities. This would be temporary and localised and unlikely to substantially modify, destroy or isolate an area of important habitat. • Indirect impacts to water quality from an oil spill (refuelling accident). Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1.The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. This assumes no intervention. Management measures have been proposed to further minimise the scale of any oil spill. The Proposal is unlikely to modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for these species.

MNES Significance criteria	Significant impact assessment
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	The Proposal is unlikely to result in the introduction of an invasive species that would be harmful to the threatened species. Furthermore, management measures would be implemented to avoid the risk of invasive species becoming established in the region as a result of contaminated ballast waters/hulls.
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	Apart from the indirect impacts to water quality discussed above, the Proposal has the potential to disrupt the lifecycle of the species as a result of construction noise. Generally, elevated underwater noise can affect marine organisms in three main ways (Richardson et al., 1995; Simmonds et al., 2004): • by causing direct physical effects on hearing or other organs (injury) • by marking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey) • through disturbance leading to behavioural changes or displacement of animals from important areas. Physical effects can occur but only likely at a very short range and high sound intensities. Physical impacts are unlikely to occur in the majority of large marine species as species will display avoidance behaviour well before they get within the range at which physical effects may occur. Dolphins hear tones with a frequency up to 160 kHz with the greatest sensitivity ranging from 40 to 100 kHz Due to their high frequency hearing compared to the majority of construction activities, which will produce noise at lower frequencies, dolphins are not likely to be impacted upon. Piling activities mayproduce underwater noise audible to the dolphins. However, a recent study showed only minor impacts to dolphins at sites in the vicinity of impact piling or vibration piling; with dolphins spending a reduced period of time in the vicinity of construction works during both impact and vibration piling (Graham et al., 2017). Direct impacts from vessel strikes is unlikely considering the mobility of the species who would be able to avoid vessels. The Proposal is therefore unlikely to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of this species.
CONCLUSIONS	The Proposal would not result in permanent or long term impacts to the species or its habitat. Impacts would occur during construction and result in temporary localised degradation of water quality as well as potential direct impacts from vessel strikes. These impacts are unlikely to be significant with the implementation of the recommended management measures.

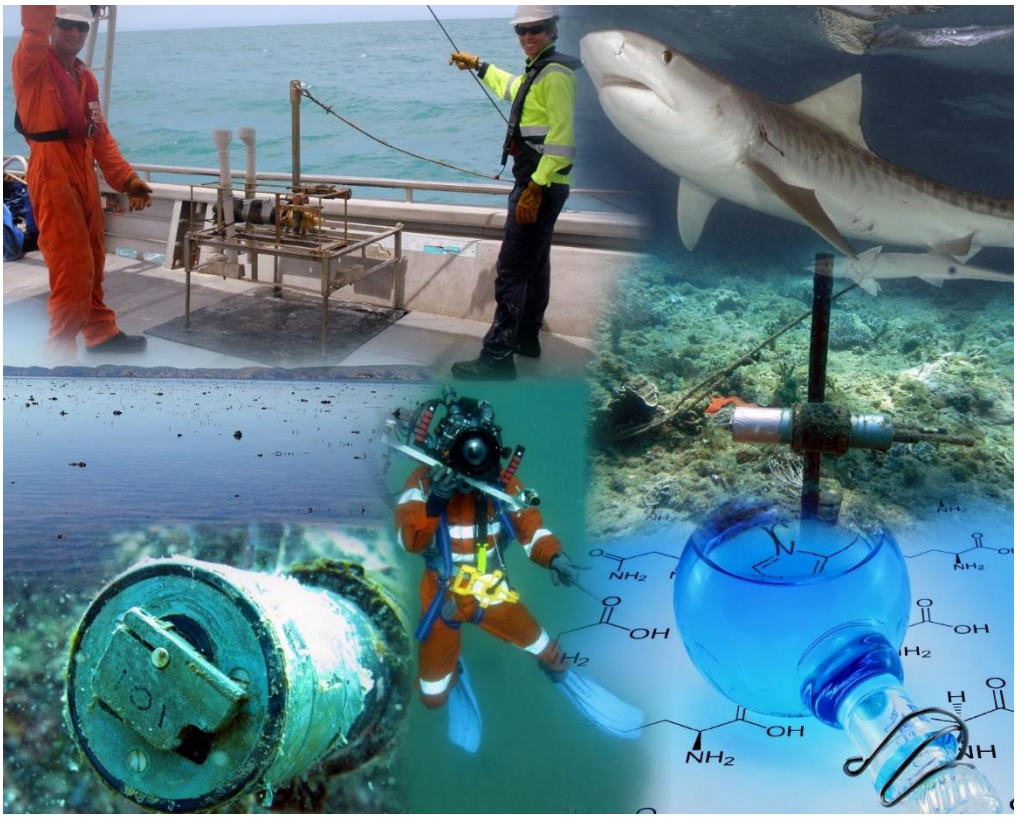
MNES Significance criteria	Significant impact assessment
Migratory species	*Caretta caretta* Loggerhead Turtle*; Chelonia mydas* Green Turtle*; Dermochelys coriacea* Leatherback Turtle, Leathery Turtle, Luth*; Eretmochelys imbricata* Hawksbill Turtle*; Natator depressus* Flatback Turtle
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	As detailed further up, with the proposed management measures implemented, the Proposal is unlikely to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for these migratory species.
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	The Proposal is unlikely to result in the introduction of an invasive species that would be harmful to the threatened species. Furthermore, management measures would be implemented to avoid the risk of invasive species becoming established in the region as a result of contaminated ballast waters/hulls.
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	As detailed further up, with the proposed management measures implemented, the Proposal is unlikely to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of these migratory species.
CONCLUSIONS	The Proposal would not result in permanent or long term impacts to any of the species or their habitats. Impacts would occur during construction and result in temporary localised degradation of water quality, construction noise and light pollution as well as potential direct impacts from vessel strikes and/or entrainment during dredging. These impacts are unlikely to be significant with the implementation of the recommended management measures.

MNES Significance criteria	Significant impact assessment
National Heritage Place	Dampier Archipelago (including Burrup Peninsula)
An action is likely to have a significant impact on the National Heritage values of a National Heritage place if there is a real chance or possibility that it will cause: • one or more of the National Heritage values to be lost • one or more of the National Heritage values to be degraded or damaged, or • one or more of the National Heritage values to be notably altered, modified, obscured or diminished.	The Proposal would not have any direct impacts to the Dampier Archipelago (including Burrup Peninsula) as it is located at least one kilometre from any construction activities and 1.6 kilometres from the trunkline at its closest location. The listing includes the waters surrounding some of the islands of the Dampier Archipelago. The Proposal has the potential to cause the following indirect impacts: • water quality impacts from dredging potentially resulting in increased turbidity levels and sedimentation. Dredge plume modelling and rates of sedimentation were previously undertaken for the Pluto LNG Facility development which included spoil disposal within the same spoil grounds proposed for the current proposal as well as the installation of a trunkline immediately to the east of the proposed Scarborough trunkline. The Scarborough trunkline is proposing to use a similar methodology to the Pluto LNG Facility trunkline installation. The Pluto LNG Facility trunkline modelling identified that as the dredging activities move along the gas trunkline deposition is predicted to remain elevated but localised, thus following the dredging footprint away from shore. Furthermore, previous monitoring studies have highlighted the high levels of suspended solids and sedimentation that occur through natural events (for example, swells and storms) and other port operations (such as ship movements) and previous dredge impact modelling studies that examined resuspension by storm events (SKM, 2004) concluded that additional TSS and sedimentation that would be contributed by dredged material would be insignificant in relation to the wider resuspension and sedimentation budget of the area. Therefore, any potential impacts on heritage values are highly unlikely and are unlikely to result in the loss, degradation, damage, or notable alteration, modification of any of the heritage values of the Dampier Archipelago (including Burrup Peninsula). • Water quality impacts from accidental oil spill from refuelling operations. Potential events and/or activities leading to an accidental hydrocarbon spill are discussed in Section 4.4.5.1. Receptor responses will vary depending on the size and location of the spill event. However, the risk of a spill occurring is considered highly unlikely with implementing the recommended management measures (Section 4.4.6). In the unlikely event a spill occurs, the small volumes which would be released would limit the overall extent of the area impacted and the limit of exposure to sensitive receptors. This assumes no intervention. Management measures have been proposed to further minimise the scale of any oil spill. • The trunkline would be located on the seabed and no indirect visual impacts would result.
CONCLUSIONS	Proposed activities have been undertaken in Mermaid Sound in the past and the proposed trunkline is located further away from any shore line compared to the previous trunklines previously installed to the east. The installation of these trunklines did not result in any significant impacts to the Dampier Archipelago (including Burrup Peninsula) heritage place. The Proposal is highly unlikely to result in significant impacts to the heritage values of the heritage place considering the distance of the Proposal to the heritage place and the likely minor impacts that would result from both planned and unplanned events during construction. Management measures have also been recommended to further minimise the risk of any impacts.

APPENDIX E

MScience 2018 Report – Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program 2009

Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program 2009



10 July 2018

A Review

Report to Worley Parsons

From

MScience Pty Ltd

Highgate, Western Australia 6003

mScience
marine research

Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program 2009

A Review

Document Information

REPORT NO.	MSA271R01
DATE	10 July 2018
CLIENT	Worley Parsons
USAGE	This report is provided as a record of studies undertaken during the Pluto LNG Project marine environmental monitoring and studies program.
KEYWORDS	Dredging trunkline turbidity
CITATION	MScience 2018. Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program 2009. Unpublished report MSA271R01 to Worley Parsons, Perth Western Australia, pp31

Version History

Version/Date	Issued as	Author	Approved
1/15.06.2018	For client review	DGM	JAS
1/10.07.2018	Final	DGM	JAS

CONTENTS

FIGURES

TABLES

LIST OF ACRONYMS AND TERMS

ANZECC & ARMCANZ	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*, Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
BoM	Bureau of Meteorology
BPP	Benthic Primary Producers
d	Days
EOSDIS	Earth Observing System Data and Information System
Kd	Light Attenuation Coefficient calculated using natural logarithm
km	Kilometre
LNG	Liquified Natural Gas
m	Metres
median	The value below which 50% of the distribution lies
MODIS	Moderate Resolution Imaging Spectroradiometer
Nephelometer	Instrument for measuring turbidity
NASA	US National Atmospheric and Space Agency
NTU	Nephelometric Turbidity Units
Overflow	Sediment-laden water overflowing from the dredge hopper during uplift of sediment
PAR	Photosynthetically Active Radiation
PSU	Practical salinity unit approximates g/l
SSC	Suspended Sediment Concentration – sediment weight/volume in a sample of water collected
TSS	Total Suspended Solids – sediment weight/volume in a subsample of water collected
TSHD	Trailing Suction Hopper Dredge
WAEPA	Western Australian Environmental Protection Authority
Woodside	Woodside Burrup Limited
80^{th} percentile	The value below which 80% of the distribution lies

1 EXECUTIVE SUMMARY

This review examines the results of a previous study on dredging-related changes in water quality and plume characteristics around a trunkline dredging program adjacent to the western side of the Burrup Peninsula in north-western Australia. Findings are contrasted with the current best understanding of levels of elevation of suspended sediments that might cause impacts to the sensitive benthic marine communities of the area.

As part of the 2007 – 2010 Woodside Burrup Limited (Woodside) Pluto LNG development program in Mermaid Sound, Western Australia, dredging of a trench for placement of a second trunkline to carry gas from offshore fields to the Karratha Gas Plant was completed. Trenching was required to ensure that the trunkline was protected within the shallow waters of Mermaid Sound within the Port of Dampier. The trunkline was dredged with a medium-large trailer-suction-hopper dredge over 17 days, from 28/3/2009 to 14/4/2009. The trunkline passed within 1-2 km of the west of the fringing coral communities of Conzinc, Angel and Gidley Islands.

A comprehensive program of plume and water quality monitoring was implemented during trunkline dredging. The study integrated boat-based monitoring of turbidity of the waters to the east of dredging between dredging and coral communities, satellite-derived (MODIS) imagery of the location of turbid plumes, and monitoring of turbidity by *in situ* instruments adjacent to the coral communities. A predictive modelling study that used the on-site results for development and validation was also completed.

During dredging, boat-based monitoring indicated an increase in turbidity within 500 m east of the dredge with a rapid decrease in turbidity at distances beyond 500 m east. The median turbidity outside 500 m east was below both the median and 80th percentile of turbidity at two reference sites located in an area unaffected by dredging. As the relevant coral sites were all east of dredging, turbidity measurements were not made to the west of the dredge. Time-series of turbidity measurements from *in situ* instruments located close to sensitive coral communities did not identify any changes in turbidity associated with dredging. During the trunkline dredging, the median turbidity (7 day rolling statistics) of the *in situ* sites adjacent to coral never exceeded the 80th percentiles of turbidity at coral reference sites.

Cloud cover during the monitoring period constrained availability of satellite imagery. Of the four MODIS images suitable for calibration, only one indicated the possibility of the dredge plume overlapping with coral sites. This was not consistent with measured turbidity and may have been caused by sediments flowing from the nearby Flying Foam passage or by sediment re-suspension from the spoil ground.

The modelled plume was consistent with both the boat-based and MODIS imagery. Indications were that the plume tended to move west from the dredge and did not impact on the Burrup Peninsula shoreline. The consistency between modelled and measured turbidity indicates the model may be useful for planning future trunkline dredging programs when weather conditions may be different and for prediction of both intensity and duration of turbidity change.

Weather patterns during trunkline dredging were either light winds or winds with a strong easterly component (strong winds from 3/4/2009 to 8/4/2009) which restricted the potential for plumes to reach the coral communities to the east of the trunkline dredging.

The impacts of this dredging program on water quality around the nearest sensitive coral communities have been compared with the results of recent research conducted by the Western Australian Marine Science Institute's Dredging Science Node. That research has indicated that at distances greater than 500 m from dredging, reduction in light available for photosynthesis represents the major source of dredging-related stress on corals. While the 2009 monitoring program did not measure light attenuation impacts, there is a strong correlation between light attenuation and turbidity elevation. The outcome of that comparison was that the minimal impacts shown by the various components of the monitoring were well below light

attenuation and turbidity thresholds which might indicate a source of physiological stress. Under thresholds consistent with the WAMSI studies and EPA management guidance, areas >500 m from trunkline dredging would have been categorized as a Zone of Influence, but not as a Zone of Moderate Impact.

Future trunkline dredging programs are likely to have a similar minimal impact, if conducted with characteristics similar to that of the 2009 dredging. Should weather patterns during future dredging be less favourable to moving plumes away from sensitive receptor communities (i.e. if winds are of a more westerly nature than in the 2009 program), the relatively rapid progress of trunkline dredging along linear structures is likely to maintain the duration and frequency terms of any intensity-duration-frequency threshold of turbidity elevation below that currently predicted as required to generate material levels of coral stress. Both the relatively short period of trunkline dredging and daily movement of the dredge mean the potential for elevated turbidity at any site, other than a spoil ground, would be likely to be <5 days.

2 INTRODUCTION

2.1 Background

During the period November 2007 to May 2010, Woodside Burrup Ltd (Woodside) undertook a program of dredging and construction within Mermaid Sound, Western Australia to support development of the Pluto LNG Project (SKM 2008). In addition to construction of berths, a swing basin and channels, dredging of a trench for placement of a second trunkline to carry gas from offshore fields to the Karratha Gas Plant on the Burrup Peninsula was completed. Trenching was required to ensure that the trunkline was protected within the shallow waters of Mermaid Sound within the Port of Dampier.

The majority of dredging for the trunkline was undertaken in 2009 by the trailing suction hopper dredge (TSHD) *Nile River*. The *Nile River* is a medium-large TSHD with a hopper capacity of 17,000 m^3. Between the 12/3/2009 and the 5/5/2009, the Nile River dredged approximately 1.2 Mm^3 in 262 loads, disposed in roughly equal proportions to Spoil Grounds 2B and 5A with a typical cycle time of 3-4 hr.

The route of the trunkline within Mermaid Sound passed 1 – 2 km to the west of the fringing coral communities of Conzinc, Angel and Gidley Islands (Figure 2-1). The potential for that trunkline dredging to impact on these coral communities through elevated suspended sediments was investigated during dredging by a study which integrated boat-based monitoring of the turbidity of waters between dredging and coral communities, satellite-derived imagery of the location of turbid plumes, and monitoring of turbidity by *in situ* instruments adjacent to these coral communities. Results from those data sources, and other data from the Pluto dredging, were used in a predictive modelling study to provide spatio-temporal distributions of suspended solids concentrations for use in predicting impact zones based on intensity-duration criteria used at that time (APASA 2011).

This document presents the results of those studies and relates them to current estimates of intensity-duration-frequency criteria developed by the Western Australian Marine Science Institute's Dredging Science Node investigations.

2.2 Structure of this Document

The document lists:

- The background to this study;
- The components of the 2009 study;
- Results from the 2009 studies; and
- A discussion of the results of those studies and their significance.

The document is current as at the date on the cover page and is referenced as Version 1 (Documents with a lower version number are superseded by this document).

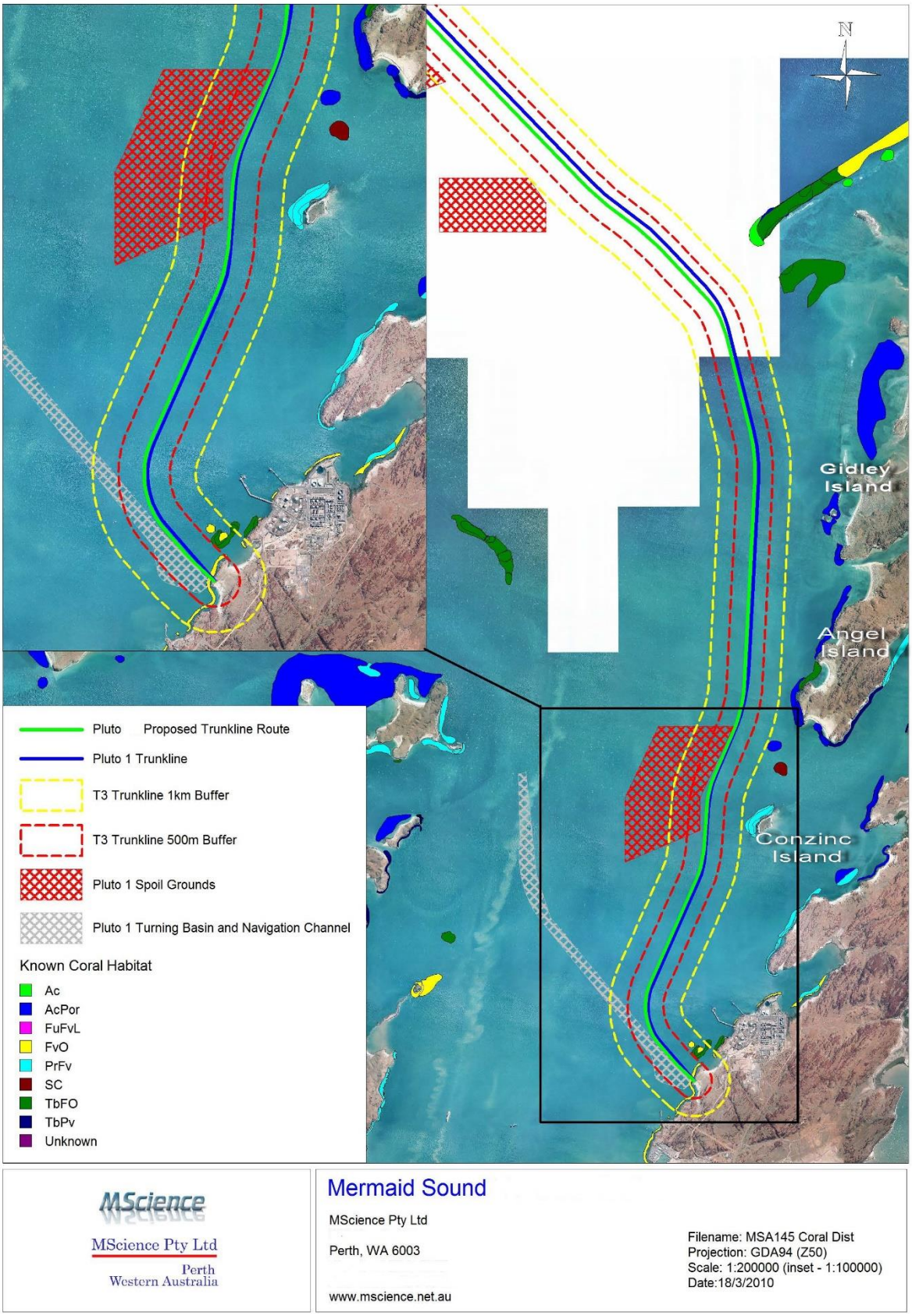


Figure 2-1. Trunkline dredging route adjacent to the Burrup Peninsula and islands showing proximity to various coral community types

3 STUDIES UNDERTAKEN IN 2009

Studies of the effects of trunkline dredging undertaken in the 2009 investigation are listed Table 3-1. The methodology and results for each are then described in the relevant sections of this chapter. Monitoring of coral health within coral communities adjacent to each of the *in situ* sites was also undertaken on a fortnightly basis. While the findings of that program are referenced later, its methodology is not presented here.[1]

Table 3-1. Studies conducted in 2009

Study#	Comprising
Boat-based monitoring	Intensive boat-based monitoring around the operating dredge when within 3 km of Inner Zone C western boundary.
Remotely sensed plumes	Moderate Resolution Imaging Spectroradiometer (MODIS) imagery collected to coincide with boat-based monitoring
In situ monitoring	Time series turbidity from sites along Gidley and Angel and Conzinc Islands
Predictive modelling	Comparison of modelled plume with boat-based, MODIS and *in situ* measurements

3.1 Boat-based Monitoring around the Dredge

3.1.1 Objectives and methods

For part of the trunkline dredging program (28/3/2009 to 14/4/2009), a boat-based monitoring program was implemented to collect daily information on the water quality and plume characteristics close to the fringing coral communities of Conzinc, Angel and Gidley Islands (the western side of the Burrup Peninsula). Measurements were taken whenever the dredge was within 3 km of the western side of the Burrup Peninsula as indicated in Figure 3-1. During this period, a total 133 loads with 394,367 m^3 was dredged.

Where comparisons were made with reference site values, the sites used were the inner reference sites (WINI and MIDI) as per the compliance monitoring program (Figure 3-1).

Monitoring was carried out daily for each of the 17 days as follows:

1. Each day turbidity measurements were taken at 20 sites to the east, south and north of the dredge. The sampling sites were in 2 parallel rows approximately 0.6 and 1.2 km east of the dredge (10 sites each transect) and approximately 0.5 km from each other. An additional 2 samples were taken approximately 0.2 km to the east of the dredge (Figure 3-1).
2. The sampling zone moved as the dredge moved to remain in the same position relative to the dredge each day.
3. At each site turbidity was measured 1 m from the surface, mid water and 1 m from the bottom.

Turbidity at each site on each day (1122 total measurements) was then compared with 2x the reference site mean for the same day.

At the end or dredging, data were sorted into distance categories prior to a compiled analysis. Categories were defined as < 500 m, 500 – 1500 m or >1500 m from the location of the dredge.

[1] See (MScience 2010a) for methods and a full discussion of coral monitoring

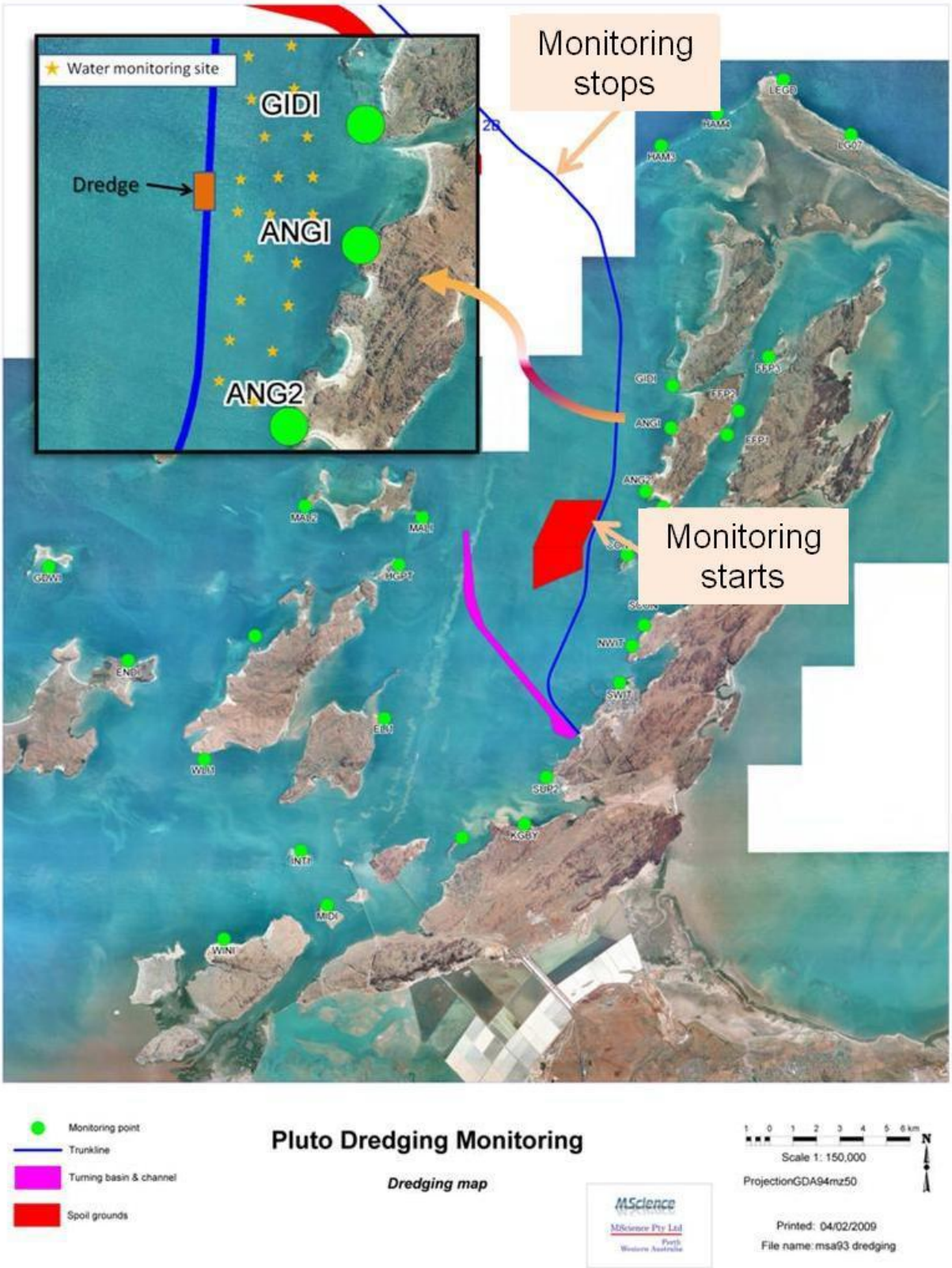


Figure 3-1. Trunkline section used for intensive boat-based monitoring and sampling protocol around the dredge (inset)

Table 3-2. Summary of individual boat-based site measurements

D	Tran-sect	28/03/ 2009	29/03/ 2009	30/03/ 2009	31/03/ 2009	1/04/ 2009	2/04/ 2009	3/04/ 2009	4/04/ 2009	5/04/ 2009	6/04/ 2009	7/04/ 2009	8/04/ 2009	9/04/2 009	10/04/ 2009	11/04/ 2009	12/04/ 2009	13/04/ 2009	14/04/ 2009
S	200	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1
	600	10	10	10	10	10	10	10	10	10	10	10	2	10	2	10	10	10	10
	1200	10	10	10	10	10	10	10	10	10	10	10	10	10	1	10	10	10	10
M	200	2	2	2	2	2	2	2	2	2	2	2	1	2		1	2	2	2
	600	10	10	10	10	10	10	10	10	10	10	10	2	10	4	10	10	1	10
	1200	10	10	10	10	10	10	10	10	10	10	10		10	10	10	10	1	10
B	200	2	2	2	1	2	2	2	2	1	2	2	1	2	2	2	1	2	2
	600	10	10	10	1	10	10	10	1	10	10	10	3	10	10	3	2	6	1
	1200	10	10	10	10	10	10	10	10	10	10	10	10	1	10	1	10	1	10

all sites < 2 times the daily turbidity mean of the reference sites.

at least 1 site > 2 times the daily turbidity mean of the reference sites.

Numbers indicate sites recorded in each transect distance category

S- surface; M- mid water, B- near seabed

3.1.2 Results and conclusions

Over the 17 d of dredging, 1122 measurements were made from the 22 sites. Turbidity at those sites between the dredge and receptors was more than 2x the mean reference turbidity for only 53 of those 1122 measurements (Table 3-1).

During trunkline dredging, turbidity to the east of the dredge increased only slightly within 500 m and remained below the reference median outside of 500 m. During this time, winds were variable but blew strongly from the east from 3/4/2009 to 9/4/2009. This wind direction is likely to have reduced the movement of the dredge plume towards the Burrup Peninsula for at least part of the study period.

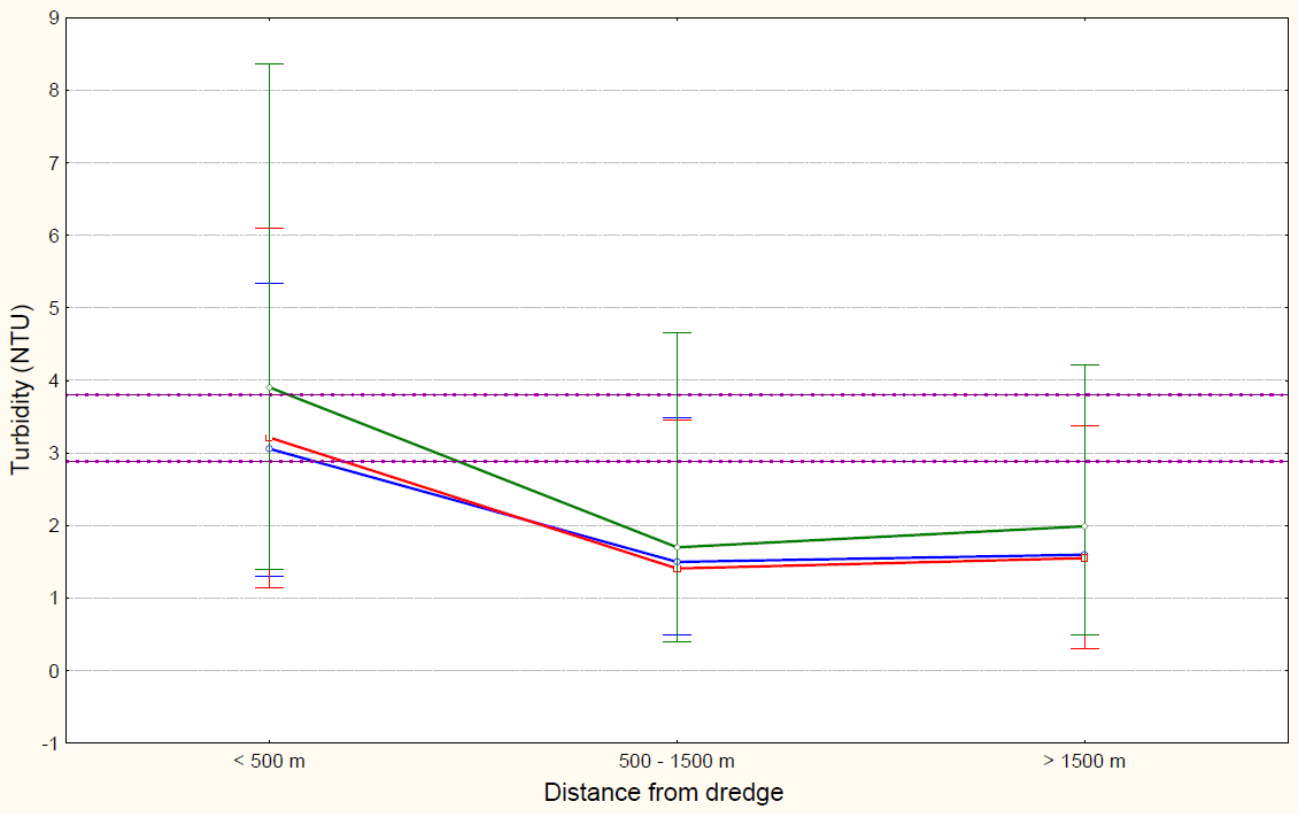


Figure 3-2. Turbidity changes with distance from the dredge (median ± 20th and 80th percentiles at the surface (blue), midwater (red) and bottom (green). Purple lines are the Reference median (lower line) and 80th percentile measured over the same period

This observation is consistent with near-dredge modelling (MScience 2010b) and the conclusion that turbidity may decrease by an order of magnitude over distances of several hundred metres with a generally narrow plume, streaming away in the direction of the prevailing current.

Boat-based measurements did not indicate that the coral sites along the western side of the Burrup Peninsula were subject to increased turbidity during the trunkline dredging in March and April 2009. Under the dredging and metocean conditions, the plume did not extend more than 500 m to the east of the dredge.

3.2 Remotely Sensed Data

3.2.1 Objectives and methods

MODIS satellite images captured at the times of boat-based monitoring were calibrated for turbidity when image quality conditions permitted (MScience 2010a). Estimated turbidity levels in images were used to assess the plume around dredging and to compare this plume to model predictions.

Images which were unable to be processed digitally and their sampling dates are shown in Appendix 1.

A selection of calibrated images coinciding with the available dredge log data were used for comparison against boat-based measurements and modelled plume predictions.

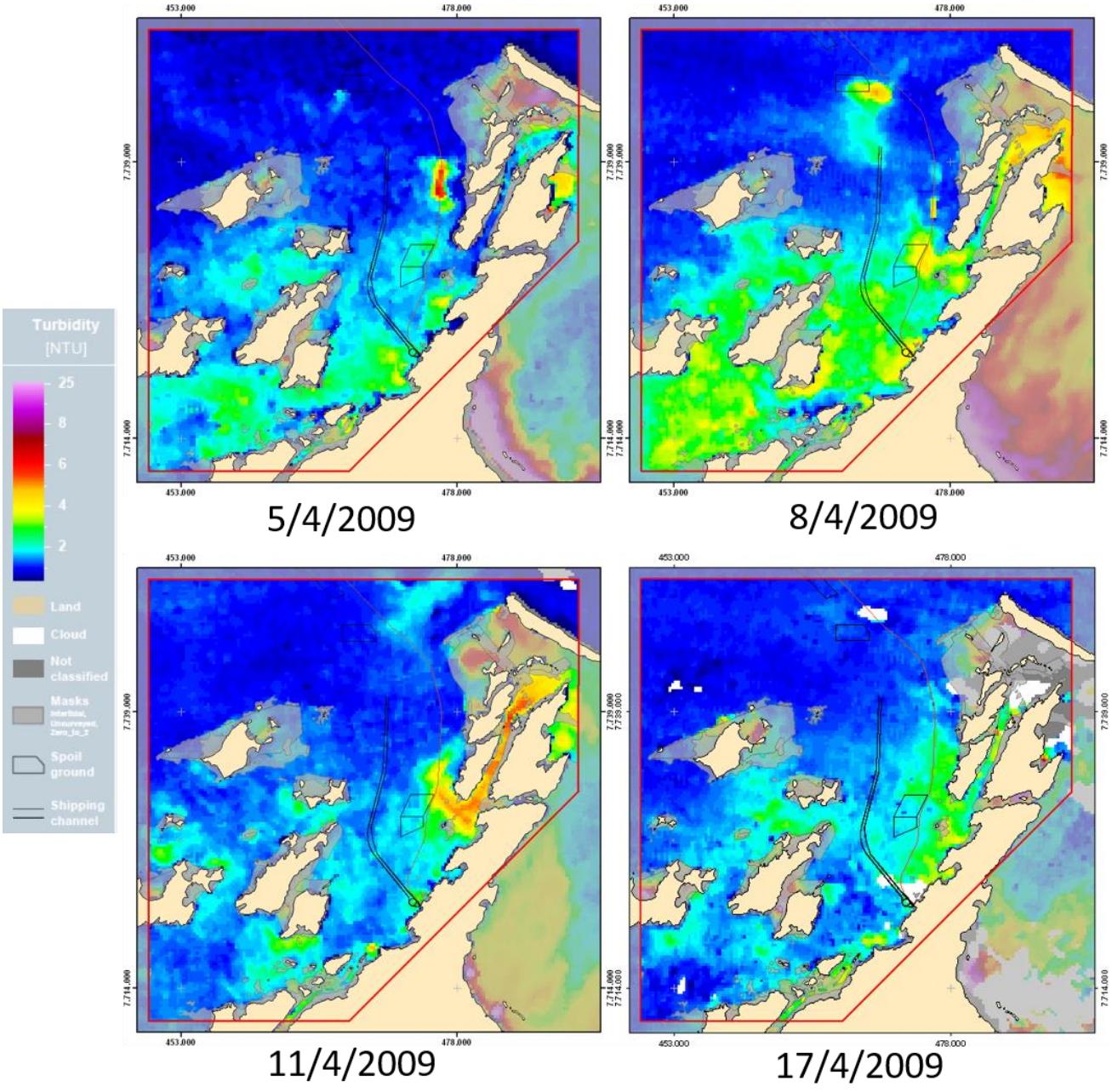


Figure 3-3. Calibrated MODIS images for selected days during trunkline dredging.

3.2.2 Results and conclusions

The calibrated images (APASA 2011) show a turbidity plume around the dredge and spoil grounds on April 5 and 8. On these days the images indicated turbidity within the plume as 6 NTU or less with the plume not reaching the western edge of the Burrup Peninsula (Figure 3-3). There is an obvious, but spatially restricted elevation of turbidity around the dredging area on both days. On the 8/4/2009 there is a plume pattern which could be interpreted as one arising from the spoil ground and being transported towards Conzinc Bay and Flying Foam Passage. However, modelling for that indicated currents flowing in the opposite direction (see Section 3.4.2) and it is more likely that the plume originated through Flying Foam Passage and travelled west.

The images on April 11 and April 17 show elevated turbidity around the coral monitoring sites, which could be interpreted as a dredge-related plume overlapping with coral sites. However, trunkline dredging was completed 3 days before the April 17 image was taken. The overlap was not consistent with measured turbidity and may have been caused by sediments in surface waters flowing from Flying Foam passage or by sediment re-suspension from the spoil ground rather than directly by trunkline dredging. The 5 – 10 knot south easterly wind, measured at the time of boat-based sampling on April 11would have pushed the plume away from Angel Island.

3.3 *In Situ* Monitoring at Receptors

3.3.1 Objectives and methods

Time series turbidity from *in situ* instruments located close to sensitive coral communities on Conzinc (CON1), Gidley (GIDI) and Angel (ANG2 and ANG3) Islands (Figure 3-1) was collected during trunkline dredging as part of a program running throughout the entire dredging period. Turbidity measurements were made every 30 minutes using instruments located within 1 m of the bottom. This data was examined to determine if trunkline dredging changed turbidity at sensitive coral sites.

3.3.2 Results and conclusions

During the boat-based monitoring there were no exceedences of the compliance triggers (i.e. 7 d rolling medians of turbidity at *in situ* potential impact sites did not exceed the reference 7-day rolling 80th percentiles of turbidity at reference sites (MScience 2010b). In daily comparisons, the daily median of the *in situ,* potential impact sites did not exceed the 80th percentile of either reference site (Figure 3-4). Both statistical comparisons indicated trunkline dredging did not increase turbidity at the sensitive coral sites[2].

[2] ANZECC criteria recommend a comparison of the median at an impact site against the 80th percentile of a reference to indicate whether degradation of water quality has occurred.

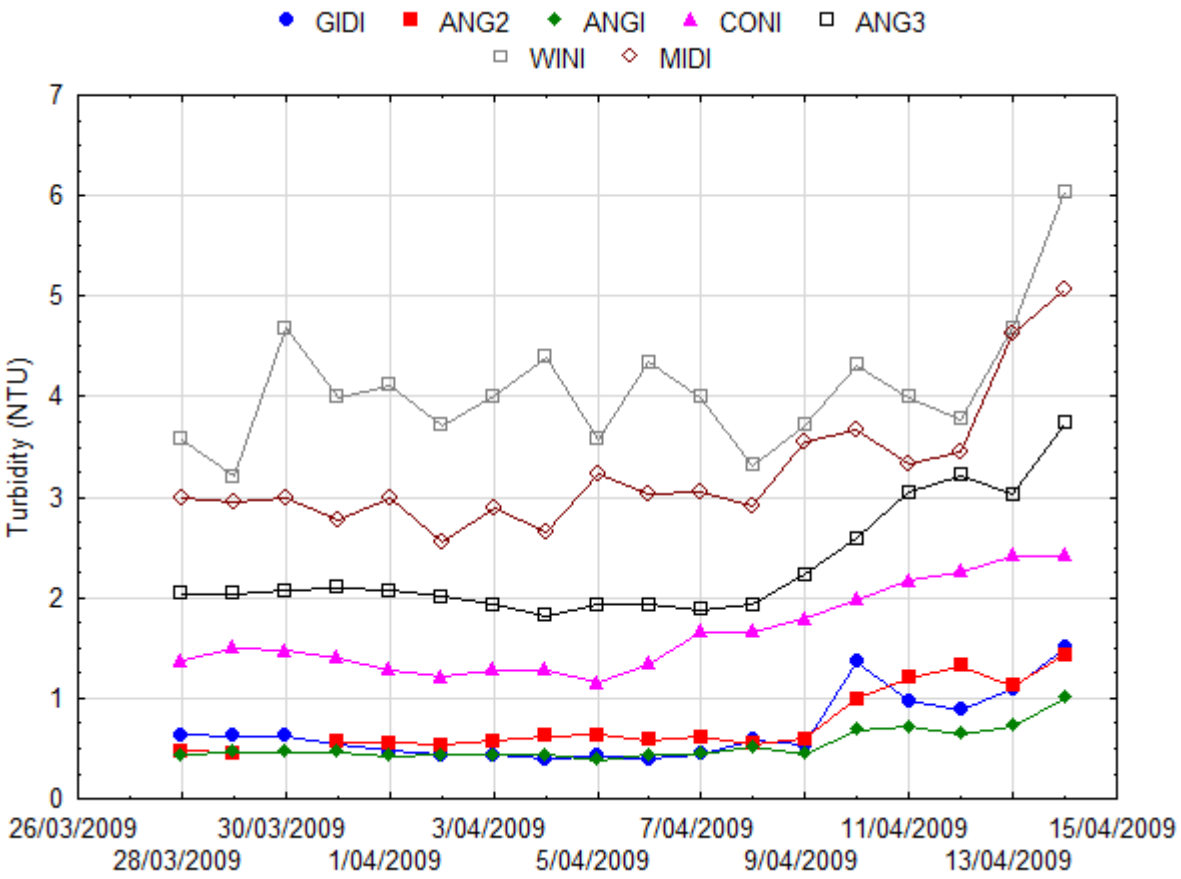


Figure 3-4. Daily median turbidity at the sensitive coral sites of GIDI, ANG2, ANG1, CONI and ANG3, compared with the daily 80th percentile turbidity at reference sites WINI and MIDI

3.4 Predictive Modelling

3.4.1 Objectives

The turbidity and sedimentation associated with dredging the trunkline was modelled (APASA 2011). This modelling included calibration and validation using the dredge logs, combined with boat-based and *in situ* turbidity and MODIS imagery. The objective was to validate and improve the existing dredge fate model and to further assess the potential impact of trunkline dredging on the western boundary of the Burrup Peninsula.

3.4.2 Results and conclusions

Qualitative comparison with boat-based measurements

The combined locations of all boat-based sampling sites and *in situ* sites are shown on Figure 3-5.

For model comparisons, the dominant overflow cases on March 31, April 8 and April 11were compared with the boat-based measurements. Measured turbidity was converted to (TSS, total suspended solids) to be consistent with the model output. Specific comparisons for each day are presented in the original report (APASA 2011). The overall results are shown on Figure 3-6. It was concluded that the model was in reasonable agreement with the mean and often also the maximum values from boat-based measurement.

Qualitative comparison with MODIS satellite images

MODIS images are shown in Figure 3-7 and Figure 3-8 along with the spatial model results with approximately the same colour scale. The figures show that the near-surface plume is reasonably well represented, particularly in the comparison for 5/4/2009.

In general, the model possibly over-predicting the magnitude of the near-surface plume, however it was difficult to quantify this given the uncertainties involved, such as the relevant MODIS measurement depth, and the lack of detailed positioning information provided in the dredge logs. Certainly, outside of the main dredging zone the model predicted little in the way of intense and persistent plumes.

The comparison for the 8/4/2009 clearly shows a consistent location of the plumes. The model image represents a time 20 minutes prior to the MODIS image, so it is expected that the intensity may be greater in the model, and the overall spread less, as is the case.

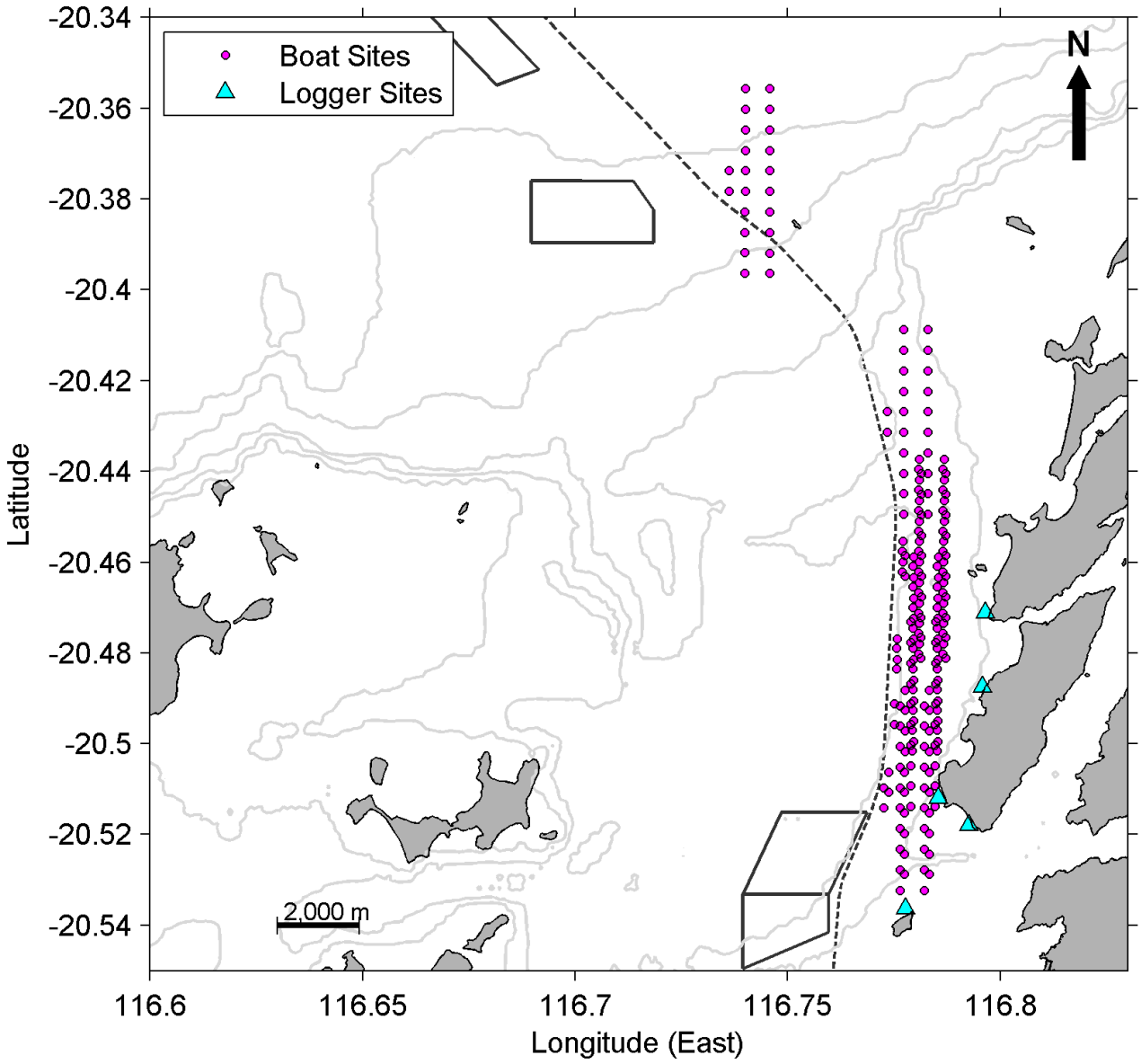


Figure 3-5 Location of all the monitoring sites (pink dots) for the boat-based sampling for the trunkline dredging by TSHD Nile River. In situ monitoring sites are shown as blue triangles

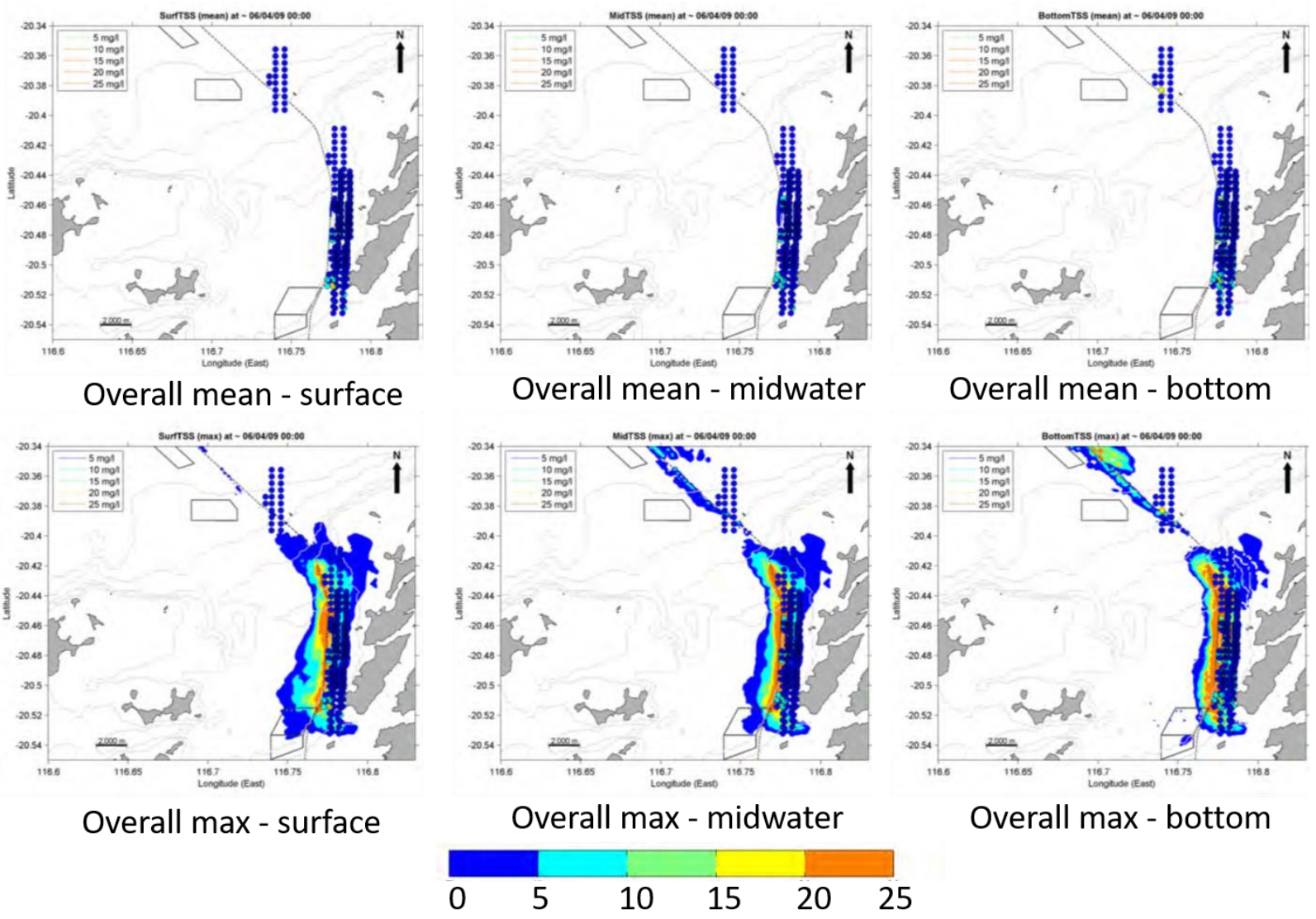


Figure 3-6. Comparison of model predictions and boat-based measurement (coloured circles) for the whole comparison period (March 20 - April 19). Results for surface, midwater and bottom samples.

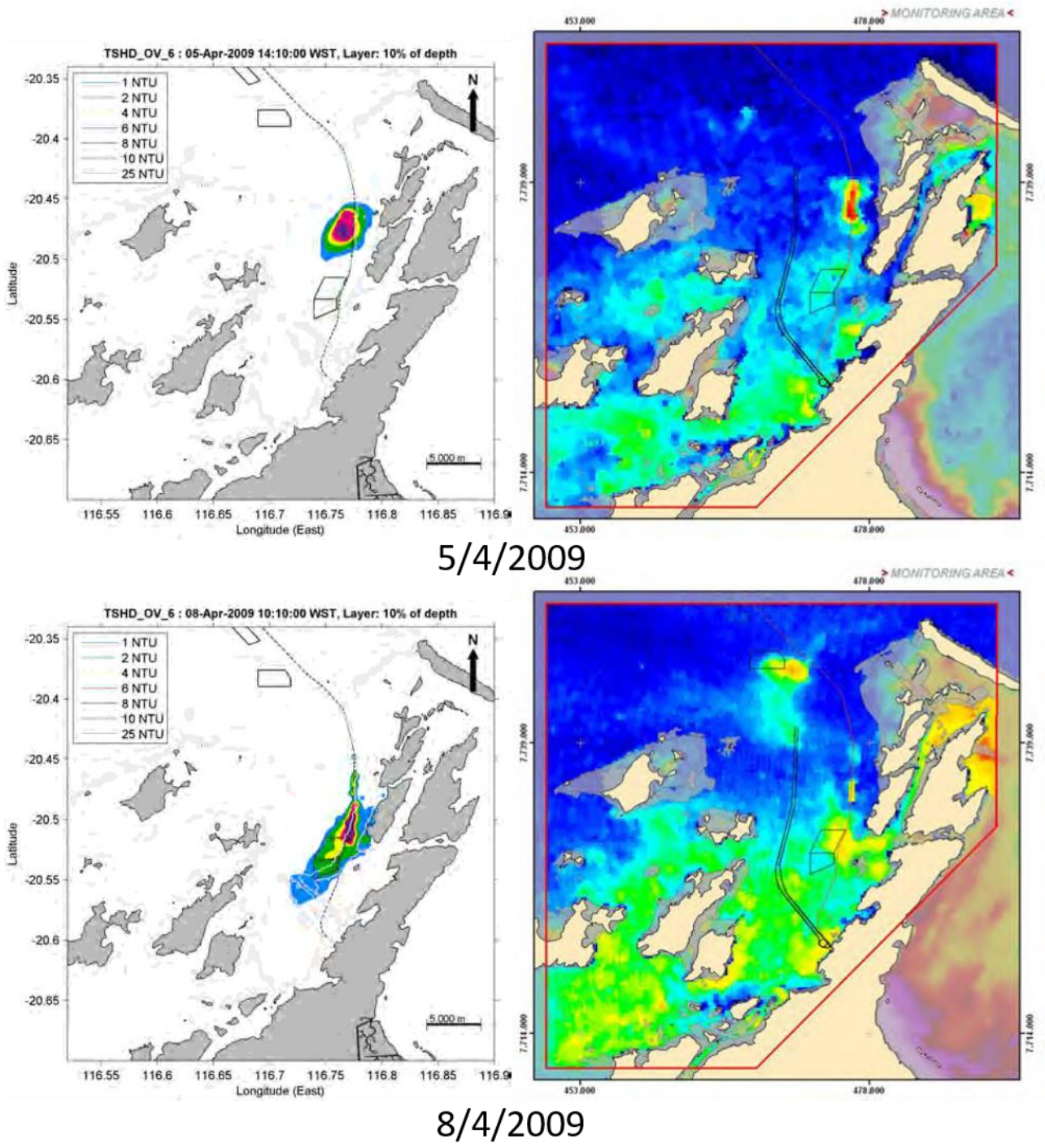


Figure 3-7. Comparison of modelled (left) and MODIS (right) for the TSHD Nile River trunkline dredging on April 5 and 8. Disposal site modelling not shown.

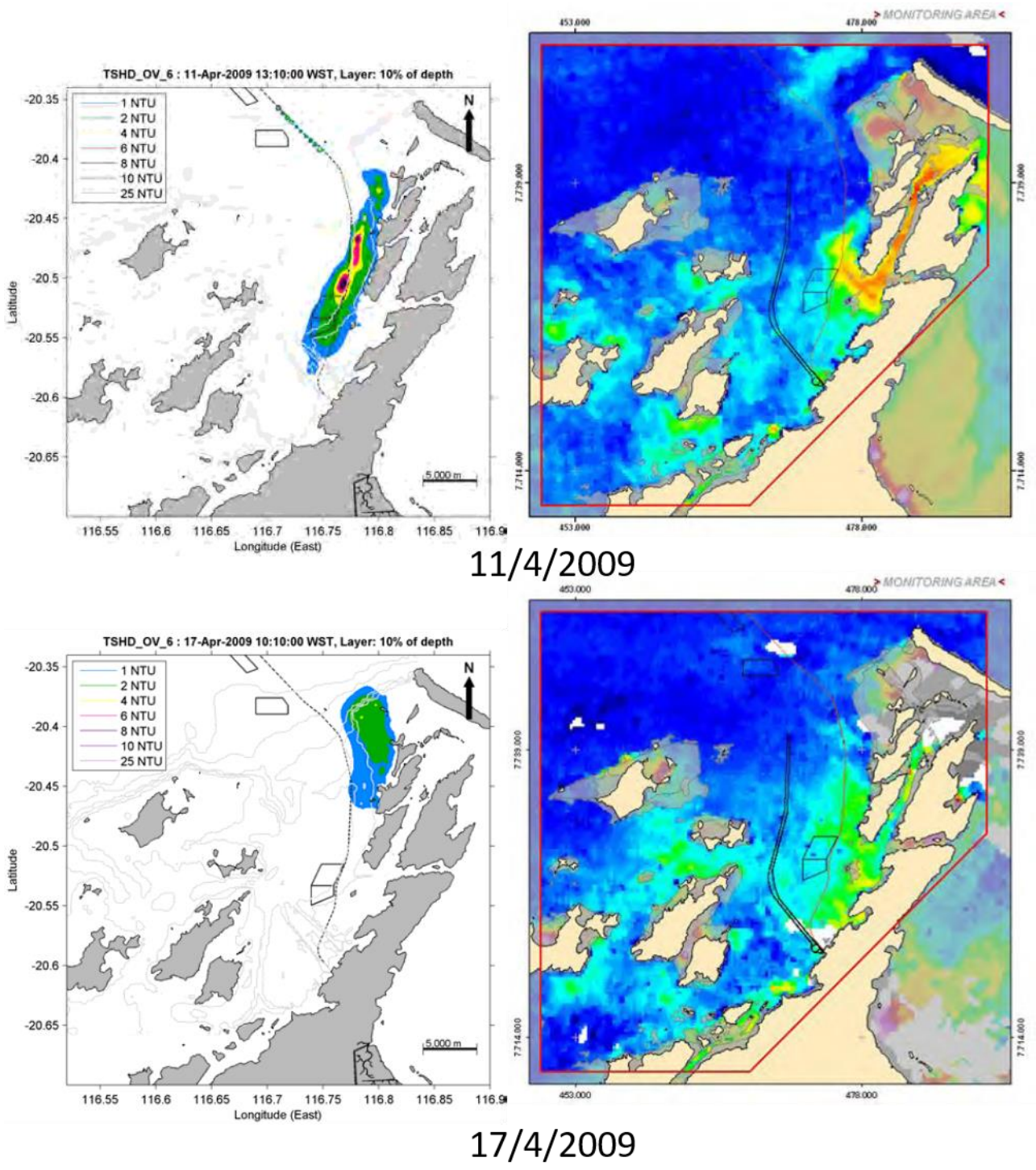


Figure 3-8. Comparison of modelled (left) and MODIS (right) for the TSHD Nile River trunkline dredging on April 11 and 17. Disposal site modelling not shown.

4 DISCUSSION

4.1 The Extent and Intensity of Plumes Recorded

The combination of intensive boat-based monitoring around the operational dredge, daily MODIS imagery of the dredging area, continuous (24 hours per day) *in situ* measurement of turbidity at sensitive sites and modelling of expected plume dispersion provides a comprehensive insight into the impact of trunkline dredging on water quality.

The boat-based monitoring indicated that turbidity was increased within 500 m of the eastern side of dredging but declined rapidly beyond that distance. At more than 500 m from the dredge, turbidity was below that measured at reference sites elsewhere in Mermaid Sound (Figure 3-2). This conclusion is consistent with continuous measurement of turbidity at sensitive sites on Angel, Gidley and Conzinc Islands. These sites were, at some times, less than 3 km from dredging but at no time indicated exceedences of site medians above the reference site 80th percentiles.

Both MODIS and plume modelling essentially confirm that the dredge plume remained within 500 m of the eastern side of the dredge. Modelling was consistent with boat-based measurement showing up to 5 mg/L overall mean increase in suspended sediments to the east of the dredge. The maximum increase in turbidity, as shown on the overall dredge map (Figure 3-6) indicated the elevation in sediments and turbidity was predominantly to the west of dredging.

Some of the calibrated MODIS images showed elevated turbidity along the western edge of the Burrup Peninsula. Interpretation of those images as showing a dredging/disposal origin of those plumes was not consistent with other evidence. The image from 5/4/2009 shows the dredge clearly visible as an intense but small plume that extends only half way to the shore to the east. Images from 11/4/2009 and 17/4/2009, showing turbidity near the shoreline of Angel Island and through Flying Foam passage are better explained by plumes emanating from Flying Foam Passage when compared with current flows at the time. On 17/4/2009 the dredge was not operating in the vicinity of the MODIS plume. The 11/4/2009 image is less conclusive with an increase in turbidity that is not consistent with the boat-based or *in situ* measurements.

In other intensive studies around dredging in the Pluto berthing pocket and channel, a similar rapid decline in turbidity at distance from the dredge was reported. Turbidity was within normal, background levels 1200 m or more from the dredge (MScience 2010b). The trunkline study indicated normal turbidity at more the 500 m from the dredge. The slightly more extensive plume measured during the berthing pocket studies is most likely related to sampling differences in the studies. During the berthing pocket study, water was sampled in all directions from the dredge and not just to the east.

The trunkline study conclusions needed to be considered within the context of the weather conditions prevailing during the observation period. From 28/3/2009 to 2/4/2009, the winds measured during boat-based sampling tended to be light (<10 knots) and usually from the north. From 3/4/2009 to 8/4/2009 winds were often strong but always had an easterly component. Easterly winds would have pushed the plume away from Gidley, Angel and Conzinc Island. After 8/4/2009 winds again became light from the south west of south east. Winds therefore were conducive to the movement of dredging plumes away from the Burrup Peninsula and thus the minimisation of water quality impacts to the east of the dredge.

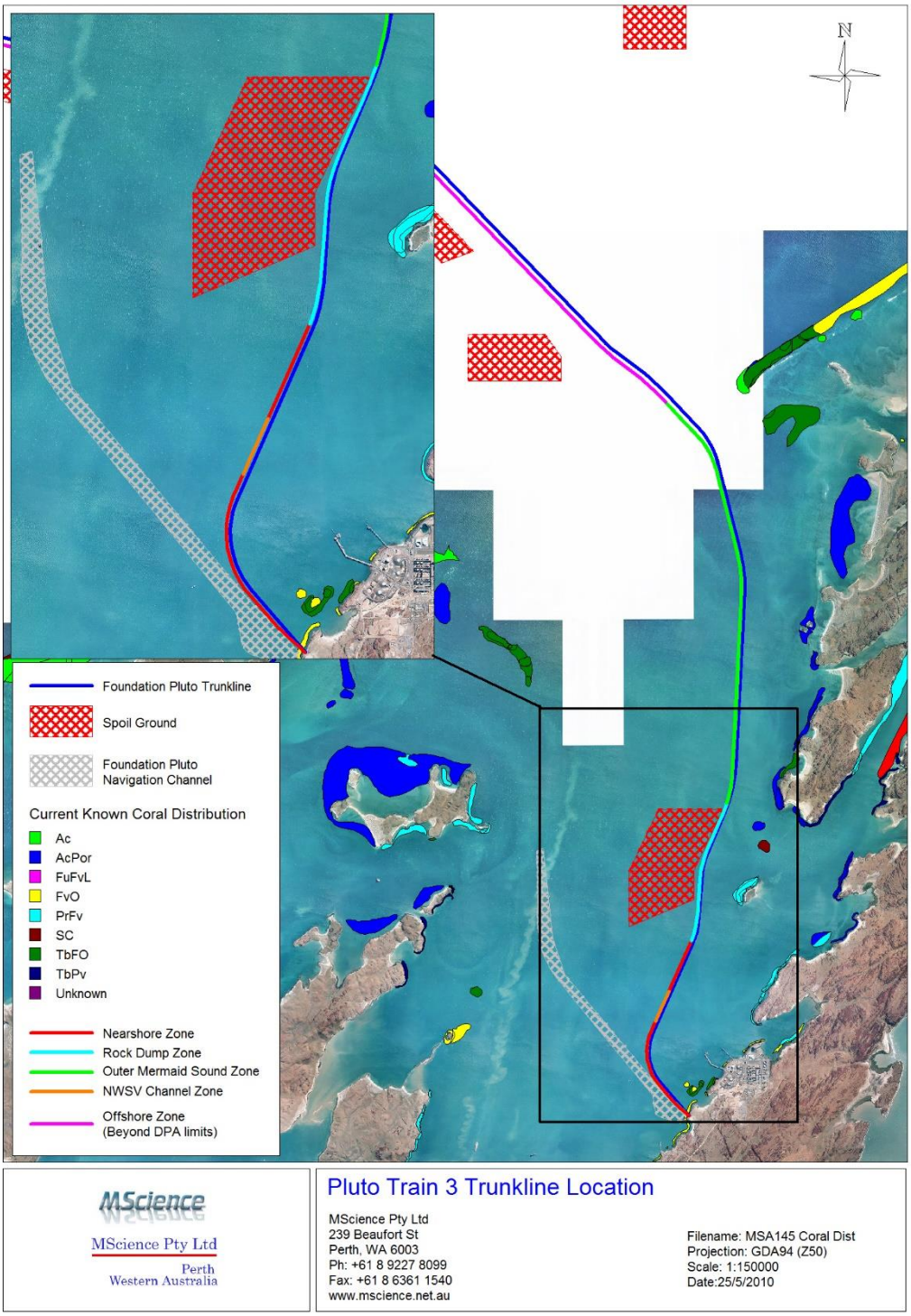


Figure 4-1. Location of dredging relevant to coral communities

4.2 Insights from Modelling

Overall, the modelling was consistent with other measurements and interrogation of the results provides further insight into the behaviour of dredged sediments. The modelling indicated plume movement to the west of dredging away from sensitive coral sites. This was a consequence of weather conditions.

These modelling results provide confidence that the dispersion model could be reused to predict plume movements and develop a dredging strategy in a future trunkline dredging program. In particular, for projects where the dredge operates within 3 km of the Burrup Peninsula

5 IMPLICATIONS FOR IMPACTS ON SENSITIVE RECEPTORS

5.1 Benthic Communities Adjacent to Dredging

Marine communities along the western margins of the Burrup Peninsula were first described by Semeniuk et al. (1982). Unlike the region's oceanic reef structures, the habitats within Mermaid Sound are not of biogenic origin, but are formed on an inundated landmass comprised predominantly of igneous Precambrian rock. Within the area adjacent to the current trunkline study, habitats include:

- intertidal rocky areas of the Burrup Peninsula, Conzinc Island, Angel Island and Gidley Island dominated by molluscs, including chitons, rock oysters and barnacles;
- sublittoral areas from 0 LAT to – 15 m LAT dominated by coral communities growing on rock, interspersed with macroalgae such as *Sargassum* and *Dictyopteris* (abundance of macroalgae being highly seasonal, with peak canopy cover experienced in late summer); and
- sea floor communities, predominantly soft sediment with occasional areas of exposed hard bottom supporting filter feeders. A raised sill of filter feeders and corals exists across the outer margin of Mermaid Sound.

Seagrasses are uncommon in the area (Bertolino 2006), although some appear to occur seasonally inside Conzinc Bay and may be abundant in parts of Withnell Cove at the southern margin of the study area. Seagrass in this area is exclusively *Halophila*, most likely *H. ovalis* (or possibly *H. decipiens*).

An assessment of the benthic habitats of this area undertaken in 2008 used a drop camera (Waddington et al. 2008) to categorise habitats within the seafloor category (the sublittoral areas dominated by coral communities were not accessed by this survey due to constraints of the survey vessel and the drop camera method) by quantifying cover type. That survey found that there were few clear dominant habitat classes, and biotic habitats were all designated as either "macroalgal dominated" (where macroalgae was 2x the cover of other classes) or 'mixed assemblages'. Survey sites around the area of the trunkline contained both habitat types and included sites in all assigned cover levels (from abiotic to dense). Sites in the medium-dense cover categories were predominantly located on the sill across the mouth of Mermaid Sound between Nelson Rocks and Cohen Island.

Previous assessments by Western Australia's Environmental Protection Authority (WAEPA) have determined that the coral communities of this area are the habitats most sensitive to the effects of elevated suspended sediments (e.g. EPA 2006; EPA 2007). The coral communities of the area have been described in Griffith (2004) and Blakeway and Radford (2005). Typically, these communities occupy a relatively narrow depth band which is possibly constrained at the upper limit by high temperature, exposure to sunlight and periodic freshwater layers formed from heavy rainfall, and the lower limit set by light attenuation and exposure to sediment bedloads.

Contrasting the species distributions presented in the latter report with the assessment of species-specific susceptibility of corals to sediment effects (Gilmour et al. 2006; Jones et al. 2015a) suggests that there

would be a gradient of sensitivity to elevated suspended sediment which increases as the trunkline route becomes more distant from its shore crossing. That would also be consistent with the exposure of communities on the southern section of the trunkline route to greater intensity-frequency-duration events of elevated suspended sediments than those communities in the outer areas of Mermaid Sound (MScience 2010a). It may be postulated that the coasts of Angel and Gidley Islands represent a transition between coral communities dominated by the more sediment tolerant inshore coral species with a history of exposure to higher levels of suspended sediment concentrations, and those communities with a composition and history indicative of a more oceanic nature.

5.2 Relevant Thresholds for Impact Zones

As concluded above, coral communities in Mermaid Sound are the habitats most sensitive to changes in water quality. It is therefore appropriate that coral species should be used for the determination of water quality thresholds for impact zones to manage the effects of dredging in this area.

Recent research in Western Australia (https://www.wamsi.org.au/dredging-science-node) has focussed on improving the science underpinning the capacity to predict and manage the environmental impacts of dredging. It has had a strong focus on Pilbara conditions. While the regulatory guidance from that work is still under development, the research programs to inform that guidance are complete. The section below employs the findings of Theme 4 *Defining Thresholds and Indicators of Coral Response to Dredging Pressures* in developing an assessment of the potential for the measured effects of the 2009 trunkline dredging to influence management zones.

One clear finding of the studies was that a sustained reduction in light available for photosynthesis of the coral symbionts was likely to be the most significant impact mechanism for corals outside the area immediately surrounding dredging (notionally 500 m), where acute impacts of sedimentation might occur (Bessell-Browne et al. 2017a; Jones et al. 2015a). While experimental studies are available for only a few corals, it is clear that the capacity to withstand differing intensity-duration-frequency (I-D-F) levels of light attenuation varies widely between species (Bessell-Browne et al. 2017b; Sofonia and Anthony 2008). Within the, frequently turbid, waters of the present study area, this species-specific response pattern has important implications. Bessel-Browne (2017b) shows that *Acropora millepora* suffers effectively no mortality at I-D-F treatments causing >50% mortality in *Pocillopora acuta*. *A.millepora* occurs along the shorelines of Angel and Gidley Island, while *P.acuta* does not (Blakeway and Radford 2005), while within Conzinc Bay, the sediment tolerant genus *Turbinaria* (Sofonia and Anthony 2008) is common.

Previous WAEPA guidance on establishing zones for management of the environmental effects of dredging (EPA 2011) has recommended a Zone of Influence as the most benign management zone (one where the effect of dredging does not cause any mortality or clear physiological stress to organisms). Typically, this might be seen as a zone in which water quality impacts were not sufficient to cause a very sensitive species to show sublethal indicators of stress. Once that stress level is exceeded, the area is defined as a Zone of Moderate Impact. Within the Bessel-Browne et al. (2017b) study, that indicator was represented by an index of coral colour. Notwithstanding the finding above that coral species found in the relevant areas of this study are likely to be more tolerant of low light than the most sensitive species in the Bessel-Browne et al. study, it is possible to derive some approximation of an upper Zone of Influence threshold for the most sensitive species in that study. Supplementary Figure S3 of that study suggests that a light reduction to a level somewhere below 1 mol photons.m^2.d caused a small reduction in the colour index after 10d of exposure. That is an I-D value only, however the study does not test how frequency of occurrence might modify that I-D event.

A review of water quality and coral monitoring data from the Gorgon LNG dredging (Fisher et al. 2018) provides threshold figures for light, turbidity and deposition in an I-D-F context. It is evident from that

paper, that I-D-F combinations for three interrelated water quality parameters makes the generation of practical thresholds inordinately difficult. Interrogation of Table S1.3 of that paper provides some potential thresholds which might indicate a possible transition between low and moderate stress of corals. These provide I-D figure of 10 consecutive days above 3.2 NTU or 3 consecutive days above 10 NTU, or an I-F figure of 25% of the 203 d dredging period above 3.2 NTU. Again, it should be noted that the corals of Barrow Island would have been less adapted to turbid conditions than those of Mermaid Sound.

5.3 Implications of the 2009 Studies for Predicting Impacts

Light reaching corals was not measured in the 2009 monitoring program. However, light reduction would have been in direct proportion to turbidity elevation. As the 2009 study found that turbidity elevation was minimal at the sensitive receptor communities around Conzinc, Angel and Gidley Islands, light reduction would have been equally small and certainly not of the extent required by the thresholds above to cause a stress to corals. Equally, the 2009 trunkline dredging did not cause turbidity around the coral communities to reach levels of 3.2 NTU.

The extent of the 'Duration' terms found by the WAMSI studies to be required prior to the causation of stress is particularly relevant to the prediction of impacts from trunkline dredging. Dredge logs examined during the 2009 study demonstrated that trunkline dredging is a relatively rapid process, with the dredge often progressing over 1 km per day along the route. This rapid movement of the source of suspended sediment coupled with the propensity of all dredging to cause relatively short-lived elevations in turbidity (Jones et al. 2015b) means that duration terms exceeding 2-3 d for any material increase in turbidity are extremely unlikely. The only exception to that would be for communities near spoil grounds receiving spoil from the dredging.

Monitoring of turbidity around trunkline dredging during the 2009 campaign demonstrated that at distances greater than 500 m from dredging, turbidity elevations were so low as to be below the threshold of a Zone of Moderate Impact (ZOMI). Turbidity levels monitored at coral sites nearest to the spoil ground used in that campaign were also below intensities which could indicate a ZOMI threshold. Satellite tracking of plumes did show occasional plumes within areas >500 m from dredging, thus these should be identified as Zones of Influence.

The 2009 program was completed under weather conditions which would have helped reduce any effects on water quality around the sensitive receptor communities which were all to the eastern side of dredging. Should future such projects be dredged under westerly wind conditions, greater impacts on turbidity at distances outside 500 m might be predicted. While the degree to which this might raise the intensity of turbidity elevations is speculative for now, the duration of such events should be less than that determined above to be required to exceed thresholds which would see a Zone of Moderate Impact predicted for these coral communities.

Overall, the agreement of results from boat-based, satellite-based and *in situ* monitoring of turbidity with the predictions of a model based on suspended sediment concentrations, provide strong support to the finding that trunkline dredging within this area of Mermaid Sound has a very low potential to cause damage to the local benthic primary producer communities.

6 REFERENCES

APASA (2011) Pluto Trunkline Dredged Sediment Fate Modelling: Revision 1 - 7th February 2011. Unpublished Report by Asia-Pacific ASA for MScience & Woodside Energy Ltd, Perth, WA

Bertolino C (2006) Seagrasses of the Port of Dampier: Distribution, Abundance and Morphology. University of Western Australia

Bessell-Browne P, Negri AP, Fisher R, et al (2017a) Impacts of turbidity on corals: The relative importance of light limitation and suspended sediments. Mar Pollut Bull. doi: 10.1016/j.marpolbul.2017.01.050

Bessell-Browne P, Negri AP, Fisher R, et al (2017b) Impacts of light limitation on corals and crustose coralline algae. Sci Rep 7:11553. doi: 10.1038/s41598-017-11783-z

Blakeway DR, Radford B (2005) Scleractinian corals of the Dampier Port and Inner Mermaid Sound: Species list, community composition and distributional data. In: Stoddart JA, Stoddart SE (eds) Corals of the Dampier Harbour: Their Survival and Reproduction During the Dredging Programs of 2004. MScience Pty Ltd, Perth, WA, pp 1–8

EPA (2006) Dredging Program Dampier Port Upgrade. Hamersley Iron Pty Ltd. Report and Recommendations of the Environmental Protection Authority. Bulletin 1225. Environmental Protection Authority, Perth, WA

EPA (2007) Pluto LNG Development: Burrup Peninsula: Report and Recommendations of the Environmental Protection Authority. Report: Bulletin 1259, Environmental Protection Authority, Perth, WA

EPA (2011) Environmental Assessment Guidelines 7: Environmental Assessment Guideline for Marine Dredging Proposals. Western Australian Environmental Protection Authority, Perth, WA

Fisher R, Walshe T, Bessell-Browne P, Jones R (2018) Accounting for environmental uncertainty in the management of dredging impacts using probabilistic dose-response relationships and thresholds. J Appl Ecol 55:415–425. doi: 10.1111/1365-2664.12936

Gilmour JP, Cooper TF, Fabricius KE, Smith LD (2006) Early Warning Indicators of Change in the Condition of Corals and Coral Communities in Response to Key Anthropogenic Stressors in the Pilbara, Western Australia. Australian Institute of Marine Science, Townsville, Qld

Griffith JK (2004) Scleractinian corals collected during 1998 from the Dampier Archipelago, Western Australia. In: Jones DS (ed) Report on the Results of the Western Australia Museum/ Woodside Energy Ltd. Partnership to Explore the Marine Biodiversity of the Dampier Archipelago, 1998-2002. Records of the Western Australian Museum, Supplement No. 66: pp v-xv, 1-401. pp 101–120

Jones R, Bessell-Browne P, Fisher R, et al (2015a) Assessing the impacts of sediments from dredging on corals. Mar Pollut Bull 102:9–29. doi: 10.1016/j.marpolbul.2015.10.049

Jones R, Fisher R, Stark C, Ridd P (2015b) Temporal patterns in water quality from dredging in tropical environments.

MScience (2010a) Pluto LNG Development: Final Report on Coral and Water Quality Monitoring: 5 Oct 2010. Report: MSA93R160, Unpublished Report to Woodside Burrup Pty Ltd Contract OC00002273 by MScience Pty Ltd, Perth, WA

MScience (2010b) Pluto LNG Development: An Evaluation of Dredging Impacts on Water Quality - November 2007 to February 2010. Report: MSA145R2, Unpublished Report to Woodside Burrup Pty Limited by MScience Pty Ltd, Perth, WA

Semeniuk V, Chalmer PN, Le Provost I (1982) The marine environments of the Dampier Archipelago. J R Soc West Aust 65:97–114.

SKM (2008) Pluto LNG Development: Dredging and Spoil Disposal Management Plan / Environmental Management Plan. Rev 8 - March 2008. Sinclair Knight Merz for Woodside Burrup Limited, Perth, WA

Sofonia JJ, Anthony KRN (2008) High-sediment tolerance in the reef coral Turbinaria mesenterina from the inner Great Barrier Reef lagoon (Australia). Estuar Coast Shelf Sci 78:748–752.

Waddington K, Meeuwig J, Harvey E (2008) Pluto LNG Project – Baseline Marine Habitat Survey (Drop Camera)). Report: CMF 2008-002, Unpublished report to Sinclair Knight Merz from Centre for Marine Futures University of Western Australia

7 APPENDIX 1 MODIS IMAGES DURING BOAT-BASED MONITORING

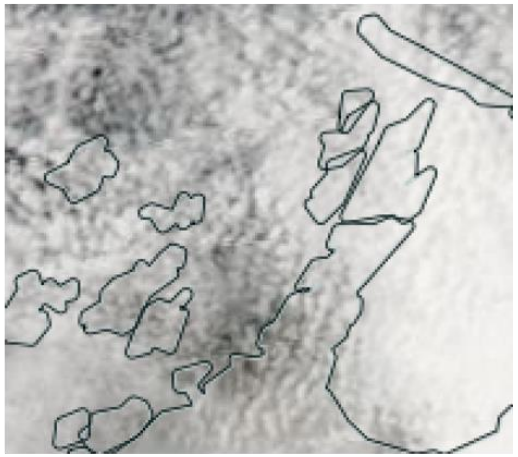
28/3/2009

29/3/2009

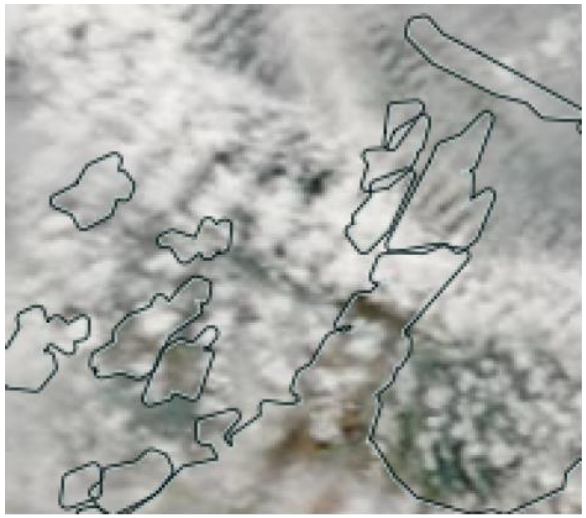
30/3/2009

31/3/2009

1/4/2009



2/4/2009



3/4/2009

4/4/2009

5/4/2009

6/4/2009

7/4/2009

8/4/2009

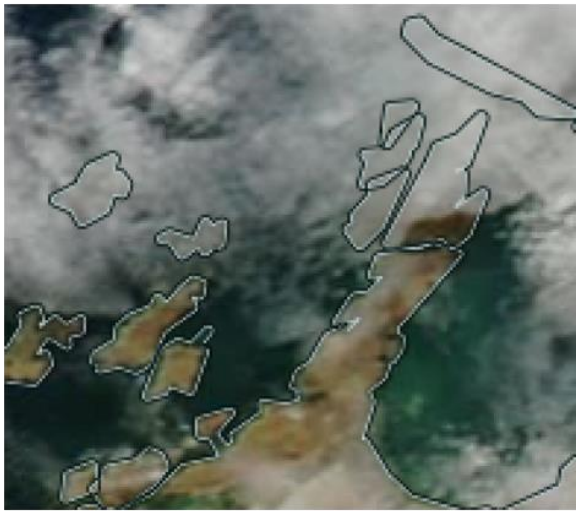
9/4/2009

10/4/2009

11/4/2009

12/4/2009

13/4/2009



14/4/2009