BAS-210 0045

Santos

Darwin Pipeline Duplication (DPD) Project –Marine Megafauna Noise Management Plan (MMNMP)

PROJECT / FACILITY	Barossa DPD Project
REVIEW INTERVAL (MONTHS)	No Review Required
SAFETY CRITICAL DOCUMENT	NO

Rev	Owner	Reviewer/s Managerial / Technical / Site	Approver
	Project Environmental Lead	Project HSE Manager	Project Director

Rev	Rev Date	Author / Editor	Amendment
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E	9.03.2023	RPS	Issued for review

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Acronyms, terms, units of measurement and definitions

Abbreviations and acronyms

Acronym	Definition
ALARP	as low as reasonably practicable
AOO	area of occupancy
ASSDMP	acid Sulphate Soils and Dewatering Management Plan
BHD	backhoe dredge
BIA	biologically important area
BOM	Bureau of Meteorology
CEMP	Construction Environment Management Plan
CSD	cutter suction dredge
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DENR	Northern Territory Department of Natural and Environmental Resources, now the Northern Territory Department of Environment, Parks and Water Security
DEPWS	Northern Territory Department of Environment, Parks and Water Security
DHAC	Darwin Harbour Advisory Committee
DITT	Northern Territory Department of Industry Tourism and Trade
DIPL	Northern Territory Department of Infrastructure, Planning and Logistics
DLNG	Darwin Liquified Natural Gas
DoE	Commonwealth Department of Environment
DP	dynamic positioning
DPD	Darwin Pipeline Duplication
EMP	environmental management plan
ENVID	environmental impact identification
EP Act	*Environmental Protection Act 2019*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GEP	gas export pipeline
HF	high frequency
HSEQ	health, safety, environment and quality
HSEQ-MS	health, safety, environment and quality management system
LAT	lowest astronomical tide
LF	low frequency
MFO	marine fauna observer
MNES	matters of national environmental significance
MMNMP	Marine Megafauna Noise Management Plan
MFE	Mass flow excavation

Acronym	Definition
NMR	North Marine Region
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NSW	New South Wales
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
NW	North western
PMST	Protected Matters Search Tool
PPE	personal protective equipment
PTS	permanent threshold shift
ROV	remotely operated underwater vehicle
SEL	sound exposure level
SER	Supplementary Environmental Report
SHB	split hopper barge
SPL	sound pressure level
SPRAT	Species Profile and Threats Database
TSDMMP	Trenching and Spoil Disposal Management and Monitoring Plan
TSHD	trailer suction hopper dredge
TSSC	Threatened Species Scientific Committee
TTS	temporary threshold shift
TPWC	Territory Parks and Wildlife Conservation
WA	Western Australia

Glossary

Term	Definition
Biologically important area	Areas spatially defined and mapped by the Commonwealth Department of Environment (DoE) where aggregations of individuals of a species are known to display a biologically important behaviour such as breeding, foraging, resting or migration.
Cetacean	A marine mammal of the order Cetacea; a whale, dolphin, or porpoise.
Consequence	Impact of an event or incident e.g. a loss, injury or concern. May be expressed qualitatively or quantitatively.
Effect	A change to the environment (including socio-economic changes) resulting from the DPD Project that may be positive or negative.
Environment	Consistent with the Envir*onment Protection and Biodiversity Conservation Act 1999*, the definition of environment encompasses physical, biological, heritage, cultural, social, health, safety and economic aspects.
Environmental Performance Standard	A statement of performance required of a management action.

Term	Definition
Environmental Performance Objective	Measurable level of performance required for the management of environmental aspects of an activity to ensure that environmental impacts and risks are of an acceptable level.
Impact	A positive or negative effect the DPD Project would have on the environment (including physical, ecological and socio-economic environments.
Listed species	Species of conservation importance listed under the Envir*onment Protection and Biodiversity Conservation Act 1999*, or *Territory Parks and Wildlife Conservation Act 1976*.
Measurement Criteria	A system of measurements that define whether a project is successful.
Performance Criteria	The standards by which success of management actions is evaluated.
Project Area	The Project Area is an area extending 500 m either side of the pipeline, within which the Construction Activity will take place.
Residual risk	Risk remaining after implementation of mitigation measures.
Risk	A combination of the potential consequence of an event occurring and the likelihood of the consequence occurring.
Sensitive receptor	A receptor that could be subject to adverse impacts from the DPD Project.
Significant impact	Under the Envir*onment Protection and Biodiversity Conservation Act 1999*, Significant Impact Guidelines 1.1, a 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment, which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.
Target	Specific and measurable performance requirements to achieve Environmental Performance Objectives.

Measurement units

Measurement unit	Definition
°	degrees
µS	microSiemens
cm	centimetre
dB	decibels
dB(A)	a-weighted sound pressure level in decibels
Hz	hertz
kHz	kilohertz
km	kilometre
km^2	square kilometre
M	metre
m^2	square metre
mg/L	milligrams per litre

Measurement unit	Definition
Nm	nautical mile (1.856 km)

1 Introduction

1.1 Project overview

Santos NA Darwin Pipeline Pty Ltd is the operator of the existing Bayu-Undan to Darwin Gas Export Pipeline (GEP) in the Timor Sea. The Bayu-Undan to Darwin GEP is a dry natural gas export pipeline transporting gas from the Bayu-Undan Field located in Timor-Leste waters to the Darwin liquefied natural gas (DLNG) facility at Wickham Point peninsula near Darwin, Northern Territory (NT), Australia. The Bayu-Undan to Darwin GEP has been operational since 2005. In anticipation of the end of the Bayu-Undan Field's commercial production in 2022 – 2023, the Barossa Field is being developed to supply gas to the DLNG. The original base case for the supply of backfill gas to the DLNG facility was originally for the installation of a new 262 kilometres (km) Barossa GEP to a tie-in point on the existing Bayu-Undan to Darwin GEP.

In recognition of potential Carbon Capture and Storage opportunities at the Bayu-Undan Field, Santos NA Barossa Pty Ltd (Santos) has approved an alternative solution to transport backfill gas to the DLNG facility through the construction of an additional segment of pipeline to extend the Barossa GEP to the DLNG facility instead of tying into the existing Bayu-Undan to Darwin GEP. Construction of this segment of pipeline is referred to as the Darwin Pipeline Duplication (DPD) Project, as it will be installed parallel to the existing Bayu-Undan to Darwin GEP. The effective 'duplication' of the existing Bayu-Undan to Darwin GEP is considered the optimal route to minimise potential environmental and social impacts.

The pipeline will run from a location where the Barossa GEP approaches the existing Bayu-Undan pipeline and continue through Darwin Harbour into the DLNG facility at Wickham Point (**Figure 1-1**). Santos' DPD Project includes a ~23 km segment in Commonwealth waters and ~100 km segment in NT waters and lands adjacent to the existing Bayu-Undan to Darwin GEP. The DPD Pipeline (NT) will be located for the most part ~100 m from the existing Bayu-Undan to Darwin pipeline, to minimise potential environmental and social impacts. The Project Area for the DPD Project includes a 2 km buffer around the pipeline route in NT waters, the onshore construction area at the DLNG facility and an offshore spoil disposal ground for the trench spoil disposal (**Figure 1-1**).

Pre-lay trenching is required to meet a number of objectives, including providing pipeline protection and stability (in combination with rock installation), reducing pipeline spanning and ensuring compliance with shipping channel clear water requirements. Sections of the pipeline route within the harbour, with a combined length of up to ~16.5 km, will be trenched using various equipment with the remainder of the pipeline laid directly on the seabed. Rock sourced from a local quarry will be used to backfill for anchor protection in some areas where anchor protection or additional stabilisation is required.

Potential underwater noise impacts generated by the construction of the pipeline in NT waters is covered under this draft Marine Megafauna Noise Management Plan (MMNMP).

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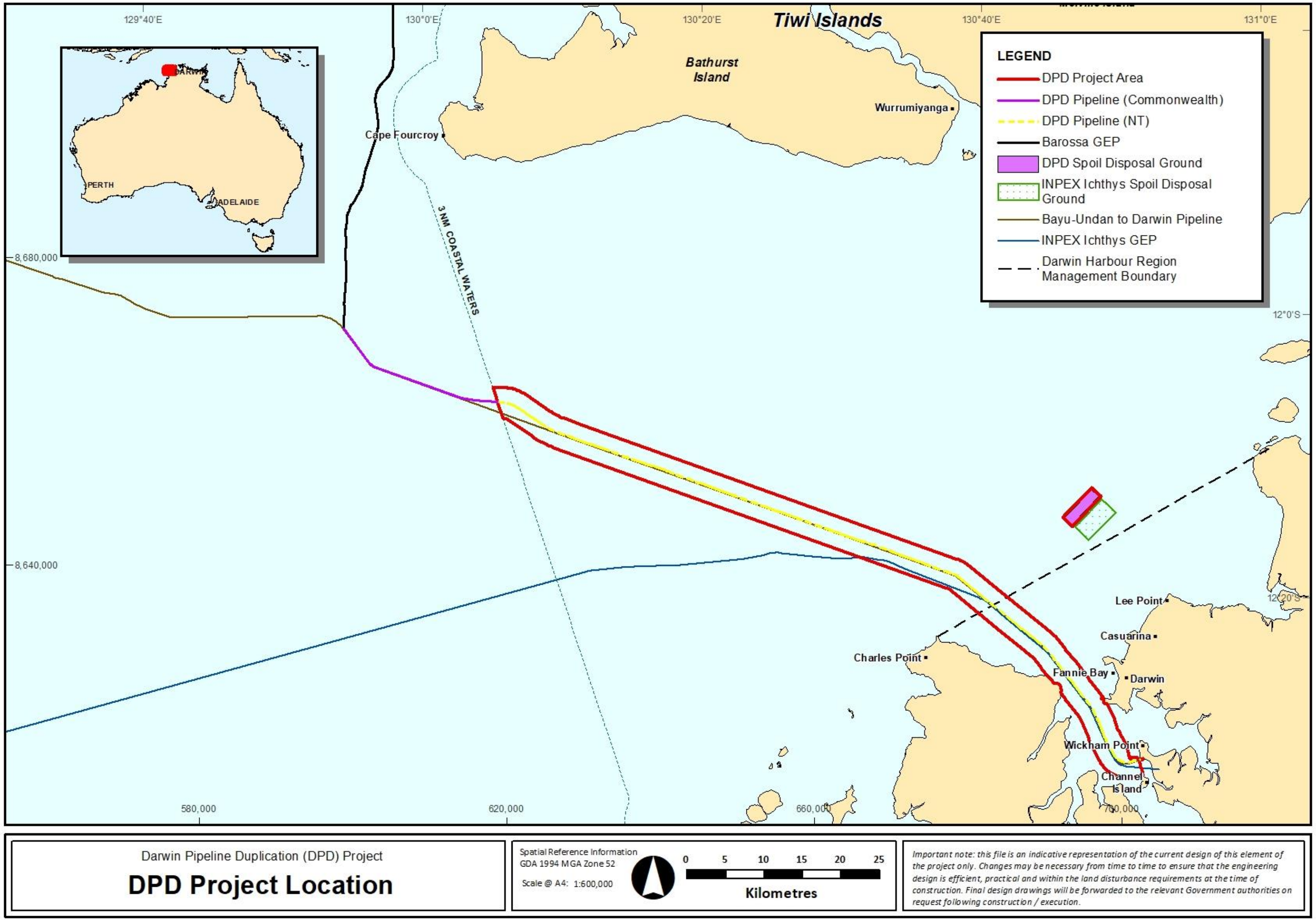


Figure 1-1: DPD Project Location

1.2 Purpose

This draft MMNMP details the likely impacts associated with underwater noise-generating activities during construction of the DPD pipeline in NT waters (DPD Pipeline (NT)), in particular trenching activities in Darwin Harbour. Assessment of these impacts is based on the results of project-specific underwater noise modelling undertaken during the environmental assessment phase of the DPD Project.

Further, this draft MMNMP identifies and details measures that will be implemented as required to manage and mitigate potential environmental impacts to marine megafauna due to underwater noise emissions from construction of the DPD Pipeline (NT).

The purpose of this draft MMNMP is to:

+ Demonstrate that all measures deemed reasonable and practicable will be implemented to manage underwater noise impacts and other potential environmental impacts to marine megafauna arising from the proposed DPD Project construction activities.
+ Prior to finalisation, demonstrate how the requirements of relevant conditions of approvals under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the NT *Environment Protection Act 2019* (EP Act) will be met.
+ Satisfy the Northern Territory Environmental Protection Authority (NT EPA) requirement for a draft marine megafauna management plan for construction activities that includes:
  - baseline (pre-construction) cumulative noise within the zone of influence of the proposal and relevant parameters to be monitored to detect impacts.
  - noise trigger levels for relevant parameters (and description of their derivation) corresponding to actions that must be taken in the event that monitoring indicates that construction activities are likely to impact protected species.
  - management actions to be applied if noise triggers are exceeded in accordance with the environmental decision-making hierarchy.
  - Santos has interpreted the latter two requirements as the application of management zones, as informed by noise modelling, and monitoring of sensitive fauna (using trained marine fauna observers (MFOs)) within these zones with associated management actions if sensitive fauna are observed.

1.3 Scope

This draft MMNMP addresses the noise generating activities during the construction of the ~100 km section of the DPD pipeline from the shore pull onshore termination point to the 3 nm Commonwealth/NT waters boundary (**Figure 1-2**).

The noise generating activities considered in the draft MMNMP, include:

+ Trenching along segments of the pipeline route within Darwin Harbour, with a combined length of up to ~16.5 km:
  - Sediment cutting using a cutter suction dredge (CSD)
  - Suction dredging using a trailer suction hopper dredge (TSHD)

– Rock breaking (hydraulic tools; Xcentric Ripper or Hydraulic hammer tool) using a backhoe dredge (BHD)

– Excavation dredging using a BHD

+ Mass flow excavation (MFE)

+ Vessels (various, including the use of survey equipment)

+ Helicopters

This draft MMNMP forms part of a suite of environmental management plans (EMPs) under an overarching Santos Darwin Pipeline Duplication Project Offshore Construction Environmental Management Plan (Offshore CEMP; BAS-210 0024) which covers construction activities from the 3 nm Commonwealth/NT waters boundary to the shore pull onshore termination point. The construction of the remaining section of pipeline between the onshore termination point and the upstream weld of the beach valve will be subject to the DPD Project Onshore Pipeline CEMP (BAS-210 0025; Onshore CEMP) (**Figure 1-2**).

In addition to this draft MMNMP there are two further draft EMPs under the Offshore CEMP that address specific activities during construction (**Figure 1-2**). These are the:

+ Trenching and Spoil Disposal Monitoring and Management Plan (TSDMMP) (BAS-210 0023) that addresses all trenching and spoil disposal activities from the 3 nm Commonwealth/NT waters boundary to the shore pull onshore termination point

+ Acid Sulfate Soil and Dewatering Management Plan (ASSDMP) (BAS-210 0049) that addresses all activities associated with acid sulfate soils (ASS) from lowest astronomical tide (LAT) to the upstream weld of the beach valve.

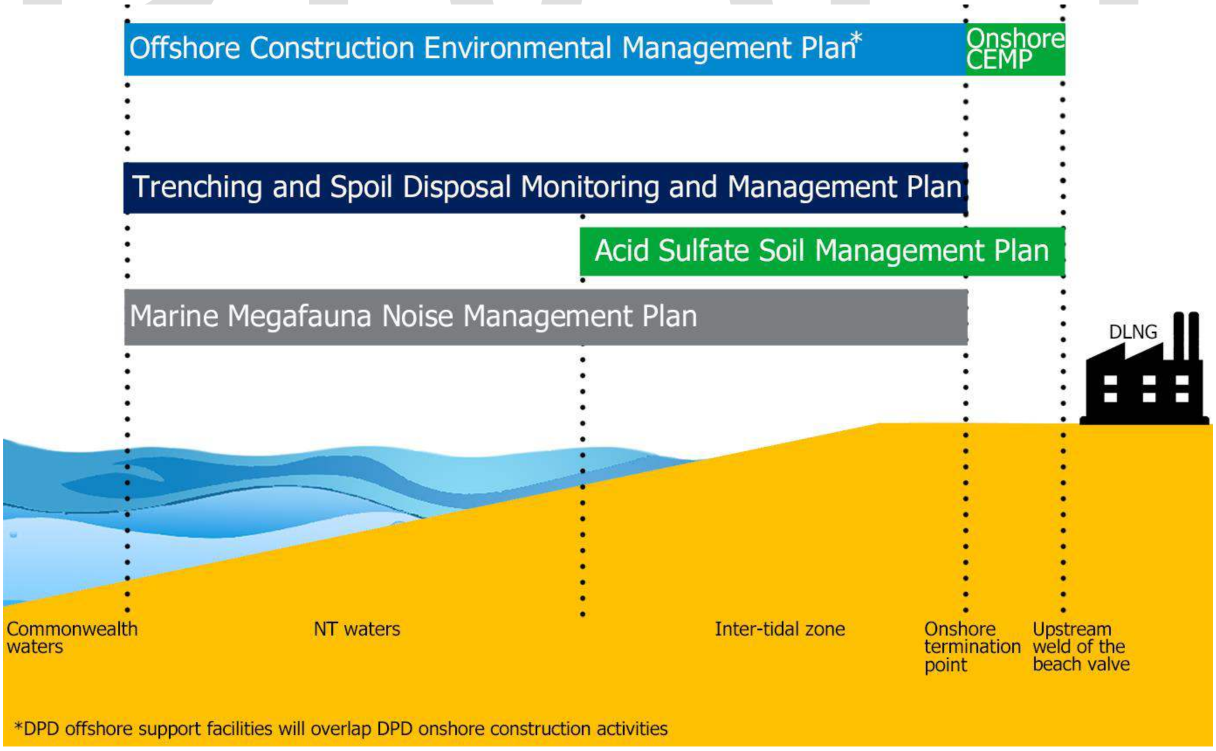


Figure 1-2: Conceptual model of management plan geographical scopes.

1.4 Plan structure

This draft MMNMP has been prepared and structured in accordance with the Northern Territory Environment Protection Authority: Draft Guideline for the Preparation of an Environmental Management Plan (NT EPA, 2015). The guideline requirements and where they have been addressed within the draft MMNMP are detailed in **Table 1-1**.

Table 1-1: Marine Megafauna Noise Management Plan Structure

Regulatory requirement Northern Territory Environment Protection Authority: Draft Guideline for the Preparation of an Environmental Management Plan 2015	Relevant MMNMP Section
Project Overview Proponent details Key contacts	**Section 1**: Introduction
Clear and comprehensive project description	**Section 2**: Detailed Activity Description
Legal and other obligations	**Section 3**: Legal and Other Obligation
Environmental management framework	**Section 4**: Environmental Management Framework
Existing environment	**Section 5**: Existing Environment
Conceptual Site Model Environmental risk assessment	**Section 6**: Noise Modelling Assessment **Section 7**: Environmental Impact Assessment The requirement for a conceptual site model is addressed within the impact assessment.
Environmental Management Strategies	**Section 8**: Environmental Management Strategies
Corrective actions and contingencies Auditing Reporting and Review Training and awareness Communication	**Section 9**: Implementation Strategy

1.5 Proponent

1.5.1 Details of the proponent

Santos, as the operator of the Barossa Joint Venture, has applied to the NT Department of Industry Tourism and Trade (DITT) for two pipeline licences for the DPD Pipeline (NT):

+ Coastal and Territorial Waters Licence for the section of the Pipeline under the jurisdiction of the *Petroleum (Submerged Lands) Act 1981* (i.e. between the NT Coastal Waters Limit and the Territorial Sea Baseline)
+ Inland Waters Licence for the section of Pipeline under the jurisdiction of the *Energy Pipelines Act 1981* (i.e. between the Territorial Sea Baseline and the upstream weld of the beach valve).

Both licences are applicable to the section of Pipeline within the scope of the draft MMNMP. The proposed proponent details are provided in **Table 1-2**, with the nominated operator shown in bold.

Table 1-2: Proponent details for Barossa DPD Project's Pipeline licences

Title	Proponent (nominated operator in bold)	ABN	Interest	Titles
+ Coastal and Territorial Waters Licence + Inland Waters Licence	**Santos NA Barossa Pty Ltd**	109 974 932	25.0%	Business Address: Level 7, 100 St Georges Terrace, Perth, Western Australia, 6000 Telephone number: (08) 6218 7100 Fax number: (08) 6218 7200 Email address: barossa.regulatory@santos.com
	Santos Offshore Pty Ltd	158 702 071	25.0%	
	SK E&S Australia Pty Ltd	005 475 589	37.5%	Business Address: Level 6, 60 Martin Place, Sydney NSW 2000, Australia Telephone number: (02) 21213304 Fax number: None Email address: hyunjoon-kim@sk.com
	JERA Barossa Pty Ltd	18 654 004 387	12.5%	Business Address: Level 9 Brookfield Place, 125 St Georges Terrace, Perth, Western Australia, 6000

1.5.2 Details of nominated liaison person

Name: Dr Lachlan MacArthur

Title: Environmental Approvals Adviser

Business address: Level 7, 100 St Georges Terrace, Perth, WA 6000

Telephone number: (08) 6218 7100

Email: Barossa.regulatory@santos.com

1.5.3 Notification procedure in the event of changed details

If there is a change in the nominated operator or a change in the contact details for the operator or liaison person, Santos will notify the DITT and provide the updated details.

1.6 Document review, revision and availability

Santos is responsible for submitting this draft MMNMP alongside its Supplementary Environmental Report (SER) and other documents to the NT EPA and DITT for comment and final approval. Santos will review and update the document as required based on regulatory feedback and any regulatory conditions on DPD Project approval as applicable. The final MMNMP will be made publicly available on an Australian website.

2 Detailed activity description

For the DPD Project, Santos is preparing to develop a second pipeline to connect the Barossa GEP to the DLNG facility. The pipeline will run from where the Barossa GEP approaches the existing Bayu-Undan to Darwin GEP to the existing DLNG facility in Darwin Harbour. The DPD Pipeline (NT) will include a ~23 km segment in Commonwealth waters and ~100 km segment in NT waters and lands. This draft MMNMP addresses the section within NT waters to the onshore termination point at the shore crossing. For additional description of the activity, refer to Section 2 of the Offshore CEMP (BAS-210 0024).

2.1 Project Area

Santos has defined the Project Area as the DPD Project footprint and an area within which construction activity will take place. The Project Area extends nominally 2 km either side of the DPD pipeline route and additionally includes the spoil disposal ground (**Figure 2-1**).

The Project Area consists of the three key areas, being:

+ Offshore NT waters (i.e. NT waters outside Darwin Harbour). Note that this includes the proposed location for spoil disposal;
+ Darwin Harbour (i.e. waters within the Darwin Harbour Management Area); and
+ Shore crossing within the previously disturbed DLNG facility footprint.

The locations for activities along the DPD Pipeline are described using ‘kilometre points’ (KP), where KP0 is the beginning of the DPD Project pipeline from the “pipeline end termination point” (PLET) in Commonwealth waters. For the purposes of this draft MMNMP, the scope begins at the 3 nm Commonwealth/NT waters boundary at ~KP23, and terminates at the onshore termination point at KP122.484. The following sections present details of construction activities which have been considered in the MMNMP.

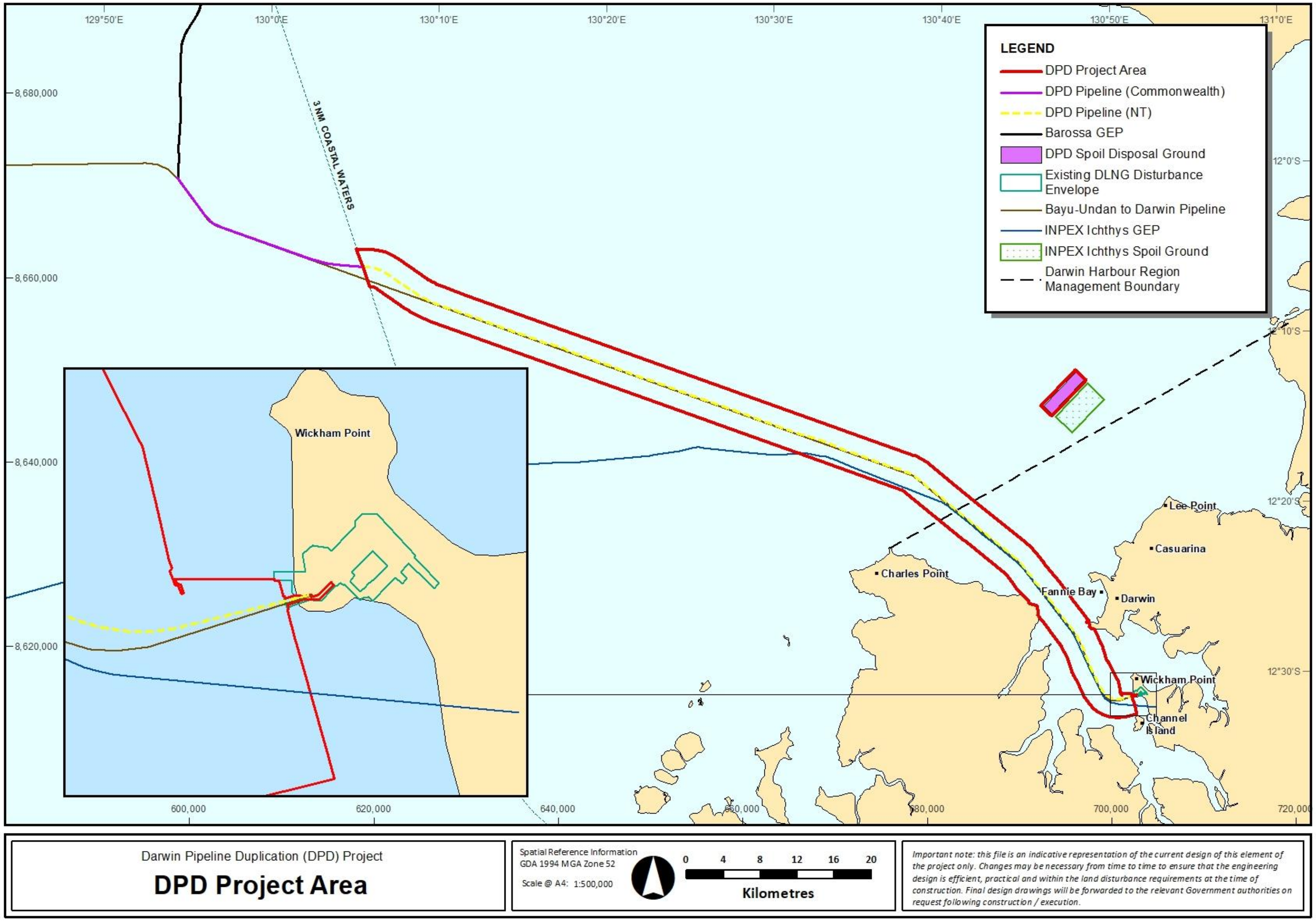


Figure 2-1: DPD Project Area (NT)

2.2 Construction activities

2.2.1 Pre-lay works

In water depths less than approximately 20 m the pipeline will require stabilisation due to exposure to waves, currents and tidal movement, and may need impact protection from third-party activities (i.e., anchors). As such, in some areas the pipeline will be installed and buried in a trench on the seafloor for stabilisation and protection. Some areas of seabed will also require intervention to reduce the potential for pipeline spanning.

2.2.1.1 Pipeline pre-lay trenching and spoil disposal

Trenching and backfill will be required in discrete sections of the pipeline route (with a combined length of up to ~16.5 km) within both nearshore DPD and shore crossing DPD locations. Locations of proposed trenching along the pipeline route are shown in **Figure 2-2**.

Offshore and within Darwin Harbour, the pre-lay trenching will involve the excavation of a trench (approximately 3 m width at its base) within an indicative trunkline corridor of 50 m width. Trailing Suction Hopper Dredge (TSHD), Cutter Suction Dredge (CSD) and a Backhoe Dredge (BHD) have been proposed for the pre-lay trenching works. Material will be excavated and disposed of at the spoil disposal ground, as shown in **Figure 2-2**.

The CSD will be sued in conjunction with the TSHD in some areas. The CSD will crush harder seabed material, where required, and leave this in-situ with the TSHD dredging the material and storing spoil within its hopper. The TSHD will deposit spoil at the offshore spoil ground by opening the bottom doors of the hopper.

Closer to shore and at the shore crossing a BHD will be used. Hydraulic rock breaking tools may also be required in conjunction with the BHD for rock breaking. The base case is to use a Xcentric Ripper tool with a hydraulic hammer used as a contingency. The BHD will be supported in shallow waters on spuds and will empty spoil onto split hopper barges (SHBs). These barges will be self-propelled or towed to the spoil disposal ground, where barges 'split' and spoil is released.

At low tide, land-based excavators will also be used to trench at the shore crossing. Excavated spoil will be placed close to low tide allowing any spoil build up to be removed on high tides by the BHD.

A maintenance dredging campaign may be required to ensure the trench is in specification prior to pipe lay. Surveys prior to the pipelay campaign will indicate if maintenance trenching is required based on the level of sediment build-up. It would be expected that only a TSHD and /or BHD would be used for maintenance trenching.

The proposed spoil disposal ground for trenched material is located to the north of Darwin Harbour, within the Beagle Gulf, approximately 12 km north-west of Lee Point. The selected site is adjacent to the spoil disposal ground approved for use by INPEX for the Ichthys Gas Field Development Project (**Figure 2-1**).

Further detail on trenching activities is provided in the TSDMMP (BAS-210 0023).

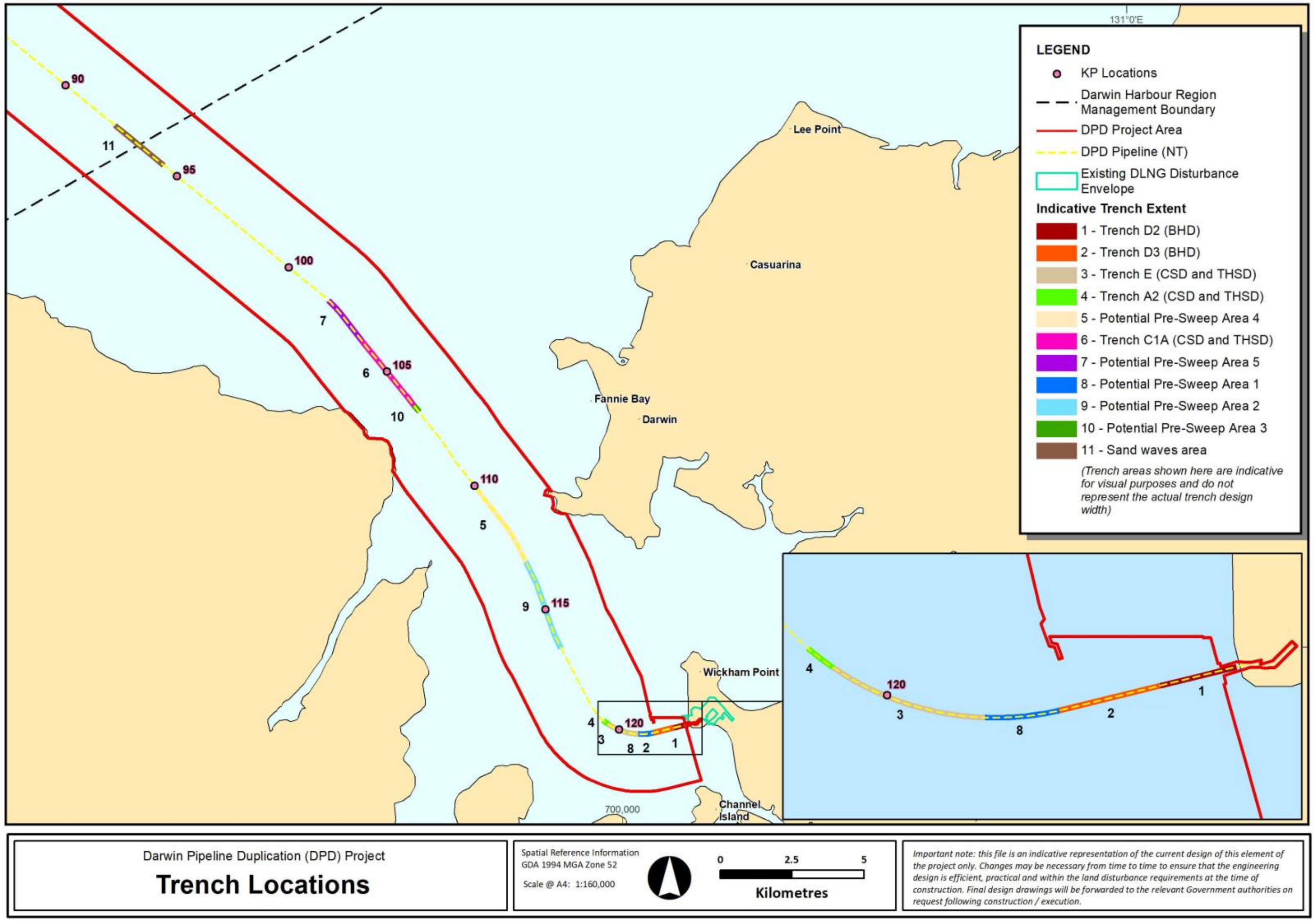


Figure 2-2: Indicative trench locations

2.2.1.2 Rock causeways

To aid in the trenching of the shore crossing, two temporary rock causeways are proposed to be installed either side of the trench in the intertidal zone. These will enable excavators to work further at low tides and provide a stable base for their operation.

2.2.1.3 Span rectification and foundation installation

Where the seabed is uneven a subsea pipeline may be left unsupported across spans between high points in the seabed. Where the spans are beyond acceptable limits and span rectification is required. One area of known sand waves (**Figure 2-2**) will be remediated by the TSHD. For other localised areas the following activities are proposed.

The use of mass flow excavation (MFE) has been identified as a potential method to reduce sediment high points (and therefore pipeline spanning) at 8 locations within two areas along the offshore pipeline route in NT waters. A MFE tool works by accelerating a mass flow of water to blow away sediments within a localised area and can be used to accurately remove sediment high points and reduce pipeline spanning.

MFE is currently the preferred alternative to the installation of numerous concrete mattresses or grout bags to rectify spanning.

Installation of concrete mattresses or grout bags to act as a 'bridge' or scour protection around foundations. A foundation may be installed for an in-line tee at KP62.8 during pre-lay activities. A construction vessel crane may be used to lift the mattresses or grout bags from the deck of the vessel onto the seabed. Each mattress is- typically ~18 m^2 and mattresses may be installed in groups and/or stacked on top of each other.

2.2.1.4 Equipment and methods

Trenching and spoil disposal for the DPD Project will be undertaken using the following equipment:

- Backhoe Dredge (BHD): For example "Pinochio/Hippopotous/Ambiorix", or similar (**Section 2.2.1.4.1**).
- BHD hydraulic rock breaking tools (if required): Xcentric Ripper tool (preferred) or hydraulic hammer (contingency) (refer to **Section 2.2.1.4.2**)
- Trailing Suction Hopper Dredge (TSHD): For example "Bonny River/Vox Amalia" or similar (**Section 2.2.1.4.3**)
- Cutter Suction Dredge (CSD): For example "Ambiorix/Athena" or similar (refer to **Section 2.2.1.4.4**)
- Split Hopper Barges (SHBs): For example "Pagadder/Sloeber/Jan Blanken" or similar (**Section 2.2.1.4.5**).
- Excavators (**Section 2.2.1.4.6**)
- Mass flow excavation will be undertaken with N-Sea Twin-prop and Quad-prop excavation tools or similar (**Section 2.2.1.4.7**)

2.2.1.4.1 Backhoe dredger

A BHD is a type of mechanical dredging equipment, consisting of a hydraulic arm and bucket system mounted on a turntable at the front of the pontoon with attached spud legs. Spud legs are driven into the seabed preventing movement due to wind, waves, and currents.

The BHD is towed to the location where the trenching works take place at the start of the operations. Trenching commences once the BHD has been positioned and is stationary. Trenching material is then lifted by the BHD bucket to the split hopper barge for transport to the spoil disposal ground.

2.2.1.4.2 Hydraulic rock breaking tools

The use of a hydraulic rock breaking tools is required for hard material that the BHD cannot cut through. An Xcentric Ripper tool (preferred) or a hydraulic hammer tool (contingency) is mounted on the BHD in place of the usual bucket. Once the tool has fractured the hard rock the bucket is reattached to the BHD and the broken or fractured strata is dredged by the BHD and loaded into the SHB for transport to and discharge at the spoil disposal ground. This method will only be used when required at specific locations and is a discontinuous process.

2.2.1.4.3 Trailing suction hopper dredger

A TSHD is a type of hydraulic dredger that is a self-propelled sea-going vessel equipped with a hopper that can be loaded or emptied via a dredging installation. Dredging via TSHD is a cyclical process of loading (dredging), transporting, and discharging. TSHDs are the only non-stationary dredger and are not anchored by spud poles.

At the trenching location the TSHD vessel slows to approximately 2 to 3 knots, then one or more suction tubes with dragheads (suction mouths) are lowered to the seabed. Whilst on the seabed swell compensators control the contact between the draghead and the seabed. Pumps then suck the material (a mixture of soil and water) from the seabed into the hopper located within the TSHD.

After the hopper is filled with dredged material, the pumps are stopped, the suction pipes and draghead lifted on deck and the TSHD sails to the spoil disposal ground. At the spoil disposal ground the dredged material is discharged by opening the bottom doors of the hopper.

2.2.1.4.4 Cutter suction dredger

CSDs are stationary hydraulic dredgers that are equipped with a cutter head. The cutter head rotates excavating the seabed which can be sucked up by dredge pumps as a mixture of water and sediment (slurry). CSDs can also be used to break up harder material which is left in-situ for subsequent removal by a TSHD; this will be the mode of operation used for the DPD Project. Whilst operating the dredger moves around the spud pole via the pulling and slacking of two fore sideline wires. The CSD to be used will have barge loading facilities.

The CSD utilised for this project will have its own propulsion, which will only be used during mobilisation, demobilisation and transport between locations.

2.2.1.4.5 Split hopper barge

SHBs are utilised for transporting and discharging of material dredged by the BHD. For this project, it is expected that two SHBs will be used to maximise efficiency and will be either self-propelled, towed or pushed by barges. A third barge may be used to further increase efficiency.

2.2.1.4.6 Excavator

An excavator will be utilised to excavate onshore and intertidal material which will be disposed of adjacent to the trench as close to lowest astronomical tide (LAT) as possible. Where this spoil builds up, the BHD will remove the spoil to a SHB for disposal at the offshore spoil ground.

2.2.1.4.7 Mass flow excavation

The use of MFE has been identified as a potential method to reduce sediment high points at 8 locations within two areas along the offshore pipeline route in NT waters. MFE is expected to take an indicative 7-14 days to complete, with an estimated six hours of operation at each site. A MFE tool works by accelerating a mass flow of water to blow away sediments within a localised area and can be used to accurately remove sediment high points and reduce pipeline spanning. MFE is an alternative to the installation of numerous concrete mattresses or grout bags.

2.2.2 Pipeline installation and pre-commissioning

Pipeline installation and pre-commissioning will comprise the following activities:

+ Pipelay activities – The DPD pipeline (NT) will be installed using a continuous assembly pipe-welding installation method. In water deeper than ~20 m the pipeline will be installed using a deep-water dynamic positioning (DP) pipelay vessel. In shallower waters and all waters within the Darwin Harbour, a shallow water pipelay barge will be used and anchoring will be required.
+ In-line tee – The in-line tee (ILT) which can facilitate future pipeline tie-ins to the DPD Project pipeline will be installed in the offshore NT waters at KP62.8 by the deep-water DP pipelay vessel. If required, a foundation for the ILT will be pre-installed during pre-lay works.
+ Pipeline shore pull – Shore pull to bring the DPD Pipeline (NT) onshore, will use a conventional winch operation.
+ Trench backfill – Rock (sourced onshore) will be used where necessary for pipeline stabilisation and protection for sections within Darwin Harbour. Trench backfilling will be required nearshore and at the shore crossing to provide pipeline stability. Where water depth allows, self-propelled DP vessels will be used to install rock, however in shallow waters, a spud barge will place the rock via excavator. Support barges will be used to transport rock for vessel/barge-based installation. Where possible for the shore crossing, the rock placement will be by shore-based excavators.
+ Post-lay span rectification – To provide pipeline stability, post-lay span rectification may be required to ensure the integrity of the pipeline and avoid failure through fatigue. Where required, spans will be rectified using ROVs to install grout bags that are then filled with grout.

2.2.3 Summary of vessel and support activities

Construction activities will include the operation of vessels, helicopters and ROVs. Support activities associated with the DPD Project will be undertaken throughout all phases of the DPD Project.

A number of vessel types will be required to complete the proposed activities, including:

+ Pipelay vessels (to install the pipeline) including: nearshore pipelay barge (shallow water pipelay vessel), dynamically positioned deep water pipelay vessel and pipe supply vessels.

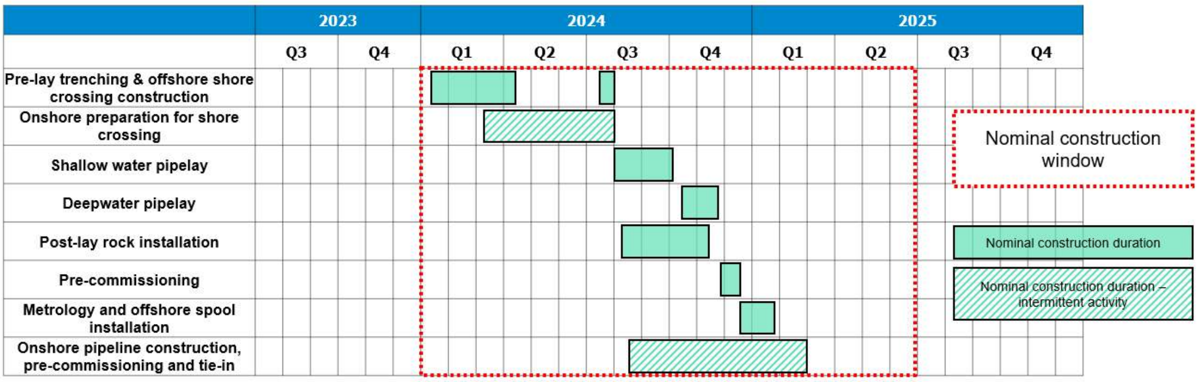
- Construction support vessels – to support installation of structures (i.e. installation of ILT protection frame, mattresses for scour protection, mechanical protection and stabilisation etc.) and use of MFE tools.
- Rock installation vessels – including fall pipe vessel, side dump vessels and non-propelled barges
- Excavation vessels – including CSDs, TSHDs, BHDs and SHBs
- Survey vessels – to verify trench depth and rock placement and support pipeline and structure placement
- Supply vessels – to provide general support and supplies to all offshore activities. Supply vessels are expected to operate from local regional ports (i.e. Darwin) to transport fuel, stores, waste and specialist supplies such as rock and pipe
- Helicopters will be used for transporting passengers and/or urgent freight to/from during offshore installation and commissioning activities.

Throughout the DPD Project, offshore activities will be supported by ROVs. The ROV can be fitted with various tools and camera systems that can be used to capture permanent records of the underwater operations and immediate surrounding environment.

2.3 Indicative construction schedule

Santos is targeting to have all DPD regulatory approvals in place by Q1 2024 to ensure construction activities do not delay Barossa first gas in the first half of 2025. A nominal DPD construction sequence and schedule is shown in **Table 2-1** representing a start of construction activities at the beginning of nominal construction window. The construction activities will span a nominal cumulative period of 15-months in the field. The actual construction sequence and schedule will be subject to the timely receipt of all regulatory approvals and drivers such as vessel availability, operational issues, and weather. Santos' regulatory approvals and stakeholder consultation consider construction activities at any time between Q1 2024 to mid-2025.

Table 2-1: Preliminary pre-lay, construction, installation, and pre-commissioning schedule for DPD.



3 Legal and other obligations

The following sections describe the legislative framework governing the impacts from noise emissions during the construction of the DPD Pipeline (NT).

3.1 Barossa DPD Project approvals

This draft MMNMP has been prepared for submission to the NT EPA with approval documents including the SER (BAS-210 0020) and for submission to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) as part of Preliminary Documentation (EPBC 2022-9372) for assessment under the EPBC Act. This draft MMNMP will also be submitted to DITT for approval under the *Petroleum (Submerged Lands) Act 1981* and *Energy Pipelines Act 1981*.

3.1.1 Commonwealth Environmental Approval

The DPD Project including the DPD Pipeline section in Commonwealth waters was referred to the DCCEEW under the EPBC Act on 7 October 2022 (EPBC 2022-9372). This draft MMNMP will be updated to reflect any relevant regulatory conditions associated with this approval. On 6 December the DPD Project was determined to be a Controlled Action requiring further assessment based on Preliminary Documentation. Further information was requested under section 95A(2) of the EPBC Act on 23 December 2022.

It was determined that the Project may have a significant impact on the following controlling provisions under the EPBC Act:

+ Listed threatened species and communities (sections 18 & 18A)
+ Listed migratory species (sections 20 & 20A)
+ Commonwealth marine areas (sections 23 & 24A)

The Preliminary Documentation is currently being prepared for submission to DCCEEW.

This MMNMP will be updated to reflect any relevant regulatory conditions associated with this approval.

3.1.2 Northern Territory Environmental Approvals

The DPD Project was referred to the NT EPA on 14 January 2022 under Section 55 of the *Environmental Protection Act 2019* (EP Act). The NT EPA determined the DPD proposal required assessment by Supplementary Environmental Report (SER) (Tier 2) in accordance with the Environment Protection Regulations 2020 (EP Regulations). The SER is required to address public submissions and include information additional to the referral document in relation to specific aspects of potential significance. This draft MMNMP will be updated to reflect any relevant regulatory conditions associated with this approval.

3.1.3 Regulatory requirements specific to noise emissions

The NT EPA considers that the DPD Project has the potential to have a significant impact on marine ecosystems. Marine ecosystems may be significantly impacted by disturbance of threatened species, recreationally or commercially significant species or maritime habitats during construction of the DPD Project.

The NT EPA requested the following additional information to support the SER and the Environmental Approval Process:

+ Provide interpreted outcomes of underwater noise modelling, including modelling of cumulative noise resulting from the proposal and existing activities at sensitive receptors.
+ Provide a draft marine megafauna management plan for construction activities that includes:
  - Baseline (pre-construction) cumulative noise within the zone of influence of the proposal and relevant parameters to be monitored to detect impacts
  - Trigger levels for relevant parameters (and description of their derivation) corresponding to actions that must be taken in the event that monitoring indicates that construction activities are likely to impact protected species
  - Management actions to be applied if triggers are exceeded in accordance with the environmental decision-making hierarchy.

This MMNMP has been prepared to address the relevant requests from NT EPA.

3.2 Legislative framework

Environmental legislative requirements governing DPD Project are described in the following sections. All activities will comply with legislative requirements established under relevant Commonwealth and Northern Territory legislation.

3.2.1 Relevant conventions, legislation, standards and guidelines

The following sections describe the conventions, legislation, standards, and guidelines applicable to noise emissions from construction activities and the impacts to marine megafauna.

3.2.1.1 International conventions, agreements, and guidelines

International conventions, agreements, and guidelines relevant to marine megafauna are presented in **Table 3-1**.

Table 3-1: International conventions, agreements, and guidelines relevant to the activity

Name	Description
United Nations Convention on Biological Diversity – 1992	An international treaty to sustain life on earth. Relevant as the activity may interact with MNES (threatened and migratory species) protected under the EPBC Act such as anthropogenic underwater noise.
Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)	The Bonn Convention aims to improve the status of all threatened migratory species through national action and international agreements between range states of particular groups of species. Relevant as the activity may interact with MNES (threatened and migratory species) protected under the EPBC Act. This includes development and implementation of the CMS Family Environmental Impact Assessment Guidelines for Noise-generating Offshore Industries.

3.2.1.2 Commonwealth legislation, standards, and guidelines

Commonwealth legislation, standards, and guidelines relevant to marine megafauna are presented in **Table 3-2.**

Table 3-2: Commonwealth legislation, standards, and guidelines

Name	Description
Blue Whale Conservation Management Plan 2015–2025 (CoA, 2015a)	The Conservation Management Plan for blue whales describes long-term recovery objectives to improve their conservation status and minimise anthropogenic threats. Noise interference and vessel disturbance are listed as threats.
Guidance on key terms within the Blue Whale Conservation Management Plan (DCCEEW, 2021)	This provides guidance on key terms found within the Conservation Management Plan for the Blue Whale 2015–2025 (CoA, 2015a).
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The Act aims to: + Protect MNES; + Provide for Commonwealth environmental assessment and approval processes; + Provide an integrated system for biodiversity conservation and management of protected areas. The Threatened Species Scientific Committee (TSSC) was established under the EPBC Act which plays a critical role in protection and management of native species and ecological communities. The TSSC have published Approved Conservation Advice for important species relevant to this project including humpback whales, sei whales and fin whales.
Environment Protection and Biodiversity Conservation Regulations 2000 (EPBC Regulations)	The regulations are designed to provide a streamlined national environmental assessment and approvals process whilst enhancing the protection and management of the environment.
Marine Bioregional Plan for the North Marine Region (DSEWPAC, 2012)	The document describes the marine environment and conservation values (protected species, protected places and key ecological features) of the North Marine Region. It sets broad objectives for its biodiversity, identifies regional priorities, and outlines strategies and actions to achieve these.
National Guidance on the Management of Whale and Dolphin Incidents in Australian Waters (DSEWPAC, 2013)	The document outlines best practice guiding principles for the management of incidents where whales and dolphins are in distress (e.g. entangled or stranded). The Guidelines may be relevant in the event that a whale or dolphin is impacted by noise emissions from construction activities during the DPD Project that may result in animal distress and stranding.
Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE, 2017)	The document describes a long-term recovery plan for marine turtles in Australia. The main objective it to minimise anthropogenic threats to allows for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list.

3.2.1.3 Northern Territory legislation, standards, and guidelines

NT legislation, standards, and guidelines relevant to marine megafauna are presented in **Table 3-3**.

Table 3-3: Northern Territory legislation, standards, plans, and guidelines

Name	Description
Darwin Port Environmental Management Plan (EMP) (Darwin Port, 2020)	The EMP provides environmental standards which are to be adhered to within Darwin Port. It provides environmental information, targets, and management strategies to prevent adverse impacts to the environment (Darwin Port, 2020).
Darwin Harbour Strategy 2020 – 2025 (DHAC, 2020)	The Darwin Harbour Advisory Committee (DHAC) developed the Darwin Harbour Strategy 2020 – 2025 to act as a contemporary strategy for the sustainable management of the Darwin Harbour region. The strategy outlines goals, objectives and outcomes that will help guide sustainable management and planning in the region. The management strategy goals are: + Foster partnerships: To protect and enhance Darwin Harbour through integrated management and in a partnership between government, industry, and the community. + Protect and preserve: To protect and enhance the natural environment of Darwin Harbour. + Celebrate connection: To protect and enhance the cultural values and heritage of Darwin Harbour. + Maintain our unique lifestyle: To protect and enhance social, recreational and lifestyle use and enjoyment of Darwin Harbour in an ecologically sustainable manner.
Environmental Protection Act 2019	The objects of this Act are: (a) to protect the environment of the Territory; (b) to promote ecologically sustainable development so that the wellbeing of the people of the Territory is maintained or improved without adverse impact on the environment of the Territory; (c) to recognise the role of environmental impact assessment and environmental approval in promoting the protection and management of the environment of the Territory; (d) to provide for broad community involvement during the process of environmental impact assessment and environmental approval; and (e) to recognise the role that Aboriginal people have as stewards of their country as conferred under their traditions and recognised in law, and the importance of participation by Aboriginal people and communities in environmental decision-making processes.
Environmental Protection Regulations 2020	The regulations provide guidance and a legislative framework for environmental impact assessments and approval processes that involve the NT EPA.
Fisheries Act 1988	The Act makes it illegal to pollute waters where the effect of the substance is that fish or aquatic life are injured, detrimentally affected or the habitats, food or spawning grounds are detrimentally affected. Consideration of this Act is required in the assessment of potential impacts and mitigation measures for the construction of the pipeline.
Guidelines for Reporting of an Environmental Management Plan (NT EPA 2015)	The document provides project proponents with advice on when an EMP may be required and what is required in preparing an EMP for assessment by the NT EPA.
Guideline for Reporting on Environmental Monitoring (NT EPA 2016)	This guideline outlines the NT EPA's requirements for environmental monitoring reports – to establish a minimum standard and consistent

Name	Description
	approach. The guideline outlines how to report the information collected through monitoring to the NT EPA.
Northern Territory *Environment Protection Authority Act 2012*	This act aims to a) promote ecology sustainable development; b) to protect the environment, having regard to the need to enable ecologically sustainable development; (c) to promote effective waste management and waste minimisation strategies; and (d) to enhance community and business confidence in the environmental protection regime of the Territory.
Territory Parks and Wildlife Conservation Act 1976 (TPWC Act) and Regulations 2001	The Act forms a framework for the establishment and management of parks and reserves and declaration of protected wildlife. This Act has been considered with regard to the potential interactions with protected wildlife.

4 Environmental management framework

4.1 Santos management system

Santos's Management System (known as the SMS) exists to support its moral, professional, and legal obligations to undertake work in a manner that does not cause harm to people or the environment. The framework of policies, standards, processes, procedures, tools, and control measures that, when used together by a properly resourced and competent organisation, result in:

+ A common HSE approach is followed across the organisation.
+ HSE is proactively managed and maintained.
+ The mandatory requirements of HSE management are implemented and are auditable.
+ HSE management performance is measured, and corrective actions are taken.
+ Opportunities for improvement are recognised and implemented.
+ Workforce commitments are understood and demonstrated.

The Implementation Strategy (**Section 9**) and Stakeholder Consultation (**Section 10**) align with the Management System structure and are designed to require that:

+ environmental impacts and risks continue to be identified for the duration of the activity and reduced to ALARP
+ controls are effective in reducing environmental impacts and risks to ALARP and acceptable levels
+ environmental performance outcomes and standards set out in this MMNMP are met
+ consultation with relevant and interested persons is maintained throughout the activity as appropriate.

4.2 Santos' Environment, Health and Safety Policy

Santos' Environment, Health and Safety Policy (**Appendix 1**) clearly sets out its strategic environmental objectives and the commitment of the management team to continuous environmental performance improvement. This EMP has been prepared in accordance with the fundamentals of this policy. By accepting employment with Santos, each employee and contractor is made aware during the recruitment process that he or she is responsible for the application of this policy.

4.3 DPD Project environmental management plans

There are a suite of environmental management plans covering DPD Project activities. The Offshore CEMP (BAS-210 0024) is an overarching management plan covering all activities from the 3 nm Commonwealth/NT waters boundary to the onshore termination point. The Onshore CEMP (BAS-210 0025) covers all activities to be completed from the onshore termination point to the upstream weld of the beach valve, except for support facilities for DPD Project offshore pipeline. The TSDMMP (BAS-210 0023), ASSDMP (BAS-210 0049) and MMNMP (BAS-210 0045) sit under these CEMPs and address specific activities. These activities are described in **Section 1.3**.

5 Existing environment

This section describes the key physical and biological characteristics of Darwin Harbour and the offshore areas within and around the Project Area, as relevant to this draft MMNMP. Further detail on the physical, biological, cultural and socio-economic environment of the Project Area is provided in the Offshore CEMP (BAS-210 0024) and the DPD Project SER (BAS-210 0020).

5.1 Physical environment

5.1.1 Coastal morphology

Darwin Harbour is a large, drowned river system approximately 500 km^2 in extent. It is comprised of three arms (East Arm, West Arm, and Middle Arm) which along with the smaller Woods Inlet converge into a single unit before opening to the ocean and into Beagle Gulf in the north.

Freshwater inflow from the Elizabeth River into the East Arm and the Blackmore and Darwin rivers into the Middle Arm generally occurs between January and April creating more estuarine conditions.

Port Darwin's main channel is approximately 1,525 m wide and 15 – 25 m deep, with a maximum recorded depth of 36 m. The channel is generally deeper on the eastern side of the Harbour, while the western side is broader and shallower areas with intertidal flats and shoal being more extensive.

The channel extends into the East Arm with depths of more than 10 m LAT, the bathymetry of this area has been modified by dredging associated with the development of East Arm Wharf. A slightly deeper channel can be found in the Middle Arm extending up to the western side of Channel Island.

5.1.2 Oceanography

Darwin Harbour has a macrotidal (more than four metres) regime with tide range reaching 8 m which is considerable by world standards. Tides are generally semidiurnal (two highs and two lows each day) with some inequality between successive tides in a single day. Neap tides result in a two-day period where tidal conditions are nearly diurnal (one high and on low each day). There is a great degree of variation in daily tidal range with the presence of spring-neap tide cycle approximately every 15 days. The spring phase of the cycle has an average tidal range of 6 m, while the neap phase average tidal range is 3 m. Large tidal movements and to a lesser extent wind, drives rapid and regular exchange of large volumes of water between Darwin Harbour and Beagle Gulf.

Darwin Harbour is considered sheltered with tsunamis and swell waves unlikely to occur due to the harbour's orientation, shallow bathymetry and protection afforded by the Tiwi Islands. Most waves are generated within Darwin Harbour or Beagle Gulf and are well below 1 m with periods of 2 – 5 seconds, under non-cyclone conditions. Tropical cyclones can cause extreme wave conditions producing significant wave height of 4.5 m and approximate periods of 7.5 seconds at the entrance to Darwin Harbour. Inside the harbour waves heights are reduced by the bathymetry to approximately 0.7 m (GHDM, 1997).

5.1.3 Underwater noise

5.1.3.1 Darwin Harbour

Underwater noise within Darwin Harbour is influenced by the existing shipping traffic, biological sources, and weather. Natural prominent sources of noise include thunderstorms, lightning strikes, and heavy wet-season rains, which all generate noise at considerable intensities, although these natural sources of noise all occur seasonally. Vessel traffic in Darwin Harbour is a year-round source of noise with the Port of Darwin recording 1,510 vessels in the 2021 – 2022 financial year (Darwin Port, 2022). Large commercial vessels, such as cargo ships, LNG tankers, cruise ships and offshore oil and gas vessels enter, exit and move around the harbour on a daily basis. Vessel movements are concentrated along designated shipping channels and around berthing and anchorage areas. The proposed DPD pipeline route and associated trenching areas are adjacent to these shipping channels.

Typical underwater noise emissions for the types of vessels using Darwin Harbour are provided in **Table *5-1*** along with typical source levels from the types of dredging vessels planned to be used for the DPD Project. Trenching vessels (BHD, CSD, TSHD) are expected to produce noise intensities and noise frequencies similar to large commercial vessels that use Darwin Harbour (**Table 5-1**).

Table 5-1 Indicative noise levels from typical Darwin Harbour vessels and DPD Project trenching vessels

Vessel Type	Source Level (dB)	Frequency	Reference
Tanker and Bulk Carriers	180-186	Low (10-30 kHz)	INPEX Browse, 2010
Offshore vessels (e.g. rig tender vessels)	177	Broadband	INPEX Browse, 2010
Powerboats with 80hp outboards (small recreational boats)	156-175	Broadband up to several kHz	INPEX Browse, 2010
Cutter Suction Dredge (CSD)	172-185	30Hz>-20kHz	Thomsen et al. 2009
Trailing Suction Hopper Dredge (TSHD)	184-188	30Hz>-20kHz	de Jong et al. 2010 Robinson et al. 2011 Reine et al. 2012
Backhoe Dredge (BHD)	175	30Hz>-20kHz	Reine et al. 2012

Underwater noise measurements have been taken in Darwin Harbour by Salgado-Kent et al. (2015) during a period where dredging and piling activities were being conducted in East Arm for the INPEX Ichthys Project. Dredging noise measurements were taken in the vicinity of a Cutter Suction Dredge (CSD) cutting an area of hard rock known as Walker Shoal (Salgado-Kent et al., 2015). These measurements revealed noise levels close to approximately 145 dB re 1 µPa at distances between 630 m and 680 m from the source, which were greater than the levels predicted by underwater noise modelling.

Given seabed hardness is expected to influence the level of noise emitted from a CSD while dredging, Santos commissioned an analysis of seabed hardness was undertaken to determine if noise measurements from Walker Shoal would be applicable for the DPD Project. Fugro (2022) undertook a comparative analysis of Walker Shoal geology and seabed refractivity against the geology and seabed refractivity of a representative CSD trenching area between KP104 and KP105 along the DPD route. This assessment compared available refractivity and bore hole data at these locations and concluded that seabed materials at the representative DPD trenching location were significantly weaker than those encountered at Walker Shoal (Fugro, 2022). Interpreted compressional wave acoustic velocities (Vp) ranged between 1,700 m/s to 3,000 m/s for the DPD Project trenching location while for Walker Shoal they ranged between 2,500 m/s and 4,000 m/s. Due the hardness of the rock at Walker Shoal and the fact that a specialised cutting tool was required to be used on the CSD for dredging in this area (INPEX Browse, 2011) it is unlikely that CSD noise measurements collected by Salgado-Kent et al. (2015) would be representative for DPD Project CSD trenching.

Salgado-Kent et al. (2015) found that in the absence of Ichthys project pile driving or dredging in East Arm, the most intense noises dominating the environment were from a range of vessel, and to a lesser extent machinery, operating in the area. Noise emissions from vessels were found to be broadband, with most energy ranging from tens of Hz to several kHz and often reaching 130 to 140 dB re 1 Pa. The study found intense broadband anthropogenic noise from vessels and machinery also occurred typically between 5 to 20 times per day throughout the recording period in the frequency band of approximately 10 Hz to 2 kHz with noise periods lasting from approximately 1 hour to 5 hours and with intensity levels reaching close to 160 dB re 1 µPa during some periods (Salgado Kent *et al.* 2015). Underwater noise measurements taken by SVT (2009) and provided within the Ichthys EIS (INPEX Browse 2010) also show relatively high measured background noise levels within East Arm of 150-170 dB re 1 µPa2/Hz.

Salgado-Kent et al. (2015) found that in comparison to East Arm, the ambient underwater noise levels in Middle Arm were on average lower, likely due to lesser vessel movements. It is also expected that, all other things being equal, received noise levels from vessel traffic will be lower in shallower areas of Darwin Harbour due to reduced sound propagation in shallow waters. This was found during surveys by SVT (2009) where measured ambient noise levels in the shallower Elizabeth River were lower than those for the broader East Arm.

When anthropogenic noise was not present, biological sounds such as fish and snapping shrimp were observed. While the program was aimed at detecting dolphins, they had a minor contribution to the soundscape and were detected infrequently. This suggests dolphins were either silent whilst travelling through the detection zone, spent limited time in the zone, or both (Salgado-Kent et al. 2015.

5.1.3.2 Offshore NT waters

There are no available ambient underwater noise monitoring data for the Project Area within offshore NT waters. It is expected that in the offshore NT waters ambient underwater noise would be minor, typically consisting of vessel noise from commercial fishers and shipping vessels.

5.2 Marine megafauna

The Darwin region supports marine megafauna including marine mammals, reptiles, sharks and birds. The EPBC Act Protected Matters Search Tool (PMST) has been used as a screening tool to determine EPBC Act listed marine megafauna that may occur within the DPD Project Area (with a 5 km buffer). Following the PMST screening, an assessment of likelihood of the species occurring within the DPD Project Area was determined based on documented records and the species habitat requirements with respect to habitat features within the Project Area.

The criteria applied to define the likelihood of occurrence for marine megafauna was:

+ **Unlikely**: the species has not been recorded within Darwin Harbour or surrounding waters; and/or its current known distribution does not encompass Darwin Harbour, and surrounding water; and/or suitable habitat is generally lacking from the Project Area.

+ **Potential**: the species has not been recorded within Darwin Harbour or surrounding waters although species' distribution incorporates Darwin Harbour and surrounding waters; and potentially suitable habitat occurs in the Project Area.
+ **Likely**: the species has been recorded within Darwin Harbour or surrounding waters in the past 10 years; and suitable habitat is present within the Project Area.
+ **Known to occur**: the species has been recorded (directly by commissioned surveys or from database records) within the Project Area in the past 10 years.

The results of PMST searches and subsequent assessments of likelihood of occurrence within the Project Area have been presented in the DPD Project NT EPA referral, EPBC Act referral and DPD Project SER (BAA-201 0003; Santos, 2021a; BAA-201 0004; Santos, 2022; BAS-210 0020).

Those species known to occur or likely to occur within the Project Area relevant to this MMNMP are described in the following sections. The search identified species of diving birds as occurring or potentially occurring in the area but have not been discussed further due to low underwater noise impact.

5.2.1 Marine mammals

Five species of marine mammals are known to occur in the Project Area, including four listed as migratory under the Commonwealth EPBC Act (**Table 5-2**). None of these species are currently listed under the *Territory Parks and Wildlife Conservation Act.* Through further assessment as described above, the species determined likely to occur in the Project Area are described in the following sections.

Table 5-2: Marine mammal species identified as known or likely to occur in the Project Area

Species	EPBC Act (Cwth)	*Territory Parks and Wildlife Conservation Act 1976*	Likelihood of occurrence in Project Area	Biological Important Area (BIA) in Project Area
False killer whale[1] (*Pseudorca crassidens*)	N/A	-	Known to occur – This species has been recorded within the Darwin Harbour. Demographically independent population(s), year-round inhabits of coastal areas in Northern Australia [2]	None
Australian humpback dolphin (*Sousa sahulensis*)	Migratory	-	Known to occur – Suitable habitat for the species is present. This species has been recorded within the Darwin Harbour.[2]	Yes – The Project Area intersects the Indo-Pacific humpback dolphin BIA for breeding.
Australian snubfin dolphin (*Orcaella heinsohni)*	Migratory	-	Known to occur – Suitable habitat for the species is present. Individuals of the species have previously been recorded in the Darwin Harbour and near Catalina Island, located to the east of the Project Area.[2]	Yes – The Project Area intersects the Australian snubfin dolphin BIA for breeding.
Indo-pacific bottlenose dolphin (Arafura/ Timor Sea populations) (*Tursiops aduncus*)	Migratory	-	Known to occur – Suitable habitat for the species is present. This species has been recorded within the Darwin Harbour.[2]	Yes – The Project Area intersects the Indo-pacific bottlenose dolphin BIA for breeding.
Dugong (*Dugong dugon*)	Migratory	-	Known to occur – Individuals of this species are known to occur within the Darwin Harbour.	None

Notes:

[1] The false killer whale was not identified in the PMST search, however the species has been recorded in Darwin Harbour and is therefore included in the below impact assessment.

5.2.1.1 False killer whale

False killer whales (*Pseudorca crassidens*) were not identified in the PMST search, however, they have been recorded in the Darwin Harbour and Beagle Gulf, therefore the species are briefly described here. False killer whales are found in all tropical and warm temperate oceans. They are typically pelagic but are also known to approach close to shore around oceanic islands. However, a recent study of 14 satellite tagged individuals has shown that the false killer whale population(s) in northern Australia are thought to be a demographically independent population and inhabit these shallow coastal waters year-round (Palmer et al, 2022). Currently, there are no estimates of global populations available but they appear to be uncommon throughout their range.

In the NT, eight sightings of false killer whale groups within the semi-closed harbours of Port Essington and Darwin have been recorded since 2007 as part of monthly surveys undertaken by the Coastal Dolphin Project (Palmer *et al.* 2009). The most recent sightings within these NT harbours have been recorded during the wet season of 2018 (December – April) (ALA, 2018). The behavioural observations associated with these sightings suggest the false killer whales were foraging (i.e. chasing schools of fish). Therefore, the species is considered as known to occur in the area.

5.2.1.2 Inshore dolphin species

Three inshore dolphin species were identified in the PMST search: Indo-pacific bottlenose dolphin, Australian humpback dolphin and Australian snubfin dolphin.

These species were monitored in the Darwin Harbour region (comprising Bynoe Harbour, Darwin Harbour and Shoal Bay) between 2011 and 2019 by the Coastal Dolphin Monitoring Program (Griffiths *et al*. 2020). The monitoring program found that populations of coastal dolphin species occurred at low densities in the Darwin Harbour region, though were similar to average densities found across NT coastal waters, and individuals or pods exhibited fluctuating movement across sites. Griffiths *et al.* (2020) noted that population sizes fluctuated over the monitoring period, however showed a general decline over time. The authors were unable to explain the reasons for year-to-year variation in abundance and declines, citing potential factors as population dynamics, environmental factors or anthropogenic factors (Griffiths *et al.* 2020).

5.2.1.2.1 Australian humpback dolphin

Humpback dolphins (*Sousa sahulensis*) are found in tropical/subtropical waters of the Sahul Shelf from northern Australia to the southern waters of the island of New Guinea (Jefferson & Rosenbaum, 2014). In Australia, humpback dolphins are thought to be widely distributed along the northern Australian coastline from approximately the Queensland-NSW border to western Shark Bay, WA (Parra & Cagnazzi, 2016). Humpback dolphins are more likely to be found in relatively shallow and protected coastal habitats such as inlets, estuaries, major tidal rivers, shallow bays, inshore reefs and coastal archipelagos, rather than in open stretches of coastline (Parra & Cagnazzi, 2016). BIAs for the Australian humpback dolphin occur along the Kimberley coast in WA, in NT waters and down the Queensland coast from Cape York to Brisbane (DSEWPaC, 2012).

The species is widely distributed across the NT with populations considered in a heathy state as per the findings of a conservation assessment by the NT Department of Natural and Environmental Resources (DENR) conducted in 2017 based on 2014/2015 surveys (Palmer *et al.* 2017). The Australian humpback dolphin was identified as having an area of occupancy (AOO) of 16,900 km^2 as well as a calculated extent of occurrence of 88% of NT coastal waters (Palmer *et al.* 2017). Highest densities of sightings were from Groote Eylandt (500), English Company Islands, Kakadu National Park, Melville Island (Aspley Straight) (Palmer *et al*. 2017) which are located on northern and eastern coasts of NT, over ~150 km from the Project Area.

BIAs (foraging, feeding and breeding) have been designated for the Australian humpback dolphin in Darwin Harbour; Port Essington, Cobourg Peninsula; East Alligator River region and South Alligator River region (DSEWPaC, 2012). The Project Area overlaps the Darwin Harbour breeding BIA for

Australian humpback dolphins (**Figure 5-1**). In the Darwin Harbour BIA, calving occurs in the months of October to April (Palmer, 2010). The proportion of dolphin calves sighted has varied considerably over the years with calving rates increasing from 3% in 2017 to 4% in 2018 for the Australian humpback dolphin, where over the previous years the rate has generally been low (Flora and Fauna Division, 2019).

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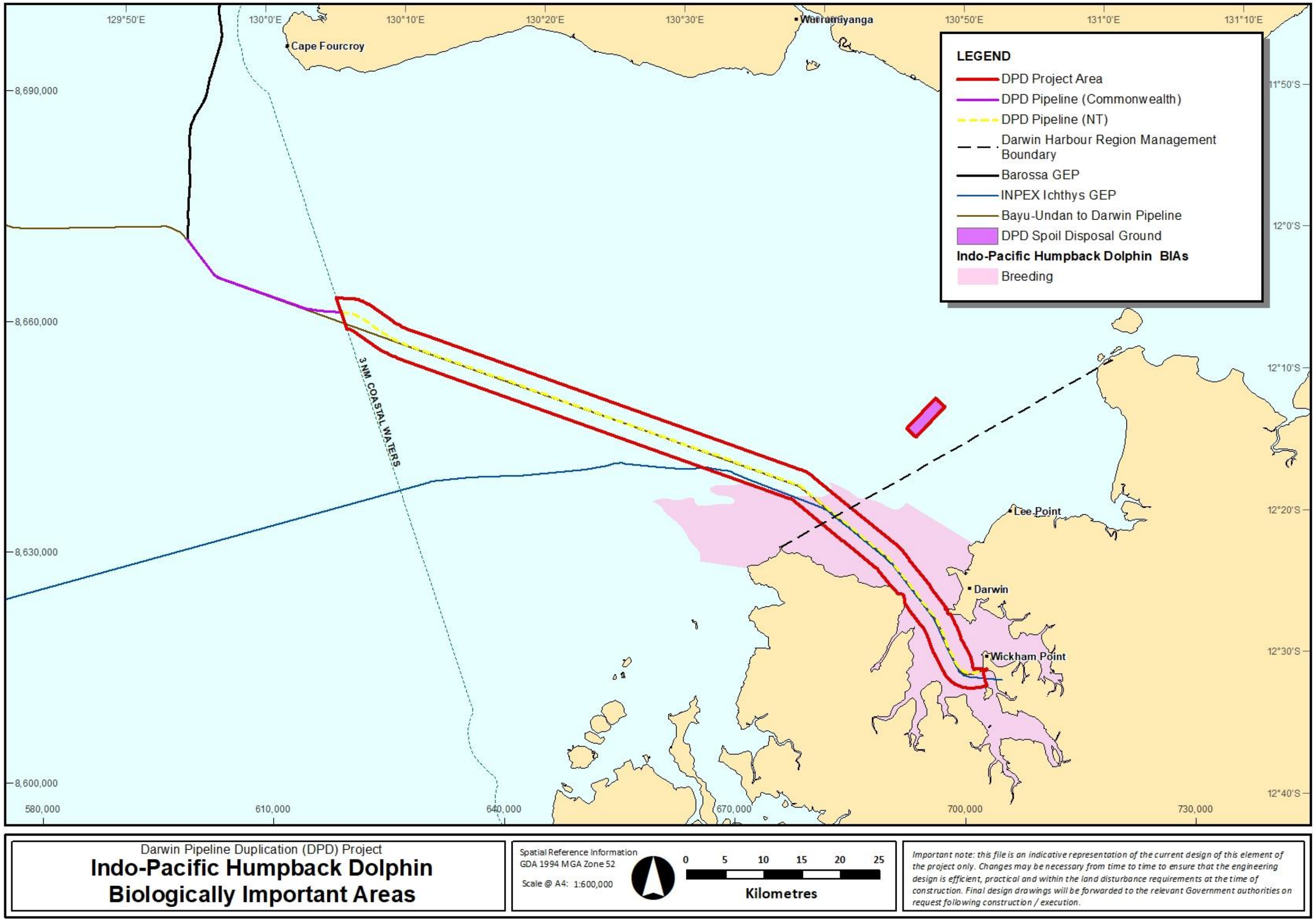


Figure 5-1: Biologically important areas for the Indo-Pacific humpback dolphin

5.2.1.2.2 Australian snubfin dolphin

The Australian snubfin dolphin (*Orcaella heinsohni*, hereafter, snubfin dolphin) was described as a separate species in 2005 and is endemic to the tropical waters of northern Australia and southern New Guinea (Beasley *et al.* 2005). Snubfin dolphins are typically found in shallow coastal waters (<20 m) and usually in proximity (<15 km) to freshwater inputs (Parra *et al.* 2002, 2006a; Parra, 2006; Bouchet *et al.* 2021). Previous research suggests they are intermittently distributed across their range as small local populations of 50 – 200 individuals (Parra *et al.* 2006b; Palmer *et al.* 2014b; Brown *et al.* 2016; Brooks *et al.* 2017; Bouchet *et al.* 2021) that exhibit site fidelity (Parra, 2006; Brown *et al.* 2016; D'Cruz *et al.* 2022) and limited gene flow between populations (Brown *et al.* 2014b, 2017). BIAs for Australian snubfin dolphins (breeding, foraging and resting) have been designated along the Kimberley coastline in WA and in NT waters.

The Australian snubfin dolphin is widely distributed across NT coastal waters, with populations considered in a heathy state, as per the findings of a conservation assessment by the NT DENR (Palmer *et al*. 2017). From aerial surveys undertaken in 2014 and 2015, the snubfin dolphin was identified as having an AOO of 24,900 km^2 and was calculated to occupy 89% of NT coastal waters (Palmer *et al.* 2017). Highest densities of sightings were from Pellew Islands, Groote Eylandt, English Company Islands / Arnhem Bay and Fog Bay (Palmer *et al.* 2017), with these sites primarily on the east coast of the NT.

The Project Area overlaps the Darwin Harbour breeding BIA for Australian snubfin dolphins (**Figure 5-2**). Limited data on breeding time are available for the Australian snubfin dolphin, however, the closely related irrawaddy dolphin is thought to mate from March to June (Ross, 2006) with calves born in August or September.

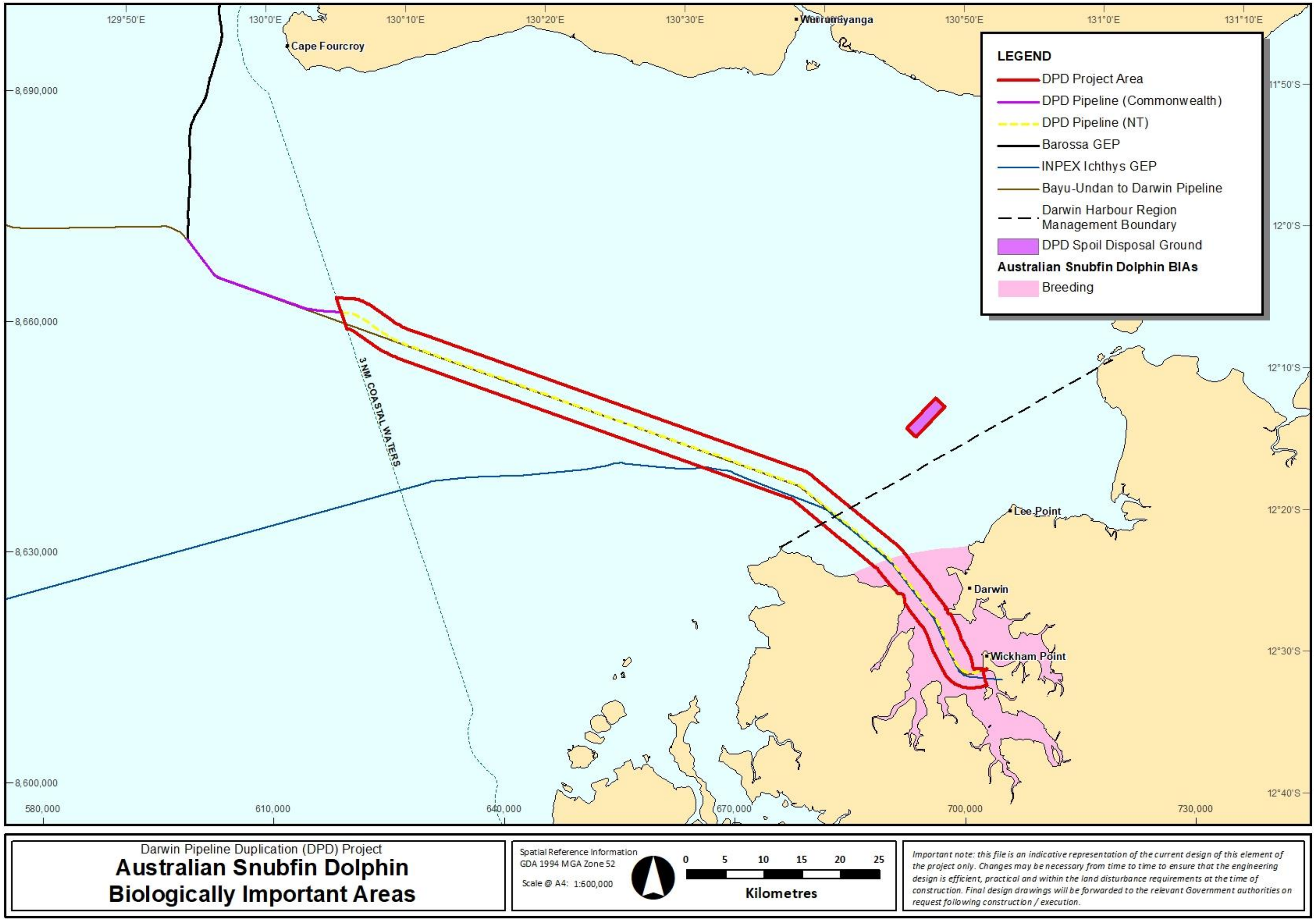


Figure 5-2: Biologically important areas for the Australian snubfin dolphin

5.2.1.2.3 Indo-Pacific bottlenose dolphin

Indo-pacific bottlenose dolphins (*Tursiops aduncas*) are found in tropical and sub-tropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific Region and the western Pacific Ocean (Möller & Beheregaray 2001; Rice 1998; Ross & Cockcroft 1990; Wang *et al.* 1999). The species has been recorded in waters of all Australian states/territories, and can be found in estuarine and coastal waters of eastern, western and northern Australia (Hale *et al.* 2000; Möller & Beheregaray 2001; Ross & Cockcroft 1990). BIAs for the species have been designated along the Kimberley Coast in WA, in NT waters and down the entire east coast of Australia from Cape York to past the New South Wales (NSW) – Victorian border.

The species is widely distributed across the NT with populations considered in a heathy state as per the findings of a conservation assessment by the NT Department of Natural and Environmental Resources (DENR) based on 2014/2015 surveys (Palmer *et al*., 2017). The species was identified as having an area of occupancy (AOO) of 17,600 km^2 and occurred within 84% of NT coastal waters (Palmer *et al.*, 2017). Highest densities were recorded from Limmen Bight, Nhulunbuy, Caledon Bay, Maningrida, Fog Bay, Anson Bay and Cape Ford (Palmer *et al.*, 2017), which are distributed across west, north and east coasts of NT.

The Project Area overlaps with a breeding BIA in Darwin Harbour (**Figure 5-3).** Calving in the Darwin Harbour BIA occurs in the months of October to April (Palmer, 2010). The proportion of dolphin calves sighted has varied considerably over the years with calving rates decreasing from 12% in 2011 to 0% in 2017 and increasing to 4% in 2018 (Flora and Fauna Division, 2019).

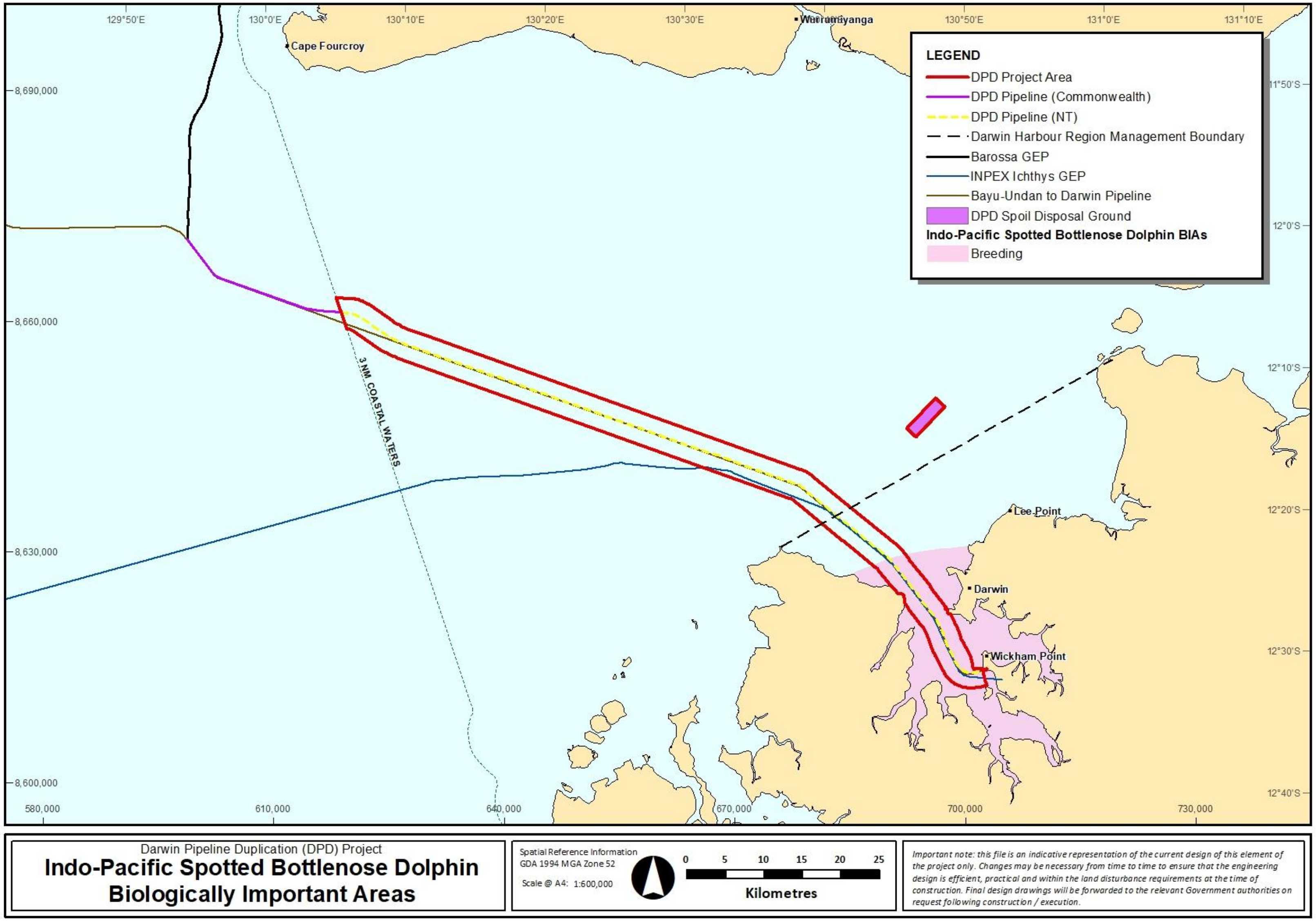


Figure 5-3: Biologically important areas for the Indo-Pacific bottlenose dolphin

5.2.1.2.4 Dugong

The Dugong (*Dugong dugong)* has a very large and fragmented Indo-West Pacific range that extends between about 26 – 27° north and south of the equator (Nishiwaki & Marsh, 1985), encompassing some 860,000 km² of shallow marine habitat across 128,000 km of coastline (Marsh *et al.* 2011). In Australia, dugongs are known to occur in coastal and island waters from Shark Bay in WA, across the northern coastline to Moreton Bay in Queensland (Marsh *et al.* 2002, 2011). The winter range includes about 24,000 km of Australia's coast, which represents about 19% of the global extent of occurrence along coastline habitats (Marsh *et al.* 2011).

The NT supports a moderate population compared with the Torres Strait, which is the largest global population (Groom *et al.* 2017). Specific areas supporting dugongs in the NT include: the northern coast from Daly River to Millingimbi, including Melville Island and Vernon Islands and the Darwin region; and the Gulf of Carpentaria, including the Sir Edward Pellew Group of Islands, the mouth of the Limmen Bight River, and the waters between Blue Mud Bay and Groote Eylandt (Marsh *et al.* 2008; Grech *et al.* 2011). The distribution and abundance of dugongs is generally associated with extensive seagrass and algal habitats, and they are usually found in coastal areas such as shallow protected bays, mangrove areas and leeward of large inshore islands where seagrass grows (O2 Marine, 2019). Aerial surveys conducted by Groom *et al.* (2017) in 2015 found that the Sir Edward Pellew Island Group and Limmen Bight on the east coast of the NT have the highest population estimates for dugongs in NT consistent with earlier survey results from 2007 and 2014.

Dugong monitoring was undertaken as part of the Ichthys Nearshore Environmental Monitoring Program from 2012 to 2014 across three areas (blocks), representing Bynoe Harbour, Darwin Harbour/Hope Inlet and Vernon islands and surrounds. Population estimates ranged from approximately 120 to 300 individuals (calculated from post-dredging phase monitoring) with a clear preference for shallow waters (0 – 10 m) and with far fewer sightings in the inner Darwin Harbour (demarcated as a line from Mandorah to East Point) than in the outer Darwin Harbour (Cardno 2015a). Highest dugong abundances from these surveys were recorded in seagrass meadows at Casuarina Beach and Lee Point in the outer Darwin Harbour and outside of the Project Area. Within the inner harbour, dugongs were observed in highest abundance (n = 19) at Weed Reef (Cardno, 2015a).

Cardno (2015a) found that sightings and densities of dugongs increased from May to October, when overall sightings were greatest. This is consistent with seasonal increase in seagrass extent and density (Cardno, 2015b). There are no BIAs for dugongs in the Marine Bioregional Plan for the North Marine Region (DSEWPaC, 2012), however the species is known to regularly occur in Darwin Harbour.

5.2.2 Marine reptiles

There are six species of marine turtle known to occur in NT waters that are either known to occur or have the potential to occur within the Project Area (**Table *5-3***). Of these only the green, hawksbill, flatback and olive ridley turtle are known to inhabit Darwin Harbour ((BAA-201 0003; Santos, 2021a; BAA-201 0004; Santos, 2022;). Through further assessment as described above, the species determined likely to occur in the Project Area are described in the following sections.

Marine turtle aerial surveys undertaken for the INPEX nearshore environmental monitoring program (NEMP) estimated a population size of between 500 and 1,000 for the Darwin region (Buckee *et al.*, 2014). Turtles were primarily observed in shallow waters (<10 m), with the highest densities recorded between East Point and Lee Point, and near Gunn Point (Cardno, 2015a). Turtles were also sighted throughout Darwin Harbour, although at lower densities. It is likely that the majority of turtles observed in the harbour during these surveys were green turtles, as they accounted for 74% of sightings during fine scale land-based observations (INPEX Browse Ltd, 2018).

In addition to marine turtles, the salt water crocodile is known to occur in the Project Area.

Table 5-3: Threatened and migratory marine reptile species identified as habitat critical and as likely to occur in the Project Area.

Species	EPBC Act (Cwth)	*Territory Parks and Wildlife Conservation Act 1976*	Likelihood of occurrence in Project Area	BIA and habitat critical in Project Area
Loggerhead turtle (*Caretta caretta*)	Endangered Migratory	Vulnerable	Potential – Possibly infrequent users of Darwin Harbour but more likely to occur in surrounding oceanic areas.	None
Green turtle (*Chelonia mydas*)	Vulnerable Migratory	-	Known to occur – Suitable habitat for the species is present. This species is known to occur within the Darwin Harbour.	None
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable Migratory	Vulnerable	Known to occur – Suitable habitat for the species is present. This species is known to occur within the Darwin Harbour.	None
Flatback turtle (*Natator depressus*)	Vulnerable Migratory	-	Known to occur – Suitable habitat for the species is present. This species is known to occur within the Darwin Harbour.	Yes – The Project Area intersects the flatback turtle habitat critical and BIA critical for survival (inter-nesting).
Leatherback turtle (*Dermochelys coriacea*)	Endangered Migratory	Critically endangered	Potential – Preferred habitat for this species is open ocean. Likely to occur in the oceanic waters outside Darwin Harbour.	None
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered Migratory	Vulnerable	Known to occur – Suitable habitat for the species is present. This species is known to occur within the Darwin Harbour.	None – Habitat critical and BIA critical for the survival of the olive ridley turtle (inter-nesting) is present to the north and south of the Project Area.

Species	EPBC Act (Cwth)	*Territory Parks and Wildlife Conservation Act 1976*	Likelihood of occurrence in Project Area	BIA and habitat critical in Project Area
Salt-water Crocodile (*Crocodylus porosus*)	Migratory	-	Likely – The species has been recorded within Darwin Harbour or surrounding waters in the past 10 years; and suitable habitat is present.	None – no important habitat for the species located within the Project Area.

5.2.2.1 Loggerhead turtle

The loggerhead turtle (*Caretta caretta*) has a worldwide distribution, living and breeding in subtropical to tropical locations (Limpus, 2009). Loggerhead turtles are known to forage in subtidal and intertidal coral and rocky reefs and seagrass meadows in inshore waters, as well as in deeper soft-bottomed habitats. Females can migrate up to 2,600 km from feeding areas to traditional nesting beaches.

In Australia, they occur in coral reefs, seagrass beds and muddy bays and estuaries in tropical and warm temperate waters off the coast of Queensland, NT, WA and NSW. The current area of occurrence is estimated to be ~1.5 million km^2.

Breeding aggregations in Australia occur on both the east coast (Queensland and NSW) and the west. Based on the percentage of nesting females per year, approximately 2 – 4% of the total global population of loggerhead turtles occur in Australia, with the majority occurring in eastern and western Australia. There are no known nesting areas in NT. The annual nesting population in WA is thought to be 3,000 females annually (Baldwin *et al*., 2003), and this is considered to support the third-largest population in the world (Limpus, 2009). Loggerhead turtles have one genetic breeding stock within WA (Commonwealth of Australia, 2017).

Loggerhead turtles are known to forage in the Oceanic Shoals Marine Park, the Arafura Sea and the Gulf of Carpentaria; however, they have not been observed breeding in the region (DEWHA, 2008a). Loggerhead turtles are expected to be infrequent users of the Darwin Harbour (Whiting 2003). The loggerhead turtle is more likely to occur in oceanic areas outside the Darwin Harbour. Benthic surveys undertaken in October/November 2021 and June 2022 found epibiota density did increase towards the shallow inner Darwin Harbour area outside the Project Area (RPS, 2022). However, there is unlikely to be suitable habitat for loggerhead turtles throughout the Project Area due to the large areas of bare silty sand with sparse epibiota. There are no BIAs for loggerheads in the Project Area and there is no evidence to suggest the species will use beaches within the Darwin Harbour for nesting.

5.2.2.2 Green turtle

Green turtles are found in tropical and subtropical waters throughout the world. The global population of green turtles is estimated to be very large (~2 million). Green turtles spend their first five to ten years drifting on ocean currents (pelagic phase). They then settle in shallow benthic foraging habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds. The shallow foraging habitat of adults contains seagrass beds or algae mats on which green turtles mainly feed. Green turtles can migrate more than 2,600 km between their feeding and nesting grounds.

Green turtles nest, forage and migrate across tropical northern Australia. The total Australian population of green turtles is estimated to be more than 70 000 individuals, distributed across seven regional populations that nest in different areas; the southern Great Barrier Reef, the northern Great Barrier Reef, the Coral Sea, the Gulf of Carpentaria, Western Australia's north-west shelf, the Ashmore and Cartier Reefs and Scott Reef. The Gulf of Carpentaria has two main nesting areas, the Wellesley Island Group, with major rookeries at Bountiful, Pisonia and Rocky Islands, and the Eastern Arnhem Land, Groote Eylandt and Sir Edward Pellew Islands area. Nesting occurs year-round, with a mid-year peak in nesting activity.

The key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) are Coburg Peninsula (~125 km from the Project Area), between Nhulunbuy and northern Blue Mud Bay (East Arnhem Land), Groote Island, offshore islands including Crocker Island, Goulburn Island, Sir Edward Pellew Islands, Bathurst and Melville Islands, Wessel and English Islands, and Rocky Island.

There are no defined or evidence of nesting or inter-nesting areas within the Project Area, however, within Darwin Harbour, it is not known if the green turtle use Casuarina Beach, Cox Peninsula Beaches and Mandorah Beach for nesting (~10 km from the Project Area) due to low survey effort, low reporting effort and low levels of turtle nesting effort in the area. Incidental sightings from other surveys indicate green turtle are present within Darwin Harbour (Pendoley, 2022; Whiting, 2001). The Project Area contains rocky reef and algae habitat (e.g. weed reef), therefore it is likely that green turtles feed in the Project Area.

5.2.2.3 Hawksbill turtle

Hawksbill turtles (*Eretmochelys imbricata*) have a global distribution throughout tropical and subtropical marine waters. The total population of hawksbill turtles in Australia is unknown. Hawksbill turtles are largely concentrated on the North West Shelf (Dampier Archipelago) of WA (Limpus, 2009), however a second major population of hawksbill turtles, which is genetically isolated from the North West Shelf population is located along the NT coast and north-eastern Queensland (Northern Territory Government, n.d).

In the NT nesting is reported to occur from July to December (Chatto, 1997; 1998). Adults tend to forage in tropical tidal and subtidal coral and rocky reef habitat where they feed on an omnivorous diet of sponges, algae, jelly fish and cephalopods (DSWEPaC, 2012a).

Incidental sightings suggest hawksbill turtles utilise Darwin Harbour regularly but occur in lower abundances compared to the green turtle (Whiting, 2001; 2003). In the Darwin Harbour, immature and adult sized hawksbill turtles were found to use the rocky reef habitat at Channel Island, and may also utilise other habitats (Whiting, 2001). Soft coral and sandy habitats are widely present throughout the Project Area within Darwin Harbour, providing suitable foraging habitat for the hawksbill turtle.

5.2.2.4 Flatback turtle

The flatback turtle (*Natator depressus*) is found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya and is one of only two species of sea turtle without a global distribution. There are no estimates of population size for the species and it is currently listed as 'data deficient' by the IUCN. Flatback turtles feed in the northern coastal regions of Australia, extending as far south as the Tropic of Capricorn. Their feeding grounds also extend to the Indonesian archipelago and the Papua New Guinea coast. Post-hatchling flatback turtles do not have an oceanic dispersal phase, this species remains within the relatively shallow Australian continental shelf waters (Salmon *et al.*, 2009).

Flatback turtles are the most widely spread nesting marine turtle species in the NT, nesting on a wide variety of beach types around the entire coastline. Flatback turtles have a preference for shallow, soft-bottomed seabed habitats away from reefs; consistent with the habitat in the Project Area. A study conducted on Field Island in the Van Diemen Gulf (~100 km from the Project Area) recorded a total of 257 individuals nesting on the island from 2002 to 2013 (Groom *et al.* 2017). The study estimated the abundance of nesting flatback turtles at Field Island and found it varied over time and ranged from 97 to 183. Peak internesting for flatback turtles in the NT occurs between June-September (DoEE, 2017a).

As shown on **Figure 5-4**, the Project Area intersects 'Habitat Critical to the survival of the flatback turtle species'. This habitat was mapped by consensus of a panel of experts in marine turtle biology and according to the EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance, is defined as areas necessary:

+ For activities such as breeding or dispersal.
+ For the long-term maintenance of the species.
+ To maintain genetic diversity and long-term evolutionary development.
+ For the reintroduction of populations or recovery of the species.

Habitat Critical to the survival of flatback turtles includes at least 70% of nesting habitat for the stock (i.e. these marine areas are extensive). The Project Area also overlaps a flatback turtle BIA (inter-nesting), which further supports the species assessment as known to occur in the Project Area.

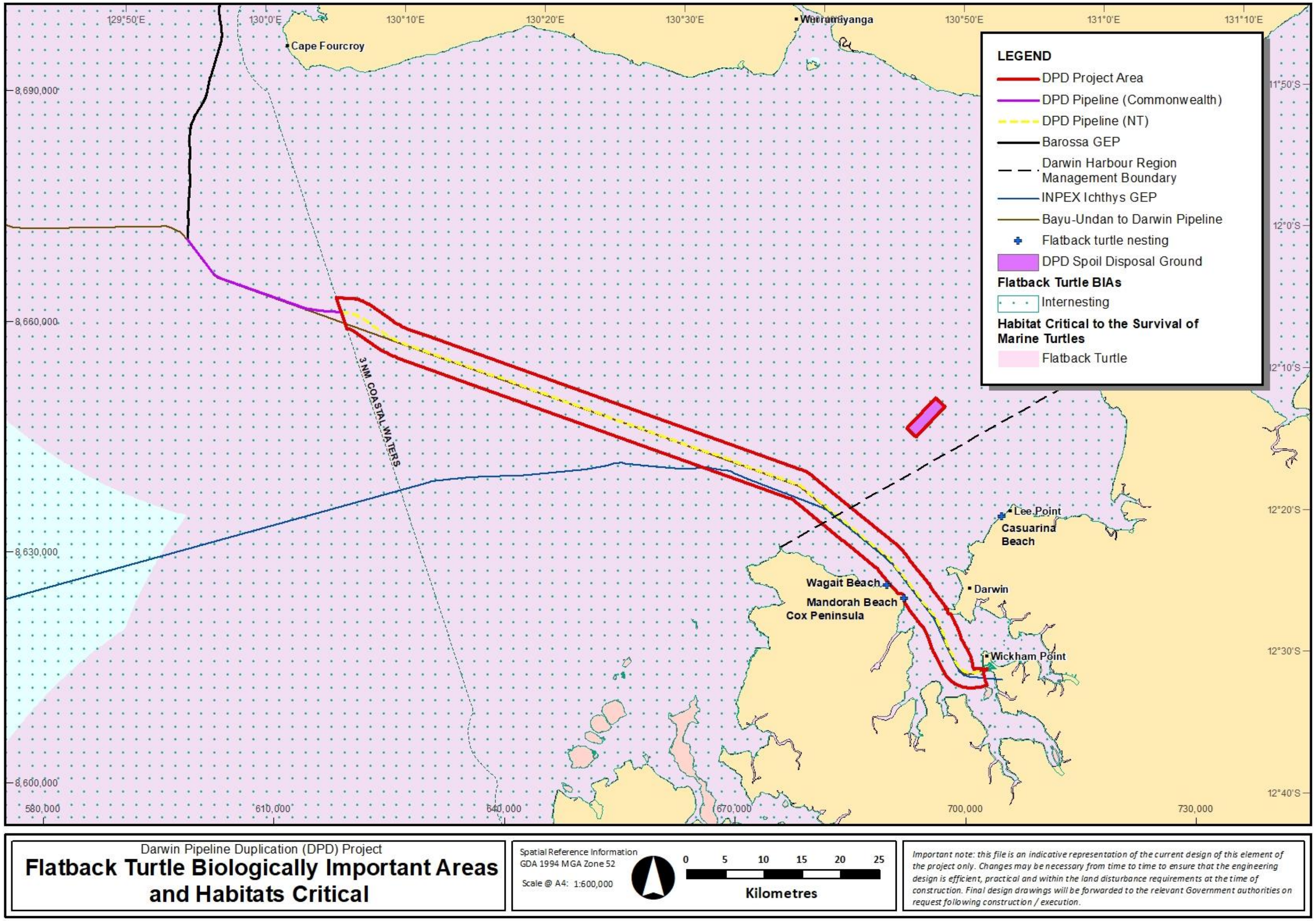


Figure 5-4: Flatback turtle biologically important areas and habitats critical to survival

5.2.2.5 Leatherback turtle

The leatherback turtle *(Dermochelys coriacea*) has the widest distribution of any marine turtle and can be found from tropical to temperate waters throughout the world. The leatherback turtle is a pelagic feeder, found in tropical, subtropical and temperate waters throughout the world. Although this species has an unusually wide latitudinal range as adults can withstand cold (10 °C) water. Leatherback turtles are presumed to migrate to Australian waters from nesting populations in Indonesia, Papua New Guinea and the Solomon Islands.

The species has been recorded feeding in the coastal waters of all Australian States (Hamann *et al.*, 2006). The species is most commonly reported from coastal waters in central eastern Australia (from the Sunshine Coast in southern Queensland to central NSW); south-east Australia (from Tasmania, Victoria and eastern South Australia) and in south-western WA. It is regularly seen in southern Australian waters. The current area of occurrence in Australia is estimated to be ~6 million km². No estimates of the numbers of leatherback turtles that forage in Australian waters are available.

There are no known major leatherback turtle nesting sites in Australia, although scattered isolated nesting (one to three nests per year) occurs in southern Queensland and the NT (Limpus & McLachlin, 1994). Nesting sites have been found at Cobourg Peninsula, Manangrida and Croker Island (200 – 250 km from the Project Area) in the NT. Only very small numbers of nests are laid per year in the NT and thus would only be a minor contributor to the global population. The species is unlikely to use beaches within the Darwin Harbour for nesting (Whiting, 2001).

The leatherback turtle is considered to be an oceanic species, which is unlikely to occur within the Darwin Harbour (Whiting, 2001).

5.2.2.6 Olive ridley turtle

The olive ridley turtle has a worldwide tropical and subtropical distribution, including northern Australia. The current area of occurrence is estimated to be in excess of 10 million km². Olive ridley turtles typically occur in shallow soft-bottomed habitats of protected waters. In Australia, they occur along the coast from southern Queensland and the Great Barrier Reef, northwards to Torres Strait, and across to the Joseph Bonaparte Gulf in WA.

A substantial part of the immature and adult population forage over shallow benthic habitats, though large juvenile and adult olive ridley turtles have been recorded in both benthic and pelagic foraging habitats. Foraging habitat can range from depths of several metres to over 100 m. A 'Habitat Critical to the survival of the olive ridley turtle species' occurs around the south-western side of Bathurst Island, extending 20 km seaward and approximately 5 – 10 km north of the Project Area (**Figure 5-5**).

An olive ridley turtle BIA inter-nesting area is located south-east of Darwin Harbour, approximately 10 km from the Project Area (**Figure 5-5**). This BIA is near the turtle nesting sites of Bare Sand Island, Quail Island and Indian Island, located near the mouth of Bynoe Harbour (~50 km from Darwin), however these sites are not considered significant on a regional scale with infrequent nesting recorded (Chatto and Baker, 2008). Within the Darwin Harbour, Casuarina Beach, Cox Peninsula Beaches and Mandorah Beach are infrequently used for nesting. In Northern Australia nesting occurs all year round, although most nesting occurs during the dry season from April to August. Hatchlings emerge from the nests about two months after laying (DoEE, 2017a).

There are no nesting beaches or defined inter-nesting area within the Project Area. However, Habitat Critical to the survival of olive ridley turtles and a BIA (inter-nesting) occur outside to the north and south of the Project Area respectively. Therefore, olive ridley turtles are likely to occur in waters outside Darwin Harbour and may transit through the Project Area.

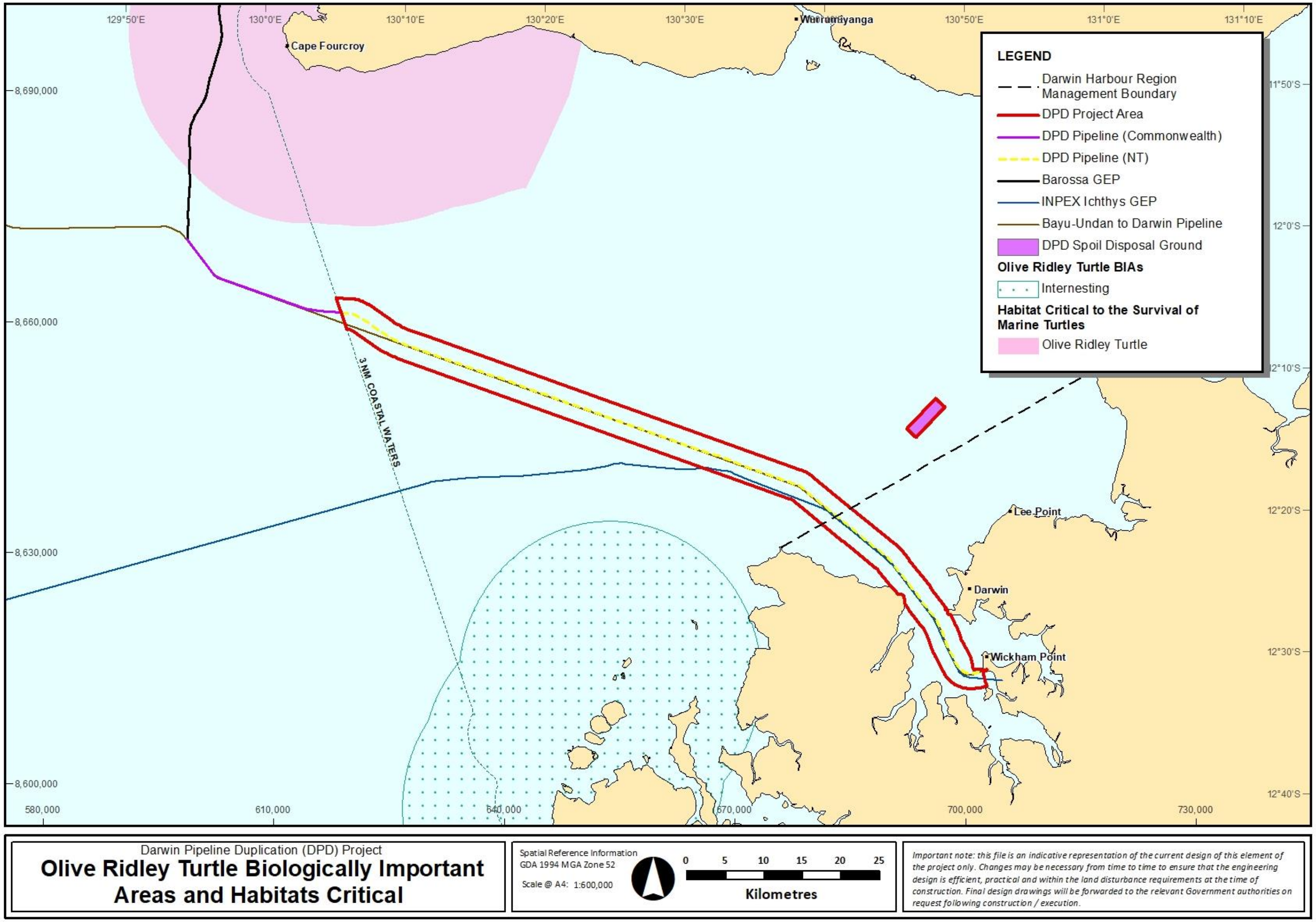


Figure 5-5: Olive ridley turtle biologically important areas and habitats critical to survival

5.2.2.7 Saltwater crocodile

The saltwater crocodile (*Crocodylus porosus*) is primarily found in inland waterways, tidal creeks, coastal floodplains and channels, billabongs and swamps across northern Australia (DoEE, 2019). The species' recognised distribution extends from Rockhampton in Queensland to King Sound in WA (DoEE, 2019). There are no identified BIAs or EPBC-listed critical habitat within the NMR for saltwater crocodiles. In the NT, saltwater crocodiles can be found in almost any type of water body, including fresh or saline, within their range (Saalfeld *et al.*, 2016). In the NT, most breeding sites are found on riverbanks or floating rafts of vegetation.

Within the NMR, the saltwater crocodile's distribution is thought to have expanded since its protection in the early 1970s, with individuals occurring up to 150 km inland, further than any historical records or knowledge (DEWHA, 2008b). Although the species is considered recovered and no longer threatened, it is recognised that strict regulation is required to avoid the population becoming depleted again (DoEE, 2019). Saltwater crocodiles breed during the wet season between October and May. Preferred nesting habitat of the saltwater crocodile includes elevated, isolated freshwater swamps that do not experience the influence of tidal movements (Saalfeld *et al.* 2016). Nesting occurs in freshwater swamps that have little tidal movement between December and March, with a peak period between January and February (DEWHA, 2008b).

The saltwater crocodile is common throughout the Darwin region and could occur in the Project Area. In 2019/2020 a total of 249 'problem crocodiles' were removed from NT waters with nearly all of these being caught within Darwin Harbour area (DEPWS, 2021).

The saltwater crocodile is commonly recorded in the Darwin Harbour, with sightings of individuals on boat ramps near the Project Area.

5.3 Sharks, rays and sawfishes

The EPBC Act PMST (BAA-201 0003; Santos, 2021a; BAA-201 0004; Santos, 2022) identified 13 species of sharks, rays and sawfishes listed as threatened and/or migratory under the EPBC Act. Through further likelihood assessment all are considered unlikely to occur within the Project Area BAA-201 0003; Santos, 2021a; BAA-201 0004; Santos, 2022).

6 Noise assessment

6.1 Underwater noise sources

There will be a period of increased noise emissions during construction activities due to the operation of vessels, survey and positioning equipment, trenching equipment and helicopters. Underwater noise emissions will be temporary and will take place for a relatively short period of time in any one location.

Research has found that the noise levels at which physiological or behavioural impacts to marine fauna occur is dependent on whether the noise being generated is classed as impulsive or non-impulsive.:

+ **Impulsive** – sounds produced are typically transient, brief (less than one second), broadband and consist of high peak pressure with rapid rise time and rapid decay (NOAA, 2019). This noise source is associated with activities such as pile driving, seismic activities and underwater blasting and results in some of the most powerful sounds produced underwater (Yelverton et al., 1973; Young, 1991).
+ **Non-impulsive** – sounds produced can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent and typically do not have the high peak sound pressure with rapid rise / decay times that impulsive sounds do (NOAA, 2019). This type of noise source is associated with activities such as dredging, vessel noise, drilling and some construction activities.

The following sections describe the potential noise generating activities and noise sources during the DPD Project. The noise sources that were modelled were determined based on the activities with the highest risk of causing underwater noise impacts and the best possible match to the activities and equipment provided at the time of assessment.

6.1.1 Vessels

Noise associated with vessel activity that could impact marine megafauna includes noise generated by vessel thrusters, engines and propellers, as well as noise emitted onboard which is converted to underwater noise through the hull (i.e., from heavy machinery) (Abrahamsen, 2012). These are considered non-impulsive noise sources. The main source of vessel noise will be from propellers or dynamic positioning (DP) thrusters. Noise will also be generated during vessel transit within the Project Area. Noise from DP systems is predominately generated from water rushing through the thruster tunnel on vessels and typically ranges between 200 Hz and 1.2 kHz in frequency. Surveys measuring underwater noise from DP vessels holding station reported maximum source levels of approximately 182 dB re 1 µPa at 1 m (McCauley, 1998). Levels emitted from vessels during activities are expected to be no higher than these reported levels.

Of the vessels used for DPD Project activities, vessels undertaking trenching activities are considered to have the highest potential noise emissions and have been modelled.

6.1.2 Trenching vessels

Depending upon the trenching area, trenching will be completed using different trenching vessels, including a BHD, a TSHD and a CSD. These are considered non-impulsive noise sources. Previous studies of underwater noise have recorded that source levels for general marine dredging operations range from 160 – 180 dB (re 1 µPa at 1 m) for 1/3 octave bands, with peak intensities between 50 and 500 Hz (Greene & Moore, 1995; Thomsen *et al.*, 2009; CEDA, 2011; WODA, 2013). Received sound levels from some large trailer suction hopper dredges operating in rocky areas have been recorded greater than 150 dB (re 1 µPa at 1 km), while large CSDs can emit strong tones from the water pumps that are audible to 20 – 30 km ranges (Richardson *et al.*, 1995; Dames & Moore, 1996; Robinson *et al.*, 2011). Operating dredges will emit sound at their maximum source levels, which are in the 180 to 190 dB (re 1 µPa at 1 m) range (Richardson *et al.*, 1995; Simmonds, Dolman & Weilgart, 2004; Thomsen *et al.*, 2009; CEDA, 2011; WODA, 2013).

In consultation with underwater noise modellers (Talis Consultants, 2023), the following source levels have been used to represent trenching vessel non-impulsive noise:

+ TSHD: 184 dB re 1µPa @1m (based on Reine et al., 2012)
+ CSD: 182 dB re 1µPa @1m (based on Thomsen et al., 2009)
+ BHD: 175 dB re 1µPa @1m (based on Reine et al., 2012)

6.1.3 Rock breaking tools (Xcentric Ripper and hydraulic hammer)

An Xcentric Ripper (preferred) or a hydraulic hammer are BHD tools that may be required to break up rocky material during the trenching activities. For the purposes of modelling, the Xcentric Ripper is considered a non-impulsive noise source and the hydraulic hammer an impulsive noise source Connell et al. (2003).

Underwater measurements of an Xcentric Ripper XR-60 have been used to inform an appropriate source level for the purposes of underwater noise modelling. Connell et al. (2003) used underwater noise measurements taken by Lawrence (2016) to calculate a source level of 184.8 dB re 1 μPa^2 s m^2.

In order to determine an appropriate source level for modelling the effects of a hydraulic hammer (Epiroc HB 10000), Connell et al. (2003) used a source-level spectra corresponding to Down-The-Hole (DTH) hydro-hammering as a proxy. DTH hydro-hammering is a percussive rotating drilling technique appropriate for hard rock formations. The proxy DTH levels used correspond to a Numa Patriot 180 hammer as detailed in Denes et al. (2016). The source level used to represent hydraulic hammering was determined to be 192 dB 1 μPa^2s m^2.

6.1.4 Survey equipment

Commercial survey vessels (multibeam echosounder (MBES), side scan sonar (SSS), long baseline acoustic positioning system (LBL) / ultra-short baseline system (USBL)) use a variety of sonar (e.g., depth sounders) that emit underwater noise (150 – 235 dB) but tend to use a higher frequency (>70 kHz). They are generally pointed directly towards the bottom in a narrow beam limiting horizontal noise propagation and are considered impulsive noise sources. Side scanning sonars (e.g., seafloor mapping) are the exception as noise is propagated horizontally (Weilgart, 2007). Most SSS and MBES operate in the frequency range of 100 kHz to 500 kHz (MacGillivary et al, 2014; Ruppel et al, 2022).

6.1.5 Noise generated by helicopters

Helicopters will also generate noise, with the main source of noise being the engines and the rotor blades. Sound traveling from a helicopter to a receiver underwater is affected by both in-air and underwater propagation processes, and processes occurring at the air seawater surface interface (e.g., wind and waves). The level of noise received underwater depends on source altitude and lateral distance, receiver depth, water depth, and other variables.

Helicopter engine noise is emitted at various frequencies however, the dominant tones are generally of a low frequency (LQ) below 500 Hz (Richardson *et al.*, 1995) and is considered an impulsive noise source. Sound pressure in the water directly below a helicopter is greatest at the surface and diminishes with increasing receiver depth. Noise also reduces with increasing helicopter altitude, but the duration of audibility often increases with increasing altitude, with sound penetrating water at angles <13°.

It is expected the duration of helicopter operations within close proximity to the marine environment is limited and intermittent. Further, helicopter operations are expected to result in received underwater noise levels lower than those associated with vessel operations.

6.2 Underwater noise thresholds

Available threshold criteria associated with behavioural and physiological impacts for sensitive marine fauna have been derived from a number of sources (NMFS, 2018; NMFS, 2014; Popper *et al.*, 2014; Southall et al., 2019). These thresholds have been used to assess modelling results and determine potential impacts to marine fauna from permanent threshold shift (PTS) and temporary threshold shift (TTS) as well as to determine potential behavioural effects.

6.2.1 Noise thresholds for marine mammals

The potential impacts of anthropogenic noise on marine mammals, specifically cetaceans, have been the subject of considerable research. Current data and predictions show that marine mammal species differ in their hearing capabilities, in absolute hearing sensitivity, as well as frequency band of hearing (Richardson *et al.*, 1995; Wartzok and Ketten, 1999; Southall *et al.*, 2007). To better reflect the auditory similarities between phylogenetically closely related species, but also significant differences between species groups among the marine mammals, Southall *et al.* (2007) assigned the extant marine mammal species to functional hearing groups based on their hearing capabilities and sound production. More recently, U.S. Navy technical reports by Finneran (2015, 2016) proposed new auditory weighting functions and the U.S. NMFS (2014, 2018) undertook a comprehensive review of PTS and TTS dual metric criteria for marine mammals and revised the threshold criteria for each frequency-weighted functional hearing category of cetacean. The only marine mammals likely to occur in the waters of Darwin harbour are dolphins (high frequency functional hearing category) and dugong and the noise effect threshold for these receptors are in **Table 6-1**.

6.2.2 Noise thresholds for marine reptiles

Marine turtles are considered to be less sensitive to noise than marine mammals as they do not have an external hearing organ but can detect sound through bone-conducted vibration in the skull with their shell providing a receiving surface (Lenhardt *et al.*, 1985). Morphological studies of green and loggerhead turtles (Ridgway *et al.*, 1969; Wever, 1978; Lenhardt *et al.*, 1985) found that the turtle ear is similar to other reptile ears but has adaptations for underwater listening.

Most studies researching the effect of seismic noise on sea turtles focused on behavioural responses, as physiological impacts are more difficult to observe in living animals. Turtles avoid low-frequency sounds (Lenhardt, 1994) and sounds from seismic surveys (O'Hara and Wilcox, 1990), but these reports did not note received sound levels. In another study, caged green and loggerhead turtles increased their swimming activity in response to an approaching airgun when the received SPL was above 166 dB (re 1 µPa) (McCauley *et al.*, 2000).

There are no known studies that have investigated the effects of noise on crocodiles so the thresholds for turtles have been applied to crocodiles and these are presented in **Table *6-1***.

Table 6-1: Noise impact thresholds for the marine fauna groups in Darwin Harbour

Marine fauna type	Marine hearing group	Hearing bandwidth	Noise type	SEL24hour (Weighted) dB (re 1µ Pa2.s)		SPL Possible Behavioural Disturbance dB (re 1µ Pa)
				TTS	**PTS**	
Dolphins	High Frequency (HF)	150 Hz to 160 kHz	Non-Impulsive[1]	178	198	120
			Impulsive[1]	170	185	160
Sirenians (Dugong)	SI	100 Hz to 50 kHz	Non-Impulsive[1]	186	206	120
			Impulsive[1]	175	190	160
Turtles and crocodiles	N/A	100 Hz to 2 kHz	Non-Impulsive[1]	200	220	Relative risk[2]
			Impulsive[1]	189	204	166

Note:

1. Thresholds are derived from Southall et al. (2019); NMFS (2018); NOAA (2019); Finneran et al. (2017); McCauley et al. 2000 and Popper et al. (2014).
2. Relative risk levels of Low, Moderate and High have been developed by Popper *et al*. (2014) for behavioural effect on turtles exposed to non-impulsive noise. Risk rankings from Popper *et al*. (2014) for 'Shipping and Other Continuous Noise' have been applied to non-impulsive noise for behavioural response. Risk rankings are provided in context of distance of Near (N) (10s of metres), Intermediate (I) (100s of metres) and Far (F) (1,000s of metres)

6.3 Underwater noise modelling

6.3.1 Overview

Of the activities and noise sources detailed in **Section 6.1**, and in discussion with underwater noise modeller, trenching activities using a combination of TSHD, CSD and BHD (including rock breaking using hydraulic tools) were considered the most significant sources of Project underwater noise. These activities have been modelled to quantify noise emissions and marine fauna exposures to inform impact assessment and marine fauna noise management measures included herein. An overview of the modelling approach is presented below with the full technical reports presented as attachments to the SER.

Underwater noise modelling initially conducted for the Project (Talis Consultants, 2023) included for dredging vessel noise emissions (TSHD, CSD and BHD), vibratory hammer (sheet piling) noise emissions and hydraulic hammer (BHD rock breaking) noise emissions. Since completion of that modelling, further definition of the Project scope was developed by Project contractors, including removal of the need to construct a cofferdam (and associated sheet piling) and further detail made available on the type and specification of rock breaking tools. For rock breaking from the BHD, the quieter Xcentric Ripper tool is considered the base case, and likely the most effective, option with a hydraulic hammer proposed as a contingency only.

To better represent underwater noise emissions and fauna exposure from the use of BHD rock breaking tools, additional underwater modelling was undertaken for an Xcentric Ripper (Xcentric Ripper XR-60) and a hydraulic hammer (Epiroc HB 10000) (Connell et al., 2023). The results presented below for an Xcentric Ripper and a hydraulic hammer have been taken from that modelling. Since sheet piling is no longer required for the Project, the vibratory hammer modelling results included in Talis Consultants (2023) have not been presented below.

6.3.2 Modelling scenarios

DPD Project underwater noise modelling scenarios were discussed initially at a workshop with the Project team, environmental advisers and a noise modelling consultant. Noise activity scenarios were identified for modelling on the basis of those with the greatest potential for environmental impact (i.e., greatest noise generating activities in proximity to species of concern).

The following Project underwater noise sources/scenarios have been modelled:

+ Trenching: trenching will be undertaken using a combination of a TSHD, a CSD and a BHD. The following indicative 24-hour cycle times for each type of trenching vessel were modelled:
  - **TSHD** – The TSHD will alternate between trenching activities and spoil disposal at the offshore spoil ground. Cycle times are dependent on distance from spoil ground (refer **Table *6-2***) but nominally have been modelled as 3 hours trenching noise (non-impulsive noise, continuous noise), 2 hours transit to spoil ground and back (i.e. 'no noise' period) repeated over period of 24 hours.
  - **CSD** – 10 hours cutting (non-impulsive, continuous noise), 2 hours downtime over 12 hours (2x 12-hour cycles per 24h).
  - **CSD + TSHD** – The cycles for TSHD and CSD were applied at the same trenching location to conservatively assess cumulative effects of these vessels if they were operating in the same location.
  - **BHD** (in an area requiring rock breaking) - 4 hours of rock breaking modelled using an Xcentric Ripper (non-impulsive, continuous noise) and a hydraulic hammer (impulsive noise), 4 hours no noise (switching between rock breaking tool and excavating tool) and 4 hours digging (non-impulsive, continuous noise) over a 12-hour period and repeated (2x 12-hour cycles per 24h) i.e., cumulative total of 8 hours each of rock breaking, digging and no noise.
  - **BHD** (hydraulic hammer sensitivity analysis) **-** In addition to modelling a Xcentric Ripper and a hydraulic hammer noise for 8 hours per 24 hours, a sensitivity analysis on the effect of reducing operation time for the hydraulic hammer was undertaken, since the modelled PTS/TTS ranges for this tool were relatively large. The sensitivity analysis modelled reduced operation times of 6, 4 and 2 hours per 24 hours for the hydraulic hammer.

Trenching scenarios have been modelled at three representative locations (**Figure 6-1**):

- Location 1 - BHD excavating and rock breaking (Xcentric Ripper or hydraulic hammer) in an area of hard rock;
- Location 2 - TSHD operating at a middle harbour trenching zone. This area was also relatively close to Weed Reef compared to other trenching zones. Weed Reef is a known hard reef area supporting greater diversity of biota (including hard corals) and may support higher marine fauna abundance.
- Location 3 - TSHD (alone) and TSHD/ CSD (operating together) operating in an outer harbour trenching zone. This zone was relatively close to Cox Peninsula shallow water and shorelines which support a higher diversity of biota and may support higher marine fauna abundance.

The sound source locations and levels used for each modelling scenario are shown in **Figure 6-1** / **Table 6-3** and **Table 6-4** respectively.

Table 6-2: Estimated cycle times for each section where the TSHD will be operating

Trenching Zone	Non-Overflow Time (min)	Overflow Time (min)	Disposal Time (min)	Sailing Time (min)	Total Cycle Time (min)
Potential Pre-Sweep Area 1	20	160	15	140	335
Trench Zone E and A2	20	160	15	132	327
Potential Pre-Sweep Area 2	20	160	15	132	327
Potential Pre-Sweep Area 4	20	160	15	96	291
Potential Pre-Sweep Area 3	20	160	15	80	275
Trench Zone C1A and Potential Pre-Sweep Area 5	20	160	15	72	267
Sand Waves Area	20	160	15	64	259

Table 6-3: Noise Modelling Locations and Scenarios

Location	Scenario	Easting (GDA94, MGA Zone 52) (m)	Northing (GDA94, MGA Zone 52) (m)	Recurring Cycle Time over 24 Hours
1	BHD (Excavating)	701 366	8 614 382	Two x 4 hours of digging over 24 hours.
	BHD (Rock breaking)			Two x 4 hours rock breaking over 24 hours.
2	TSHD	696 636	8 620 225	3 hours trenching and 2 hours transit/ spoil dump.
3	TSHD	692 710	8 625 712	3 hours Trenching and 2 hours transit/ spoil dump
	Concurrent operations – TSHD and CSD			TSHD (3 hours trenching and 2 hours transit/ spoil dump). CSD (10 hours of cutting and 2 hours downtime).

Table 6-4: Modelled noise source levels

Source type	Source Level
TSHD	184 dB re 1µPa @1m (based on Reine et al., 2012)
CSD	182 dB re 1µPa @1m (based on Thomsen et al., 2009)
BHD (excavating)	175 dB re 1µPa @1m (based on Reine et al., 2012)
BHD (Xcentric ripper)	184.8 dB re 1 $\mu Pa^2 \cdot s\ m^2$ (based on Lawrence, 2016)
BHD (hydraulic hammer)	192.4 dB re 1 $\mu Pa^2 \cdot s\ m^2$ (based on Denes et al., 2016)

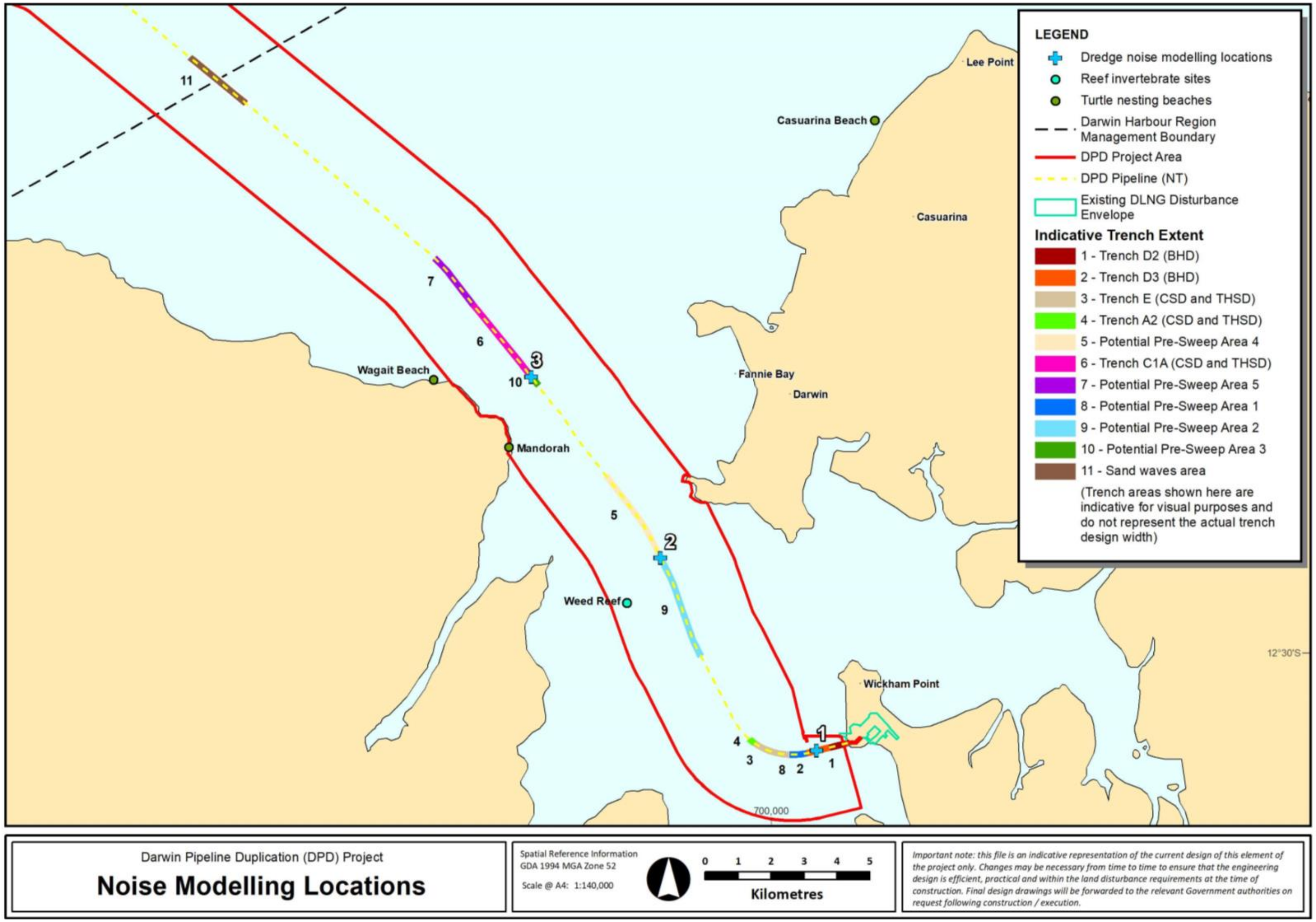


Figure 6-**1**: Noise modelling locations

Modelling of 24-hour sound exposure level ($SEL_{24\ hour}$) was conducted for each scenario to provide a conservative determination of PTS and TTS ranges from the cumulative effect of noise to marine fauna of interest over a 24-hour period. This modelling method is considered industry leading practice and is a conservative way of estimating potential effect ranges, as $SEL_{24\ hour}$ assumes the receptor (i.e., fauna) is stationary within the noise field of the noise source. In reality, the marine fauna of interest are highly mobile species which move naturally throughout the harbour and are capable of moving away from a noise source.

$SEL_{24\ hour}$ modelling presented here is based on a mean sea level (MSL) over a 24-hour period to represent average water level throughout the daily tidal cycle. This was considered the most appropriate approach for $SEL_{24\ hour}$ modelling (in comparison to presenting LAT or HAT results) since tide state varies significantly between low and high tide over a 24-hour period in Darwin Harbour (up to an 8 m range) and low and high tides are not representative of water level over a duration of 24 hours (rather they represent extreme water levels present for short periods of time).

Modelling of sound pressure level (SPL) which represents an instantaneous level of noise (in contrast to SEL) has been used for determining behavioural impact ranges to fauna. For SPL modelling, modelled results at high and low tide (as well as MSL) are considered appropriate given SPL is an instantaneous level. Highest astronomical tide (HAT) and Lowest astronomical tide (LAT) were conservatively used as water levels to represent high and low tide states, respectively, although these extremes are rarely reached. Between LAT of 0.0 m and a HAT of 8.0 m, low and high tides are on average (mean level) 2.2 m and 5.9 m, respectively as shown in **Table 6-5** (Williams et al. 2006).

Table 6-5: Tide heights within Darwin Harbour (Williams et al., 2006)

Tide type	Height
Highest Astronomical Tide (HAT)	8.0 m
Mean High Water Springs	6.9 m
Mean High Water	5.9 m
Mean High Water Neaps	4.9 m
Mean Sea Level (MSL)	4.0 m
Mean Low Water Neaps	3.1 m
Mean Low Water	2.2 m
Mean Low water Springs	1.2 m
Lowest Astronomical Tide (LAT)	0.0 m

Further description of the modelling inputs, including bathymetry, seabed types and sound profiles and further description of the noise sources used is presented in Talis Consultants (2023) and Connell et al. (2023) (attached to the DPD Project SER).

6.3.3 Results

To evaluate the potential for impact to different marine fauna, the estimated distances from the sound source at which the behavioural and physiological thresholds (as listed in **Table 6-1**) were predicted to be exceeded are presented below for each location and activity.

Table 6-6 presents the threshold ranges at mean sea level (MSL) between the noise source and the modelled PTS, TTS and behavioural response thresholds for each fauna group for each of the modelled scenarios. Equivalent figures plotting the threshold contours for TSHD, CSD and BHD trenching (non-impulsive noise) are provided in Talis Consultants (2023) with worst-case ranges illustrated in Figure 6-2 to Figure 6-4. Equivalent threshold contour figures for Xcentric Ripper and hydraulic hammer are provided in Connell et al. (2023).

For all scenarios and fauna groups, PTS $SEL_{24\ hour}$ threshold ranges were below 50 m with the exception of the BHD impulsive noise (hydraulic hammering) scenario where PTS threshold ranges were 130, 160 and 100 m for dolphins, dugongs and turtles, respectively (**Table 6-6**). Given the mobility of these species, and the threshold ranges for behavioural response being greater than the PTS range for all species, it is unlikely that these species would remain within the predicted PTS ranges for a period of 24 hours. Permanent threshold shift (PTS) injury is therefore considered unlikely for dolphins, dugongs and turtles from Project trenching activities.

TTS $SEL_{24\ hour}$ threshold ranges at mean sea level varied across scenarios and fauna groups (**Table 6-6**). For continuous noise source scenarios of TSHD, CSD and BHD trenching and BHD rock breaking using an Xcentric Ripper, TTS threshold ranges varied between 40 m and 350 m and were highest for dolphins (100-350 m), followed by dugongs (70-210 m) and then marine turtles (40-160m) (**Table 6-6**).

For the BHD hydraulic hammering scenario, TTS threshold ranges were significantly larger than those predicted for the other modelled scenarios; threshold ranges for dolphins, dugongs and turtles were predicted to be 1,830 m, 2,500 m and 950 m, respectively (**Table 6-6**). Given the relatively large size of these ranges and the fact that behavioural response thresholds were predicted to be within these ranges, it is possible that dolphins, dugongs and turtles could remain within the threshold TTS ranges for a period of 24 hours and receive TTS impact, if management measures were not in place to prevent this from occurring.

Given the above, further investigation was undertaken by Connell et al. (2023) to determine the effect of reducing BHD hydraulic hammering time on the size of PTS and TTS threshold ranges. A summary of this analysis at MSL is presented in **Table 6-7**. PTS and TTS threshold ranges decreased as hammering time decreased. For dolphins, PTS/TTS ranges dropped from 130 m/1,830 m for 8 hours hammering time (per 24 hours) to 30 m/670 m for 2 hours hammering time. For dugongs PTS/TTS ranges dropped from 160 m/2,500 m for 8 hours hammering time to 50 m/840 m for 2 hours hammering time while for turtles, PTS/TTS ranges dropped from 100 m/950 m for 8 hours hammering time (per 24 hours) to 30 m/380 m for 2 hours hammering time. While reducing operation time had a significant effect on reducing PTS/TTS ranges for the hydraulic hammer, the ranges modelled for 2 hours of operation time per 24 hours were still significantly larger that for the Xcentric Ripper tool operated for 8 hours per 24 hours (**Table 6-6, Table 6-7**).

For behavioural response thresholds, ranges for marine mammals (dolphins and dugongs) varied from 100s of metres to 10s of kilometres for scenarios modelled at MSL with the highest range being for the Xcentric Ripper tool (14 km for both dolphins and dugongs) (**Table 6-6**). A quantitative threshold for marine turtles was only considered applicable for impulsive noise (i.e. BHD hydraulic hammer scenario). The range for this threshold at MSL was predicted to be 270 m (**Table 6-6**). For non-impulsive noise from TSHD, CSD and BHD trenching and use of Xcentric Ripper, the relative risk levels for marine turtle behavioural effect are taken from Popper et al. (2014) which are high risk in the near field (scale of 10s of metres), moderate risk at intermediate ranges (scale of 100s of metres) and low risk in the far field (scale of 1000s of metres). Behavioural effect in Popper et al. (2014) is defined as a substantial change in behaviour for the animals exposed to the sound.

In addition to ranges at MSL, quantitative behavioural threshold ranges were also modelled across LAT and HAT (**Table 6-8**). The effect of water level on range size was not consistent between modelling studies (Talis Consultants, 2023; Connell et al., 2023). The greatest marine mammal (dolphin and dugong) behavioural response ranges for each scenario were: 909 m @ HAT for BHD digging; 14,700 m @ LAT for BHD Xcentric ripper use; 270 m @ LAT for BHD hydraulic hammering; 20,000 m @ HAT for the TSHD at Location 2; 17,878 m @ HAT for the TSHD at Location 3 and 20,000 m @ HAT for the TSHD and CSD operating at the same location (Location 3) (**Table 6-8**). A quantitative behavioural threshold for marine turtles was only considered applicable for impulsive noise. The largest behavioural response threshold range for marine turtles for BHD hydraulic hammering was 90 m at LAT (**Table 6-8**).

6.3.4 Marine megafauna impact discussion

The potential for physiological impacts to EPBC Act listed marine megafauna (dolphins, dugong and turtles), in the form of PTS and TTS was determined through modelling for the highest underwater noise generating activities associated with the DPD Project, i.e. the operation of trenching vessels, including the use of rock breaking tools. PTS $\text{SEL}_{24\ \text{hour}}$ threshold ranges of <50 m to 160 m were determined, with range sizes varying across species and modelled scenarios. PTS impact within these ranges requires marine fauna to be within the range for 24 hours. Given the likely behavioural response to avoid the area prior to entering into a PTS zone, and the known mobility of these species, it is unlikely that these species would remain within these ranges for long enough for PTS injury to occur. Nevertheless, the monitoring of observation and exclusion zones around trenching vessels, and appropriate adaptive management measures to cease trenching if fauna enter exclusion zones will be adopted for the Project to prevent this occurrence (**Section 8.4**).

For the continuous (non-impulsive) noise sources of TSHD, CSD and BHD trenching, and the use of an Xcentric Ripper tool for rock breaking, modelled TTS $\text{SEL}_{24\ \text{hour}}$ threshold ranges varied between 40 m and 350 m, and were highest for dolphins (100-350 m), followed by dugongs (70-210 m) and marine turtles (40-160m). As with the PTS thresholds ranges, it is unlikely that these EPBC Act listed marine fauna would remain within these ranges long enough (i.e. for 24 hours or greater) for TTS impacts to occur, and there are no known aggregation areas for these fauna within this range of trenching areas. However, the application of observation and exclusion zones, monitored from trenching vessels, together with the use of soft start operations, where practical, will be adopted to avoid TTS impacts (**Section 8.4**).

Modelling undertaken for hydraulic hammer use predicted that PTS and TTS threshold ranges would be significantly larger than for other trenching sound sources, that is, trenching using a TSHD, CSD or BHD and the use of an Xcentric Ripper rock breaking tool. In particular, the scale of hydraulic hammering TTS ranges (in the order of kms) suggests that TTS impacts would be possible to marine fauna remaining within these ranges for 24 hours or more, particularly given a behavioural response to this impulsive noise source noise may not occur until marine fauna are well within the TTS range. While an Xcentric Ripper tool is considered the base case for rock breaking from the BHD, a hydraulic hammer may be used as a contingency, therefore additional management controls were considered necessary (over and above those proposed for other trenching activities) and have been included in **Section 8.4**. This includes monitoring of significantly larger observation and exclusion zones and restricting hydraulic hammering to daylight hours only.

Based on the modelled behavioural effect ranges, in particular the continuous noise behavioural effect ranges, there is the potential for species of interest (dolphins, dugongs and turtles) to be affected by noise from dredging vessels on a scale of 100s to 1000s of metres. These ranges are expected to be similar to those associated with noise emissions from large non-Project commercial vessels that use Darwin Harbour on a daily basis, as they have similar noise source levels and frequency bands and operate in the same areas (refer **Section 5.1.3**). Given the existing noise environment, it is expected that marine fauna will have developed some level of acclimatisation to vessel noise over a range similar to that modelled for the Project trenching vessels. It is also likely that some masking of Project vessel noise above the marine mammal behavioural threshold of 120 dB re 1µ Pa would occur from other commercial vessels that transit Darwin Harbour. In support of this, ambient noise measurements taken by noise loggers in East Arm by Salgado-Kent et al. (2015) recorded that noise from transiting commercial vessels was frequently in the range of 130-140 dB re 1 µPa. Masking of Project vessel noise by other anthropogenic noise sources would be expected to diminish the range of behavioural effect ranges around Project vessels in areas and times where other vessels are active. While there may be a more prolonged exposure of marine fauna to noise above behavioural threshold levels from slow moving trenching vessels working in an activity area (i.e. a trenching zone) when compared to transiting commercial vessels, trenching activity is expected to be completed relatively quickly, within a period of 2 to 3 months and therefore any behavioural effects are considered temporary.

Within and around Darwin Harbour there are known periods for biologically important behaviours for turtles and dolphins. There are known flatback turtle nesting sites on Cox Peninsula and Casuarina Beach and a known period of increased nesting activity from May to October. However, the densities of nesting turtles in these areas are very low and not significant on a regional scale (Chatto and Baker, 2008) and furthermore, these sites are on a scale of 1000s of meters away from the pipeline route and trenching areas (as they are from existing vessel traffic using navigation channels) therefore the relative risk of behavioural effects to turtles at this scale from vessel noise is considered low (Popper et al., 2014).

For dolphins, there is evidence that there is a peak in calving within Darwin Harbour between October and April (Palmer, 2010). Important areas have not been defined however, and given the high mobility of dolphin species within Darwin Harbour and the use of adjoining coastal areas (Griffiths et al., 2019), it is unlikely that behavioural disturbance around DPD Project activities, relative to the total area of Darwin Harbour and surrounding coastal waters, would have a significant impact on dolphin calving behaviour.

Foraging activities by marine megafauna within and around Darwin Harbour are considered to occur year-round. While there is the potential for Project underwater noise to reach areas that can be used as foraging habitat (e.g. shallow areas that could support algae and seagrass), at a level above a behavioural response threshold, the Project activities will not restrict access to foraging habitats that wouldn't be available elsewhere within and around the harbour given the size of behavioural effect ranges relative to the size of Darwin Harbour and distribution of habitat.

On the basis that physiological impacts (PTS and TTS) to EPBC Act listed marine fauna from Project underwater noise emissions (in particular vessels undertaking trenching activities) will be avoided through the application of industry standard management controls and behavioural response to underwater trenching noise will be temporary and on the same scale as from existing commercial vessel using Darwin Harbour, impacts to marine fauna from underwater noise emissions are considered to be Minor.

Table 6-6: PTS, TTS and Behavioural response threshold ranges for each fauna group for each modelled scenario/location at mean sea level

Hearing Group	SEL $_{24\ hour}$ (Weighted) Threshold [dB re 1µ Pa^2.s]		Distance [m]		SPL Behavioural Response [dB re 1µ Pa]	Distance [m]
	TTS	PTS	TTS	PTS		
Location 1 – Backhoe Dredge digging (non-impulsive noise) (Talis Consultants, 2023)						
Dolphins	178	198	151	<50	120	454
Dugongs	186	206	100	<50	120	454
Turtle	200	220	80	<50	RISK[1]	High (N) Moderate (I) Low (F)
Location 1 – Backhoe Dredge rock breaking with Xcentric Ripper (non-impulsive noise) (Connell et al., 2023)						
Dolphins	178	198	100	NR	120	14,000
Dugongs	186	206	70	NR	120	14,000
Turtle	200	220	40	NR	RISK[1]	High (N) Moderate (I) Low (F)
Location 1 – Backhoe Dredge rock breaking with hydraulic hammer (impulsive noise) (Connell et al., 2023)						
Dolphins	170	185	1,830	130	160	220
Dugongs	175	190	2,500	160	160	220
Turtle	189	204	950	100	166	270
Location 2 – Trailing Suction Hopper Dredge (non-impulsive noise) (Talis Consultants, 2023)						
Dolphins	178	198	303	<50	120	1,667
Dugongs	186	206	170	<50	120	1,667
Turtle	200	220	131	<50	RISK[1]	High (N) Moderate (I) Low (F)
Location 3 – Trailing Suction Hopper Dredge (non-impulsive noise) (Talis Consultants, 2023)						
Dolphins	178	198	303	<50	120	2,273
Dugongs	186	206	200	<50	120	2,273
Turtle	200	220	120	<50	RISK[1]	High (N) Moderate (I) Low (F)
Location 3 – Trailing Suction Hopper Dredge and Cutter Suction Dredge (non-impulsive noise) (Talis Consultants, 2023)						
Dolphins	178	198	350	<50	120	3,181
Dugongs	186	206	210	<50	120	3,181
Turtle	200	220	160	<50	RISK[1]	High (N)

Hearing Group	SEL $_{24\ hour}$ (Weighted) Threshold [dB re 1µ Pa².s]		Distance [m]		SPL Behavioural Response [dB re 1µ Pa]	Distance [m]
	TTS	PTS	TTS	PTS		
						Moderate (I) Low (F)

NR = threshold was not reached.

[1] Risk rankings from Popper *et al*. (2014) for 'Shipping and Other Continuous Noise' have been applied to non-impulsive noise, for marine turtle behavioural response. Risk rankings are provided in context of distance from sound source; Near (N) (10s of metres), Intermediate (I) (100s of metres) and Far (F) (1000s of metres)

Table 6-7: Influence of BHD hydraulic hammering time on PTS and TTS ranges for each fauna group at mean sea level

Hearing Group	SEL $_{24\ hour}$ (Weighted) Threshold [dB re 1µ Pa².s]		Distance [m]	
	TTS	PTS	TTS	PTS
8 hours hammering/ per 24 hours				
Dolphins	170	198	1,830	130
Dugongs	175	206	2,500	160
Turtle	189	220	950	100
6 hours hammering/ per 24 hours				
Dolphins	170	198	1,510	90
Dugongs	175	206	1,790	110
Turtle	189	220	740	60
4 hours hammering/ per 24 hours				
Dolphins	170	185	1,200	60
Dugongs	175	190	1,410	80
Turtle	189	204	580	50
2 hours hammering/ per 24 hours				
Dolphins	170	198	670	30
Dugongs	175	206	840	50
Turtle	189	220	380	30

Table 6-8: Quantitative behavioural disturbance threshold ranges for marine fauna across varying tidal states

Receptor Type	Sound Pressure Level (SPL) Behavioural Threshold (dB re 1µ Pa)	Threshold Range (metres) for tidal state		
		LAT	MSL	HAT
Location 1 – Backhoe Dredge digging (non-impulsive noise) (Talis Consultants, 2023)				
Dolphin	120	303	454	909
Dugong	120	303	454	909
Location 1 – Backhoe Dredge rock breaking with Xcentric Ripper (non-impulsive noise) (Connell et al., 2023)				
Dolphin	120	14,700	14,000	13,100
Dugong	120	14,700	14,000	13,100
Location 1 – Backhoe Dredge rock breaking with hydraulic hammer (impulsive noise) (Connell et al., 2023)				
Dolphin	160	270	220	170
Dugong	160	270	220	170
Turtle	166	90	60	60
Location 2 – Trailing Suction Hopper Dredge (non-impulsive noise) (Talis Consultants, 2023)				
Dolphin	120	1,450	1,667	20,000
Dugong	120	1,450	1,667	20,000
Location 3 – Trailing Suction Hopper Dredge (non-impulsive noise) (Talis Consultants, 2023)				
Dolphin	120	1,515	2,273	17,878
Dugong	120	1,515	2,273	17,878
Location 3 – Trailing Suction Hopper Dredge and Cutter Suction Dredge (non-impulsive noise) (Talis Consultants, 2023)				
Dolphin	120	3,000	3,181	20,000
Dugong	120	3,000	3,181	20,000

Santos

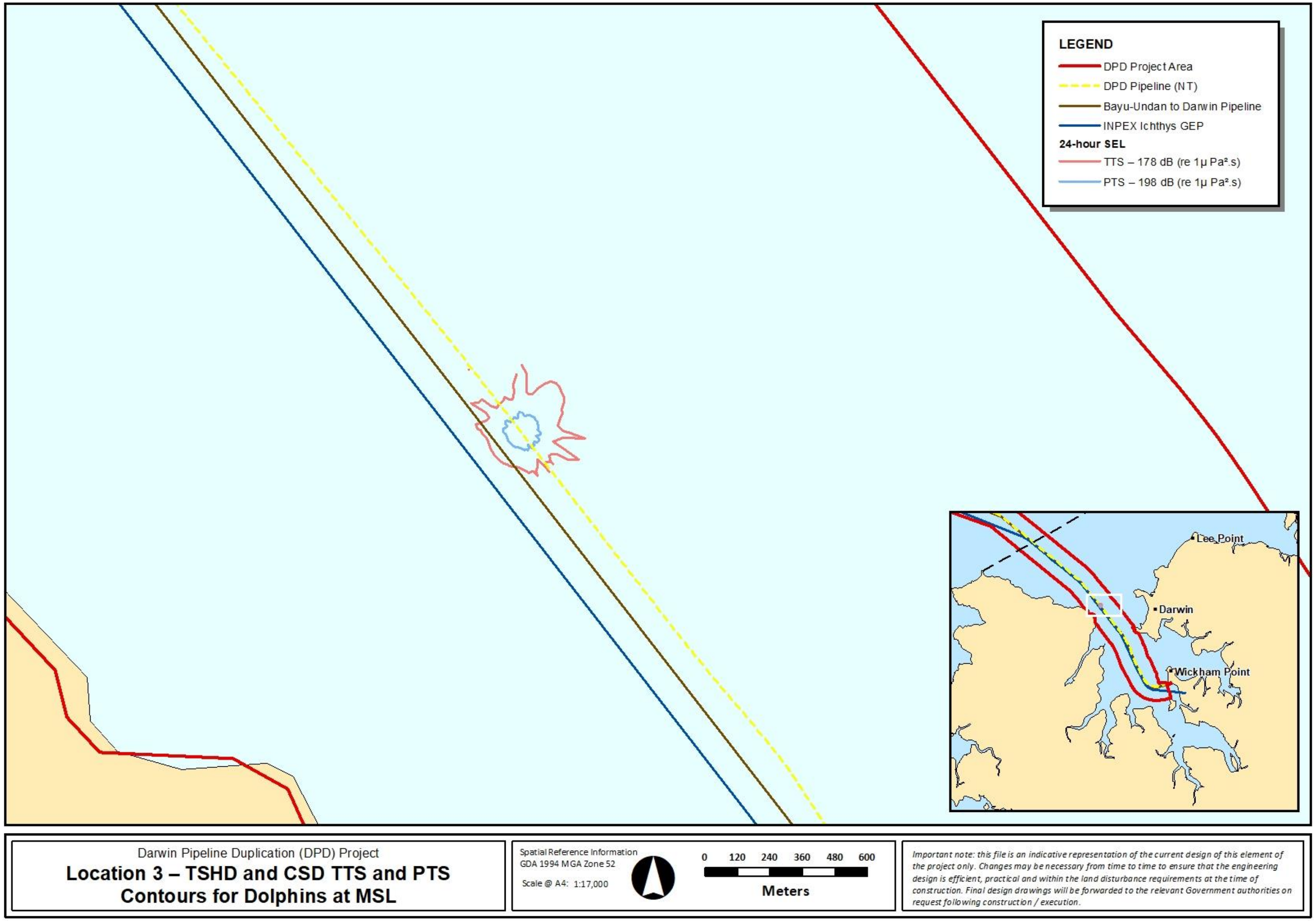


Figure 6-2: Modelling location 3 – TSHD and CSD TTS and PTS contours for dolphins (MSL)

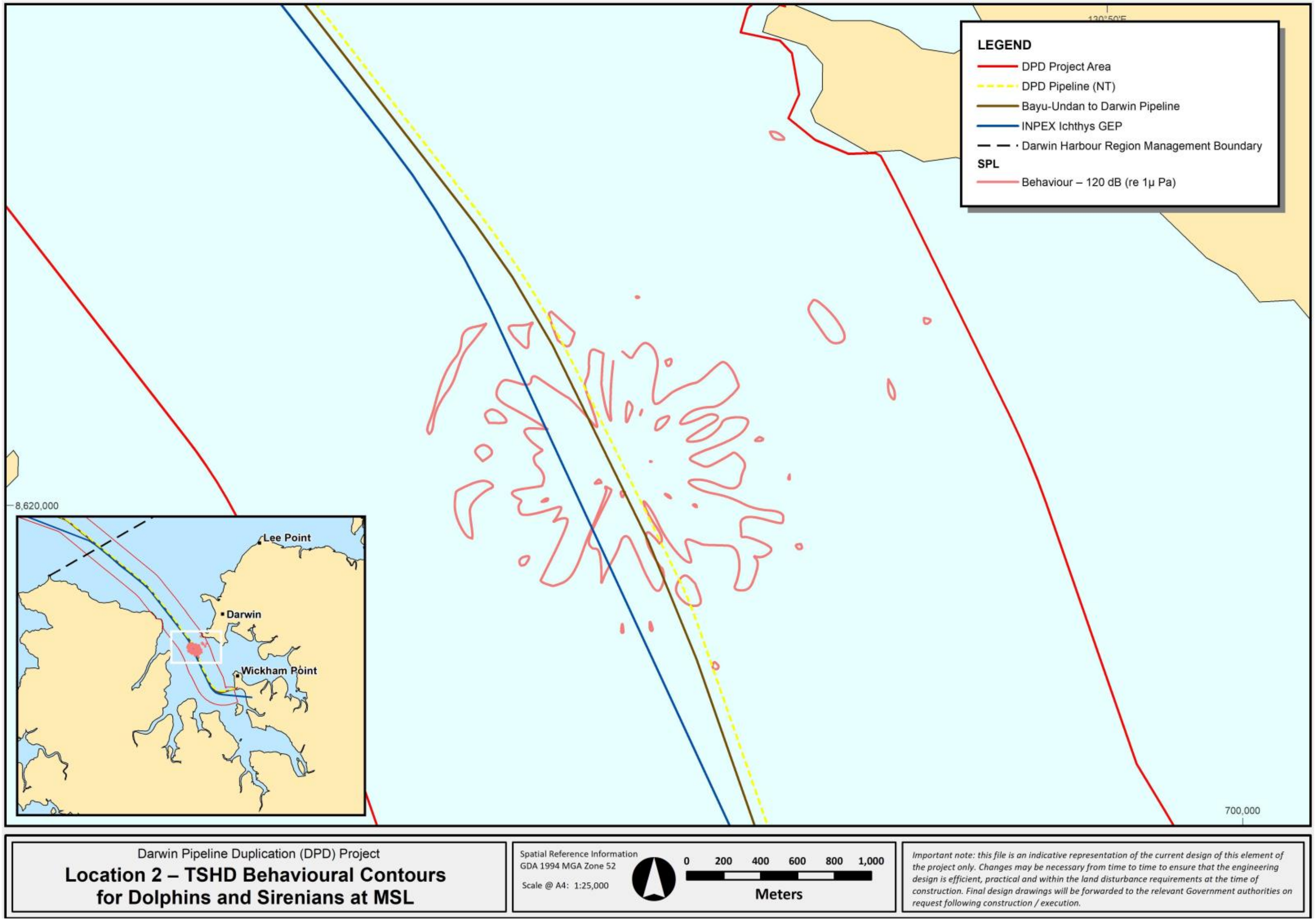


Figure 6-3: Modelling location 2 – TSHD behavioural contours for dolphins and sirenians (MSL)

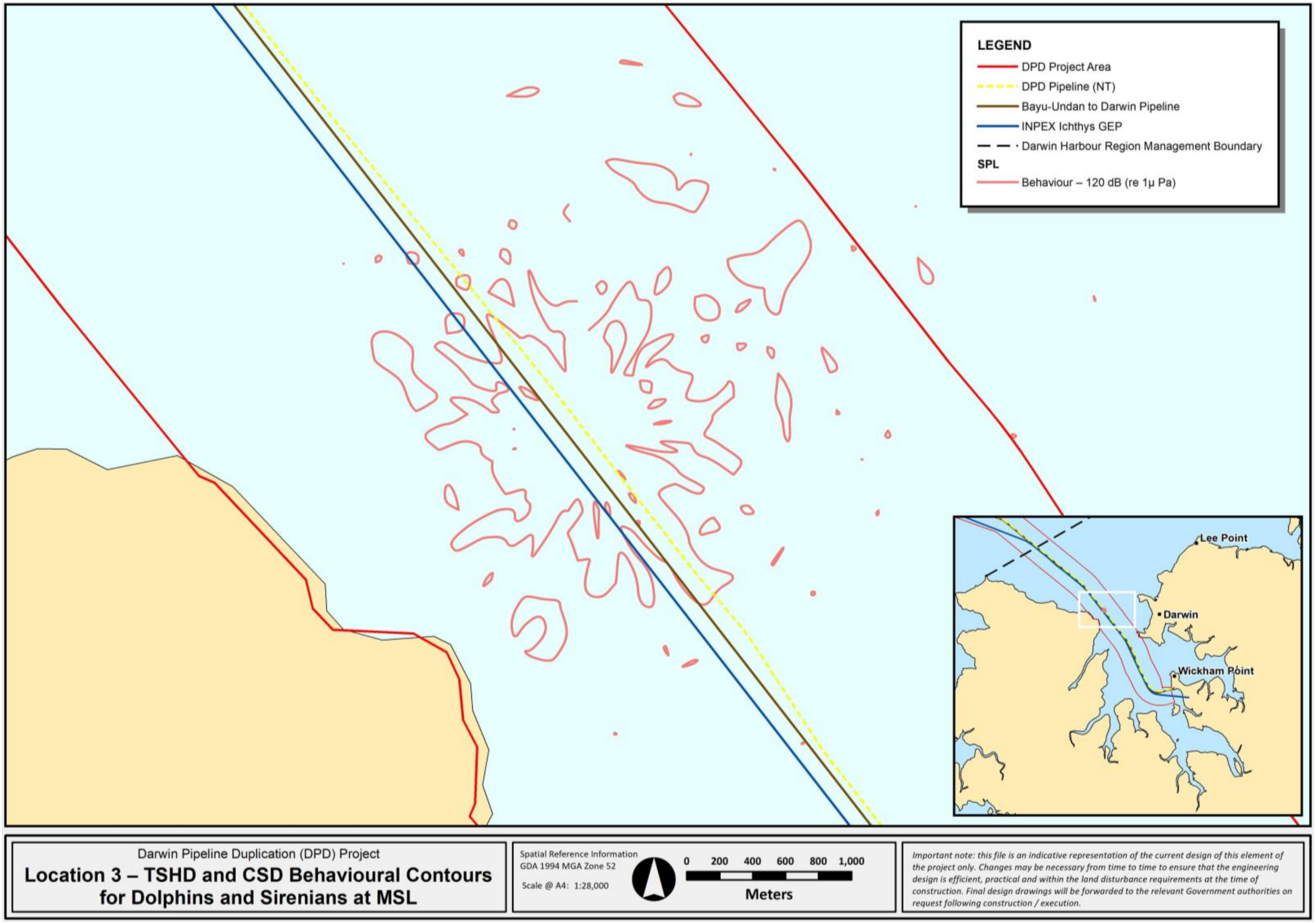


Figure 6-4: Modelling location 3 – TSHD and CSD behavioural contours for dolphins and sirenians (MSL)

7 Impact assessment

This draft MMNMP has employed a systematic impact assessment process to inform the management of underwater noise during construction activities for the DPD Project. As described below, the approach is consistent with the NT EPA Draft Guideline for the Preparation of an Environmental Management Plan (NT EPA, 2015).

7.1 Conceptual site model

A conceptual site model, as required by the NT EPA, is a written or illustrated representation of the nature, fate and transport of discharges, wastes or contaminants that allows assessment of potential and/or actual exposure of the environment to contaminants (NT EPA, 2015). The Conceptual site model for this draft MMNMP is embedded within the impact assessment, which, details receptors and impact pathways for noise emissions from construction activities, see **Section 7.3.**

7.2 Impact assessment methods

The MMNMP environmental impact assessment followed the Santos' Risk Matrix Procedure (SMS-LRG-OS01-TP02) with modified consequence descriptors to reflect the NT EPA key environmental factors and consequence descriptors (**Table 7-1**). Identification of management actions followed the Santos' Environment Hazard Controls Procedure (SMS-EXA-OS01-PD02). An environmental aspect, for the purpose of this environmental management plan, is defined as characteristics of the construction activities that could potentially affect the environment.

7.2.1 Identification of environmental hazard

Environmental hazards related to noise for this MMNMP were identified using Santos' DPD Project NT EPA Referral (Santos, 2021), DPD Project Basis of Approval (BAS-210 0005; Santos, 2022) and discussion by DPD Project team and environmental specialists. Key DPD Project construction activities and associated hazards and results from the noise modelling study (Talis, 2022) were presented during ENVID workshops to inform the impact assessment process.

7.2.2 Standard controls

The standard controls identified in **Section 8** were drawn from:

+ Santos' DPD Project NT EPA Referral (BAA-201 0002; Santos, 2021)
+ Santos' environmental plans and procedures for similar activities
+ Regulator approved management plans developed by other proponents.

Additional controls were provided by ENVID workshop attendees based on their relevant experience.

7.2.3 Impact assessment

All hazards identified were assigned a consequence level following the six levels and criteria outlined in Santos' Risk Matrix Procedure (SMS-LRG-OS01-TP02). The consequence criteria were then modified to incorporate the NT EPA Key Environmental Factors. The modified consequence descriptors shown in **Table 7-1.**

Table 7-1: Consequence descriptors

Consequence Level		**I**	**II**	**III**	**IV**	**V**	**VI**
Acceptability		**Acceptable**	**Acceptable**	**Unacceptable**	**Unacceptable**	**Unacceptable**	**Unacceptable**
Consequence Level Description		**Negligible** No impact of negligible impact	**Minor** Detectable but insignificant change to local population, industry or ecosystem factors Localised effect	**Moderate** Significant impact to local population industry or ecosystem factors	**Major** Major long-term effect on local population industry or ecosystem factors	**Severe** Complete loss of local population industry or ecosystem factors AND/OR extensive regional impacts with slow recovery	**Critical** Irreversible impacts to regional population industry or ecosystem factors
Environmental Receptors	**Marine Ecosystems** Fauna, habitat, conservation significant areas and ecological function, processes and integrity	Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity. No decrease in local population size / area of occupancy of species / loss or disruption of habitat critical / disruption to the breeding cycle/ vales of a protected area. No introduction of disease and no reduction in habitat area/function.	Detectable but insignificant decrease in local population size and threat to local population viability. Insignificant disruption to the breeding cycle of local population / area of occupancy of species / loss of habitat critical to survival of a species/ values of a protected area. Detectable but insignificant loss of area/function of habitat with rapid recovery within 2 years.	Moderate. Significant decrease in local population size but no threat to overall population viability. Significant behavioural disruption or disruption to the breeding cycle of local population / Significant reduction in area of occupancy of species / loss of habitat critical to survival of a species. Modify, destroy, remove or decrease availability of quality habitat to the extent that a long-term decline in local population or function of habitat is likely with recovery over medium term (2-10 years) Introduction of disease likely to cause significant population decline	Long term decrease in local population size and threat to local population viability. Major disruption to the breeding cycle of local population / area of occupancy of species / loss of habitat critical to survival of a species/ values of a protected area Fragmentation of existing population / Loss or change of habitat to the extent that a long-term decline in local population and function of habitat is likely with slow recovery over decades Introduction of disease likely to cause long term population decline	Complete loss of local population, habitat critical to survival of local population or protected area/conservation significant area Widespread (regional) decline in population size or habitat critical to regional population Extensive destruction of local habitat with no recovery or long term (decades) or widespread loss of area or function of primary producers on a regional scale	Complete loss of regional population Complete loss of habitat critical to survival of regional population
	Marine Environmental Quality Water quality, sediment quality, ecosystem health and parameters that support fishing, aquaculture, recreation, aesthetics and cultural/spiritual values	Negligible. No or negligible reduction in physical environment nor decrease in ecosystem function/health. No or negligible loss of value to socio-economic activities	Detectable but localised, short term and insignificant impact to physical environment or ecosystem function/health or value to socio-economic activities. Rapid recovery evident within ~ 2 years.	Significant wide-scale medium term impact to physical environment, decrease in ecosystem function/health or value to socio-economic activities. Recovery over medium term (2-10 years).	Wide-scale, long term impact to physical environment, long term decrease in ecosystem function/health or value to socio-economic activities. Slow recovery over decades.	Extensive impact to/destruction of physical environment with no recovery or shutdown of socio-economic activities Long term (decades) and widespread loss of ecosystem function/health on a regional scale that damages value to socio-economic activities.	Complete destruction of regional physical environment / habitat with no recovery Complete loss of area or function of primary producers on a regional scale

Consequence Level		I	II	III	IV	V	VI
	Coastal Processes Geophysical processes, primary productivity/ nutrient cycling, conservation significant areas/coastal landforms and cultural, aesthetic or recreation values	Short term changes to local geophysical/hydrological processes, widespread loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale	Detectable but insignificant loss or change to local geophysical/hydrological processes, area or function of primary producers/nutrient cycling or conservation significant areas with rapid recovery within 2 years.	Moderate. Significant modification, destruction, removal or change of local geophysical/hydrological processes, wide-scale loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale with recovery over medium term (2-10 years).	Long term loss or change of local geophysical/hydrological processes, widespread loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale with slow recovery over decades	Extensive destruction of local geophysical/hydrological processes, widespread loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale with no recovery or long term (decades)	Complete loss or change of geophysical/hydrological processes. Complete loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale.
	Community and Economy Includes: fisheries (commercial and recreational); tourism; oil and gas; defence; commercial shipping	No or negligible loss of value of the local industry. No or negligible reduction in key natural features or populations supporting the activity.	Detectable but insignificant short-term loss of value of the local industry. Detectable but insignificant reduction in key natural features or population supporting the local activity.	Significant loss of value of the local industry. Significant medium-term reduction of key natural features or populations supporting the local activity.	Major long-term loss of value of the local industry and threat to viability. Major reduction of key natural features or populations supporting the local activity.	Shutdown of local industry or widespread major damage to regional industry. Permanent loss of key natural features or populations supporting the local industry.	Permanent shutdown of local or regional industry Permanent loss of key natural features or populations supporting the local or regional industry
	Culture and heritage Includes: Indigenous heritage and maritime heritage (i.e. shipwrecks)	No or negligible impact on the area's cultural or heritage values. No or negligible alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Detectable but insignificant impact on one or more of the area's cultural or heritage values. Detectable but insignificant alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Significant impact on one or more of the area's cultural or heritage values. Significant alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Major long-term effect on one or more of the area's cultural or heritage values. Major alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Complete loss of one or more of the area's cultural or heritage values.	Permanent loss of one or more of the area's cultural or heritage values with no recovery.

The consequence is defined as the resulting impact from an event occurring. Consequence level for this assessment was based on the credible worst-case scenario and assumed no management actions were in place. Categories of environmental consequence and severity level are outlined in **Table 7-2**.

Consistent with the Santos' Risk Matrix Procedure (SMS-LRG-OS01-TP02), given the generation of noise is a planned event a residual risk ranking was not assigned. A comprehensive impact assessment for the planned event, and subsequent management actions proposed by Santos to reduce the impacts to ALARP are detailed in the following subsections. Within the ENVID developed by Santos some environmental aspects had multiple residual consequence ratings, in these cases the residual consequence of greater severity was chosen for this summary.

Table 7-2: Summary environmental consequence descriptors

Consequence Level	Consequence Level Description
I	**Negligible** – No impact or negligible impact
II	**Minor** – Detectable but insignificant change to local population, industry or ecosystem factors
III	**Moderate** – Significant impact to local population, industry or ecosystem factors
IV	**Major** – Major long-term effect on local population, industry or ecosystem factors
V	**Severe** – Complete loss of local population, industry or ecosystem factors AND/OR extensive regional impacts with slow recovery
VI	**Critical** – Irreversible impact to regional population, industry or ecosystem factors

7.3 Impact assessment summary

The outcomes of the planned event impact assessment are presented in **Table 7-3**, and where relevant includes reference to the relevant management strategy within this draft MMNMP proposed to manage individual environmental aspects.

Table 7-3: Summary of underwater noise impact assessment outcome

Aspect	Activity	Description of hazard	Spatial scale	Temporal scale	Potential impacts	Sensitive receptors	Residual consequence (planned impact)	Management strategy
Planned impacts								
Noise Emissions	Pre-lay works including: + Cutter suction dredge (CSD) + Trailer suction hopper dredge (TSHD) + Backhoe dredge (BHD) for excavating with potential used of hydraulic tools (Xcentric Ripper, hydraulic hammer) for fracturing rock + Mass flow excavation (MFE) + Construction of two temporary causeways either side of the trench at the shore crossing Pipelay by nearshore pipelay barge in shallower waters including Darwin Harbour. Pipelay by dynamic positioning (DP) vessel in deeper waters outside of Darwin Harbour. Operation of onshore plant and equipment within Project Area at DLNG facility Support operations including: + General vessel operations during all DPD Project activities + Vessel and subsea positioning equipment e.g. MBES, SSS, LBL) / USBL) + Helicopter operations	Vessel noise is considered non-impulsive (continuous) and broadband and includes vessel thrusters, engines and propellers, as well as noise emitted onboard which is converted to underwater noise through the hull. The main source of vessel noise will be from propellers or dynamic positioning (DP) thrusters (deeper water pipelay only). Project vessels (excluding trenching vessels) may emit noise up to ~180 dB re 1 µPa at 1 m. Trenching will be completed using different trenching vessels, including a BHD, a TSHD and a CSD. Noise includes operation of vessel engines for propulsion (as applicable), onboard equipment, pumps and interaction of trenching equipment with the seabed. The following source levels are considered representative of trenching vessel non-impulsive noise: + TSHD: 184 dB re 1µPa @1m + CSD: 182 dB re 1µPa @1m + BHD: 175 dB re 1µPa @1m BHD rock breaking tools will be either non-impulsive from Xcentric Ripper tool or impulsive from hydraulic hammer (contingency only). Representative source levels are: + Xcentric Ripper: 184.8 dB re 1 µPa2 s m^2 + Hydraulic hammer: 192 dB 1 µPa2s m^2	For TSHD, CSD and BHD trenching and Xcentric Ripper tool use, permanent threshold shift (PTS) SEL24 hour ranges for dolphins, dugongs and turtles modelled at <50 m. Equivalent threshold range for hydraulic hammer modelled at 100- 160 m. For TSHD, CSD and BHD trenching and Xcentric Ripper tool use, temporary threshold shift (TTS) SEL24 hour ranges for dolphins, dugongs and turtles modelled at 40-350 m. Equivalent threshold range for hydraulic hammer modelled at 950- 2,500 m. The PTS and TTS ranges were shown to decrease with reduced hammering time (per 24 hours) for the hydraulic hammer. For behavioural response thresholds, ranges for marine mammals (dolphins and dugongs) varied from 100s of metres to 10s of kilometres for scenarios modelled at MSL. Spatial scales for other activities are as follows: + Localised: A support vessel using main engines and bow thrusters to maintain position will become inaudible above background noise within thousands of metres. + Localised: A conservative estimate is that survey equipment (MBES/SSS) will be inaudible within thousands of metres, depending on the activity characteristics. + Localised: Helicopter noise will be highly localised and most of the noise will not transfer into the water.	Vessel noise for the duration of the construction activity (12-15 months), with intermittent survey equipment and helicopter noise. Trenching vessel noise expected over indicative period of 2-3 months. Noise will be very infrequent during operations given scale of planned vessel pipeline inspection surveys indicatively every 1-3 years.	Project activities including trenching, pipelay, additional vessel operations and will add to the existing underwater noise profile inside and outside Darwin Harbour during construction. The use of sound in the underwater environment is important for marine animals, particularly cetaceans, to navigate, communicate and forage effectively, along with reptiles, sharks/rays and other fish, for a range of functions such as social interaction, foraging and orientation. Underwater noise could result in: + Acoustic masking: – Disruption to underwater acoustic cues – Masking of vocalisations and signals from predators and prey + Behavioural response: – Modification of fauna behaviour (avoidance, attraction and disruption of normal behaviour) – Disturbance, leading to behavioural changes or displacement from areas – Indirectly by inducing behavioural and physiological changes in predator or prey species. + Physiological impacts: – Increased stress levels – Physical injury to fauna from exposure to excessive noise (barotrauma, hearing loss including TTS and PTS Onshore construction activities are not expected to have an impact as they will not occur in water.	+ **Marine ecosystem** (marine mammals particularly cetaceans, marine reptiles, sharks, rays, pelagic and demersal fish) + **Marine environmental quality** (impact to parameters that support fishing, aquaculture, recreation, aesthetics and cultural/ spiritual values) + **Community and economy** (fisheries, commercial and recreational) and tourism).	II - Minor	**Section 8**

7.4 Assessment of potential for cumulative impacts

The underwater noise emission from Project vessels and activities will add to the ambient noise environment within the Project Area which includes Darwin harbour and major shipping routes. The frequency and noise levels of DPD Project vessels are expected to be similar to that from existing shipping traffic. This is discussed in **Section 6.3.4.**

In terms of potential cumulative noise impacts between the DPD Project and other proposed projects within Darwin Harbour this is detailed within the DPD Project SER (BAS-210 0020), including an assessment of potential for overlap in time and space between projects.

Given the high level of uncertainty on the degree of overlap between specific noise generating activities of other projects with the DPD Project and the inherent difficulties in modelling multiple dynamic sound sources. Underwater noise modelling has not attempted to integrate other project noise sources. However, modelling conducted for the DPD Project has conservatively assessed impacts from the operation of two DPD Project trenching vessels (TSHD and CSD) at the same location at the same time and results from this have informed the impact assessment.

Santos has and will continue to engage all relevant proponents and authorities, to minimise the potential for cumulative impacts. The consultation strategy is further detailed in SER (BAS-210 0020).

8 Environmental management strategy

This section outlines the environmental management strategy (EMS) that will be implemented for management of noise impacts associated with the DPD Project construction works, therefore minimising and/or mitigating the risks to sensitive receptors and protected marine megafauna.

The EMS outlines the commitments and objectives that are relevant and states specific measurable targets to achieve proposed objectives. Subsequently, these targets potentially trigger the use of certain management actions. Performance indicators and monitoring activities are used to quantify success in meeting requirements and identify the need for corrective actions. This ensures the continuous improvement of the effectiveness of the DPD Project's EMS. The EMS defines the reporting requirements, terms, and responsibilities.

The EMS is structured to align with the template presented in **Table 8-1**.

Table 8-1: Environmental management strategy template

Item	Content
Environmental Performance Objectives (EPO)	Environmental management goal(s) tailored to each aspect per NT EPA requirements.
Target	Aspect specific measurable performance necessary to successfully achieve objective. Part 1 of NT EPA required performance criteria.
Performance Indicator	Quantitative or qualitative measures representing the performance related to Target(s). Part 2 of NT EPA required performance criteria.
Management actions	Tasks to be undertaken to meet objective/s. For example, install turtle deflection chains on TSHD drag head, comply with Darwin Port vessel speed restrictions etc.

8.1 NT EPA hierarchy

In the development of the EMS outlined within this draft MMNMP Santos applied the Environmental Decision-Making Hierarchy outlined within the EP Act. This hierarchy being:

+ To ensure that actions are designed to avoid adverse impacts on the environment
+ To identify management options to mitigate adverse impacts on the environment to the greatest extent practicable
+ And if appropriate, provide for environmental offsets in accordance with the EP Act for residual adverse impacts on the environment that cannot be avoided or mitigated[1]

8.2 Environmental performance objectives and performance criteria

To ensure environmental impacts will be of an acceptable level, an environmental performance objective (EPO) has been defined for noise impacts.

[1] No offsets were deemed necessary for this project.

The EPO relevant to noise emissions, including performance criteria, are described in **Table 8-2**.

Table 8-2: Noise emissions EPOs and associated performance criteria

EPO	Performance criteria	
	Target/s	**Performance Indicator/s**
No significant impacts to protected marine fauna from noise generated during the DPD construction activities	Zero incidents of injury or mortality to EPBC Act listed marine fauna from noise generated during DPD construction activities	+ Incident reports + MFO reports of sightings of injured or dead marine megafauna
	Zero incidents of trenching or rock breaking while EPBC Act listed marine fauna observed in exclusion zone	+ Activity logs in conjunction with MFO records

This EPO aligns with the following NT EPA Factor objectives:

- Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
- Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this planned impact are shown in **Section 8.4.6**.

8.3 Adaptive management mechanism

The proposed adaptive management actions are detailed in **Section 8.4.2**. Further adaptive management actions may be added based on approval conditions following assessment by NT EPA and DCCEEW.

Additionally, adaptive management can be triggered through Santos' incident response and assurance processes, with corrective actions and management adapted as required to address any incidents and non-conformances identified (detailed in Section 8.3 of the Offshore CEMP (BAS-210 0024)).

8.4 Noise impact management actions

Management actions will be implemented to meet the environmental objectives outlined above.

8.4.1 Vessel and Helicopter Approach Distances

Vessel and helicopter contractor procedures will comply with Part 8 of the Environment Protection and Biodiversity Conservation (EPBC) Regulations 2000, which includes controls for minimising interaction with marine megafauna. Whilst these measures are usually aimed at reducing the risk of collision, maintaining the correct approach distances will also help reduce the risk of disturbance and injury from noise emissions from vessels and helicopters.

The approach distances outlined in the EPBC Regulations include the 'no approach zone' which excludes vessels within 100 m to the side of and 300 m in front and to the rear of an adult whale and within 50 m to the side of and 150 m in front and to the rear of an adult dolphin. The EPBC

Regulations also include a 'caution zone' in which vessel speed must be no more than six knots (~11 km/hr), no more than three vessels are allowed, and vessels cannot enter if animals are injured, stranded, entangled, distressed or where a calf is present. The 'caution zone' is between 300 and 100 m for an adult whale and 150 and 50 m for an adult dolphin.

8.4.2 Marine Megafauna Observation and Adaptive Management Protocol

Observation and exclusion zones can reduce the risk of physical and behavioural impacts to marine megafauna as construction activities can be paused until marine megafauna have moved outside of the exclusion zone and are no longer at risk of injury or disturbance.

8.4.2.1 Routine construction operations

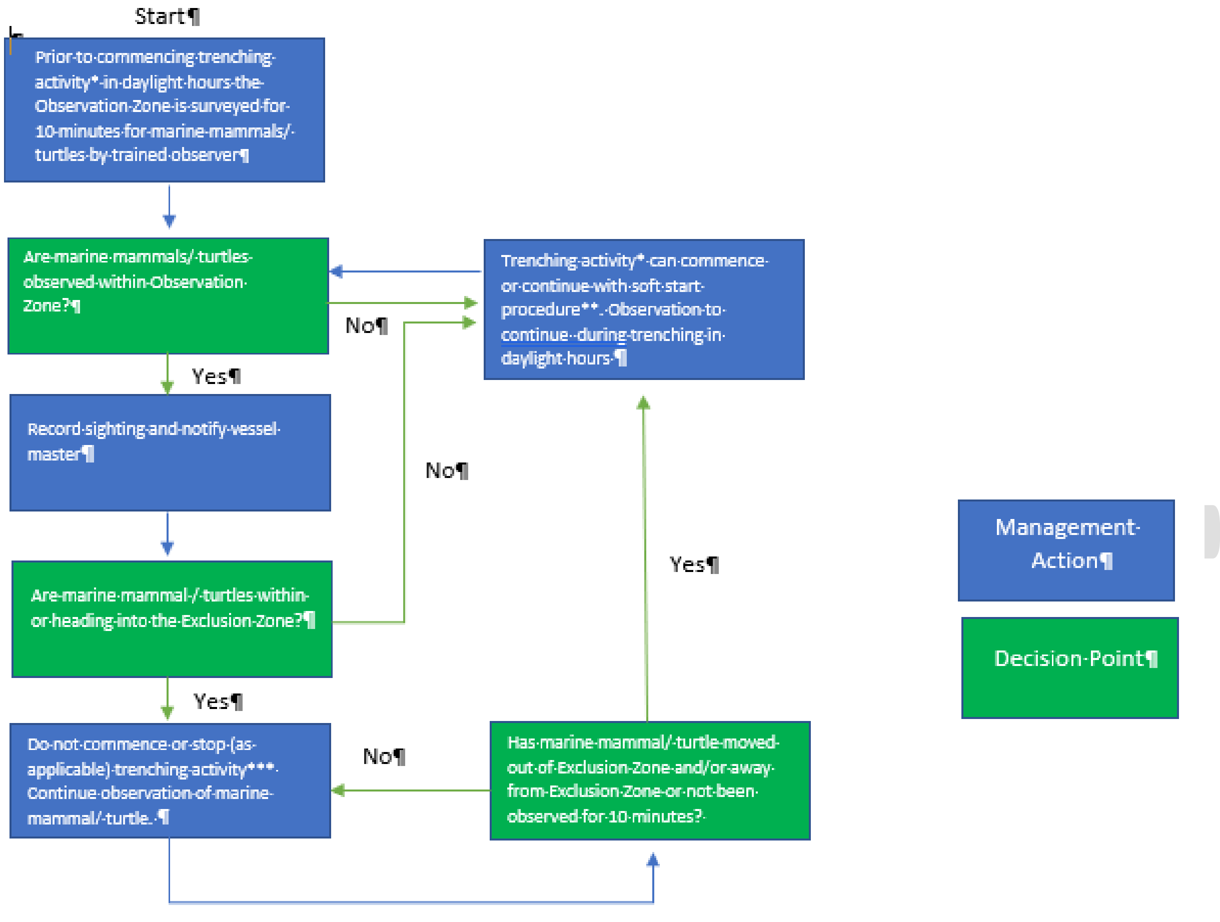
An Observation Zone of 150 m and an Exclusion Zone of 50 m has been proposed around vessels/plant engaged in routine construction activities including the use of an Xcentric Ripper rock breaking tool on the BHD where required. These zones align with Dolphin Caution Zones outlined in Part 8 of the EPBC Regulations. The 150 m observation zone also provides an appropriate range for observing marine mammals and turtles that could potentially receive temporary hearing injury over a 24-hour period. While the site-specific modelling results (**Section 6.3.3**) indicate TTS ranges could extend to 350 m for dolphins at MSL (based on concurrent operation of a TSHD and CSD in the same area), these are considered very conservative values given the known mobility and transient nature of dolphins within Darwin Harbour (Griffiths *et al.*, 2019) and the very low likelihood of dolphins remaining within this range for 24 hours. Therefore, a 150 m zone was considered sufficient on this basis and a more practical range for the observation of marine fauna by trained observers. For turtles, the proposed 150 m observation zone aligns with the TTS ranges at MSL.

The 50 m Exclusion Zone aligns with PTS ranges for marine mammals and turtles (and with dolphin No Approach Zones under Part 8 of the EPBC Regulations), although it is very unlikely these species would remain in close proximity to a trenching vessel over a full 24-hour period. Rather, the Exclusion Zone is considered to provide value in protecting marine fauna, in particular turtles, from direct interaction and injury from trenching equipment (refer to the Offshore CEMP and TSDMMP (BAS-210 0024; BAS-210 0023) for further information regarding this risk).

During daylight hours, prior to the commencement of any noise-intensive activity the Observation Zone will be monitored by a crew member trained in marine fauna observation. The Observation Zone will be monitored for a minimum of 10 minutes prior to a noise-intensive activity to ensure no key marine megafauna species (e.g., dolphins, dugongs or turtles) are present. If any such species are present within the zone, they will be recorded. If the marine megafauna is observed within or heading into the Exclusion Zone, noise-intensive activities will not commence until the animal is observed to leave and move away from the exclusion zone, or until 10 minutes of observations have passed since the last sighting and no further key marine megafauna have been sighted. Should noise-intensive activity be already underway when a key marine megafauna is observed within or heading into the Exclusion Zone, the activity will be stopped (as applicable) and observation of the marine megafauna will continue until animal is observed to leave or move away from the Exclusion Zone, or until 10 minutes of observations have passed since the last sighting.

All marine fauna interactions and observations during daylight hours will be appropriately recorded and reported to DEPWS/NT EPA and DCCEEW.

The proposed marine megafauna observation and adaptive management protocol for routine operations (including use of Xcentric Ripper tool) is summarised in **Figure 8-1**.



KEY

*Trenching activity means: BHD excavating or rock breaking, activation of CSD cutter head, activation of TSHD suction pump

**Where practicable dependent on machine capability

***Not commencing or stopping trenching means the following:

- For BHD trenching — not commencing or stopping excavating or rock breaking activities
- For CSD trenching — not starting or stopping the cutter head
- For TSHD trenching — not starting or stopping the TSH suction pump

Observation Zone = 150m zone around vessel

Figure 8-1: Marine megafauna observation and adaptive management protocol for routine construction operations including the use of Xcentric Ripper tool.

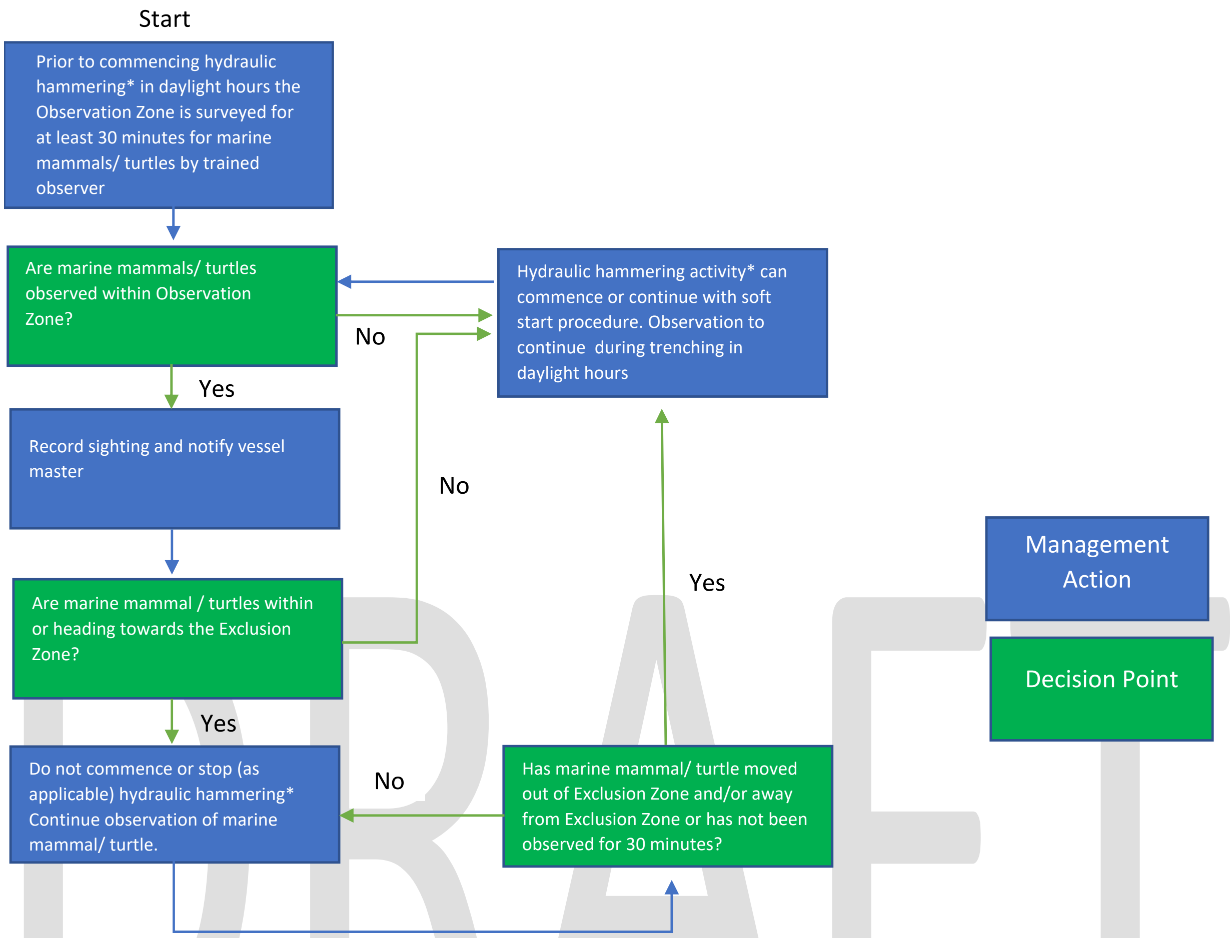
8.4.2.2 Hydraulic hammer operations

The underwater noise modelling for the hydraulic hammer has shown that hearing injury (PTS or TTS) could occur to marine turtles, dolphins and dugongs at ranges significantly greater (up to ~10x) those modelled for dredging vessel noise as well as over 10x the range determined for the Xcentric Ripper tool. The modelling indicates that hydraulic hammering could result in PTS for dolphins and dugongs if they remained (for 24 hours) within 130 and 160 m, respectively, of the rock breaking activity and result in TTS if they remained (for 24 hours) within 1.83 km and 2.5 km, respectively, of the activity. For marine turtles, the equivalent ranges were modelled as 100 m for PTS and 950 m for TTS. Given behavioural effect ranges for marine fauna applicable to hydraulic hammering are within the TTS ranges, natural avoidance of the noise source is not considered a mitigation for preventing TTS.

On the basis of the modelling results, the management actions for routine construction for preventing hearing injury to marine mammals or marine turtles are not considered adequate for rock breaking using a hydraulic hammer. They are, however, considered applicable and effective for preventing hearing injury to marine fauna during rock breaking using an Xcentric Ripper.

In the event that a hydraulic hammer is required for rock breaking (expected to occur only as a contingency), the following additional management actions will apply.

+ Hydraulic hammering for no greater than 8 hrs over a 24 hr period.
+ No hydraulic hammering at night
+ A separate vessel with MFO onboard will be required to patrol the Observation Zone prior to and during hydraulic hammering
+ Increased Observation and Exclusion Zones for hydraulic hammering based on noise modelling results will be applied through a revised marine megafauna observation and adaptive management protocol for contingency hydraulic hammering as presented in **Figure 8-2**.



KEY

*Hydraulic hammering means use of an impulsive hydraulic hammer for rock breaking. It does not apply to the use of an Xcentric ripper.

Observation and Exclusion Zones for hydraulic hammering applied as follows:

- If up to 8 hours of rock breaking is required an Observation Zone of 2.5km (marine mammals) and 1km (turtle) will apply and an Exclusion Zone of 150m for marine mammals and turtles will apply
- If up to 6 hours of rock breaking is required an Observation Zone of 2 km (marine mammals) and 750 m (turtle) will apply and an Exclusion Zone of 100m for marine mammals and turtles will apply
- If up to 4 hours of rock breaking is required an Observation Zone of 1.5 km (marine mammals) and 750 m (turtle) will apply and an Exclusion Zone of 100 m for marine mammals and turtles will apply
- If up to 2 hours of rock breaking is required an Observation Zone of 1km (marine mammals) and 500 m (turtle) will apply and an Exclusion Zone of 50 m for marine mammals and turtles will apply

Figure 8-**2**: Marine megafauna observation and adaptive management protocol for contingency hydraulic hammering**.**

8.4.3 Marine fauna observer

Crew trained in marine fauna observation will ensure marine megafauna can be reliably identified to different species during observation periods. This will improve the ability to spot and identify marine megafauna at risk from injury or disturbance due to noise emissions from construction activities. At least one marine fauna observer (MFO) will be on duty per pipelay, trenching and rock installation vessel/barge during daylight hours. The MFO will sight and record marine megafauna interactions prior to, and during, trenching and rock breaking operations.

MFOs will also reduce the risk of direct interaction and injury from vessels and trenching activities (refer to the Offshore CEMP and TSDMMP (BAS-210 0024; BAS-210 0023) for further information regarding this risk).

Given the increased size of Observation Zone required for rock breaking with a hydraulic hammer, a separate vessel with MFO onboard will be required to patrol the Observation Zone prior to and during hydraulic hammering.

8.4.4 Soft start procedures

Where practicable, soft start procedures will be implemented which may reduce the impact to marine megafauna by allowing them to move away from the area of trenching or rock breaking activity prior to noise generation reaching maximum levels. Soft start procedures generally involve a slow ramp up of the activity so that energy and noise levels increase gradually before reaching maximum operating levels. This gradual ramp up will provide greater opportunities for animals to avoid exposure the maximum noise levels by moving away from the activity during this gradual ramp up. The following controls will be applied:

+ Soft start (ramp-up) for rock breaking (Xcentric Ripper or hydraulic hammer) by BHD, where practicable
+ Soft start (ramp-up) for trenching equipment, where practicable, will apply to the CSD and TSHD

Soft start procedures will also reduce the risk of direct interaction and injury from vessels and trenching activities (refer to the Barossa CEMP and TSDMMP (BAS-210 0024; BAS-210 0023) for further information regarding this risk).

8.4.5 Reporting injured marine wildlife

Any injured marine megafauna must be reported to the NT EPA/DEPWS within 24 hours and reported to DCCEEW for EPBC Act listed species. If a marine mammal vessel strike incident has occurred it will be recorded in the National Marine Mammal Ship Strike database (AMMC, 2022).

8.4.6 Summary of management actions

A summary of management actions adopted for noise generating construction activities to reduce the risk of injury and disturbance to marine megafauna in the DPD Project Area is outlined in **Table 8-3** for routine construction operations, including the use of an Xcentric Ripper tool for rock breaking. As a contingency, a hydraulic hammer may be used if rock breaking cannot be completed successfully using an Xcentric Ripper. Additional contingency management actions for the use of a hydraulic hammer are outlined in **Table 8-4**. Environmental Performance Standards for these management actions will be developed in conjunction with Project contractors prior to finalisation of this draft MMNMP.

Table 8-3: Summary of management actions for noise emissions during routine construction including the use of an Xcentric Ripper tool

MA reference	Management actions
Standard management actions	
Avoidance	
DPD-MA46	Observation and exclusion zones for marine fauna developed based on noise modelling results and standard protocols
Mitigation	
DPD-MA49	Vessel inductions for all crew to address marine fauna risks and the required management controls
DPD-MA50	Vessel and helicopter to complete Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000, which includes controls for minimising interaction with marine fauna
DPD-MA51	Personnel trained in MFO to be present on pipelay, dredge and rock installation vessels/barges during daylight hours, including one crew member with MFO training on the bridge at all times
DPD-MA52	All marine fauna interactions and observations to be appropriately recorded and reported to DEPWS/NT EPA and DCCEEW as required
DPD-MA55	Maintenance of vessel, vehicle and equipment combustions engines and vessel incinerators as per planned maintenance system
Additional (ALARP) management actions	
Avoidance	
DPD-MA56	Observation and shut-down zones for marine fauna have been developed based on noise modelling results for trenching and standard protocols and include: + Observation (150 m) and exclusion (50 m) zones for marine mammals and turtles. + Observation zone monitored for 10 minutes prior to commencing trenching during daylight only. A Marine Megafauna Observation and Adaptive Management Protocol for routine construction operations, including the use of Xcentric Ripper tool, is to be followed as per **Figure 8-1**
Mitigation	
DPD MA62	+ Soft start (ramp-up) of hydraulic tools (rock breaking) by BHD, where practicable + Soft start (ramp-up) of trenching equipment, where practicable, will apply to the CSD and TSHD
Additional (ALARP) management actions not adopted	
1	Schedule trenching activities outside of peak flatback turtle nesting period (May to October) or outside of peak Darwin Harbour dolphin calving period (October to April). Reason for rejection: + It would not be possible to avoid both peak periods. + The potential benefit of avoiding locations of higher marine megafauna sensitivity at certain times of the year, such as nesting periods for turtles and dolphin calving periods, is considered disproportionately low compared to the implications to Project scheduling and costs – While there are known flatback turtle nesting sites (Cox Peninsula and Casuarina Beach), and a known period of increased nesting activity (May to October), the densities of nesting turtles in these areas are very low and not significant on a regional scale (Chatto and Baker, 2008). Furthermore, these sites are on a scale of 1000s of meters away from the pipeline route and trenching areas (as they are from existing vessel traffic using navigation channels) and the relative risk of behavioural effects to turtles at this scale from vessel noise is considered low (Popper et al., 2014). For dolphins, there is evidence that there is a peak in calving within Darwin Harbour between October and April (Palmer, 2010). Important areas have not been defined however and given the high mobility of dolphin species within Darwin Harbour and the use of adjoining coastal areas (Griffiths et al., 2019) it is unlikely that behavioural disturbance around DPD Project activities, relative to the total area of Darwin Harbour and surrounding coastal waters, would have a significant impact on calving behaviour.
2	The observation period for marine megafauna prior to commencing dredging and pile driving is 20 minutes and the MFO is solely dedicated to the task of sighting and recording marine megafauna interactions prior to, and during, dredging and pile driving operations. Reason for rejection: + A 20-minute observation period was considered excessive for the size of the Observation Zone (150 m) and a 10-minute observation period was considered sufficient to monitor this zone for marine fauna. An additional 10 minutes would prolong dredging operations without any appreciable benefit. + A MFO for the pre-start up observation period was considered warranted however a MFO solely to the task of sighting and recording marine megafauna for the entirety of dredging operations was not considered warranted given that the dredging vessel to have multiple crew with marine fauna observation training onboard during daylight hours and the vessel bridge to be constantly manned with at least one crew with MFO training on the bridge at all times.
3	No use of DP vessels. Reason for rejection: + Not using DP vessels will cause additional seabed and benthic habitat impacts through the need to use anchoring to hold position during pipelay. The use of DP also decreases pipelay duration and reduces impact to other users through shorter timeframe.

MA reference	Management actions
4	Cease noise generating activities (e.g. DP) when near marine fauna. Reason for rejection: + Ceasing DP activities when near sensitive fauna may reduce the potential for impacts, however, the potential for impacts beyond behavioural disturbance are very low. Engine/DP thruster noise cannot reliably be ceased due to the safety critical role of vessel propulsion. It is also not practical to cease pipelay or other critical construction activities in a short timeframe as safely abandoning such operations can often take a number of hours (namely laying down the pipeline or disconnecting from a structure), during which time the impacted fauna will have left the area. Therefore, this control is not deemed feasible.
5	Soft start/power-up procedures for use of sonar equipment and use of fauna observation and shutdown zones. Reason for rejection: + The systems being used are at a low power or are an intermittent type such that the reduced cumulative exposure would reduce TTS or PTS impacts for marine fauna and behavioural impacts were not considered credible
6	No use of helicopters. Reason for rejection: + Use of helicopters required (e.g. vessel/crew transfers) and restriction will result in an overall longer duration construction activity and therefore noise impacts
7	Avoidance of night work for routine construction and Xcentric Hammer use. Reason for rejection: + Avoidance will result in an overall longer duration construction activity and therefore noise impacts and also increase the safety risk profile. The cost of implementing this far exceeds the benefit gained

Table 8-4: Summary of additional environmental management actions for contingency rock breaking using hydraulic hammer

MA reference	Management actions
Contingency management actions	
1	Increased Observation and Exclusion Zones for hydraulic hammering based on noise modelling results will be applied as follows: + If up to 8 hours of rock breaking is required, an increased Observation Zone of 2.5km (marine mammals) and 1km (turtle) will apply and an increased Exclusion Zone of 150m for marine mammals and turtles will apply + If up to 6 hours of rock breaking is required, an increased Observation Zone of 2 km (marine mammals) and 750 m (turtle) will apply and an increased Exclusion Zone of 100m for marine mammals and turtles will apply + If up to 4 hours of rock breaking is required, an increased Observation Zone of 1.5 km (marine mammals) and 750 m (turtle) will apply and an increased Exclusion Zone of 100 m for marine mammals and turtles will apply + If up to 2 hours of rock breaking is required, an increased Observation Zone of 1 km (marine mammals) and 500 m (turtle) will apply and an increased Exclusion Zone of 50 m for marine mammals and turtles will apply
2	Contingency hydraulic hammering protocols for managing noise impacts will be followed as per **Figure 8-2**
3	Hydraulic hammering for no greater than 8 hrs over a 24 hr period.
4	No hydraulic hammering at night
5	A separate vessel with MFO onboard will be required to patrol the Observation Zone prior to and during hydraulic hammering

8.4.7 Demonstration of ALARP

Use of vessels and subsea equipment will be required to complete construction activities, therefore underwater noise emissions are unavoidable if the planned activity is to proceed. Trenching and rock breaking activities will follow industry standard measures to prevent physiological impact to marine megafauna from noise, including implementation of Observation and Exclusion Zones and associated adaptive management measures, use of marine fauna observers to monitor zones and use of soft-starts where practicable. These zones have been informed by underwater noise modelling and appropriate thresholds to ensure the scale of these zones are sufficient to meet environmental objectives. In addition to the implementation of monitored zones, marine megafauna are expected to display avoidance behaviour of sound source at close ranges, thereby reducing the potential for physiological impact. For contingency hydraulic hammering, while not expected to be required, the zones have been increased significantly and additional measures put in place to ensure physiological impacts to do not occur to marine megafauna.

While there is the potential for behavioural response on larger scales of 100s of metres to 1000s of metres from continuous noise from trenching activities, depending upon fauna type, the activities are not expected to produce emissions significantly louder than other marine vessels that frequent or transit through the vicinity of the Project Area (e.g. cargo ships, LNG tankers, cruise ships and offshore oil and gas vessels). Given construction activity is temporary and trenching is expected to last for ~2-3 months, the addition of Project noise sources to the existing ambient noise environment is not expected to result in any significant additional behavioural effects within Darwin Harbour. The activity is unlikely to affect the health of and/or displace marine megafauna, as biologically important behaviours can continue given the widespread availability of suitable habitat within Darwin Harbour relative to the size of behavioural effect ranges.

Santos has considered the actions prescribed in various recovery plans and conservation advice, such as the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017), when developing the controls relevant to potential construction activities to minimise noise impacts on marine fauna. Management controls are in place to reduce operating noise, including vessel operational protocols, and to adhere to the fauna interaction management stated in EPBC Regulations (Part 8). As such, noise emitted during the activities is not expected to significantly impact on marine fauna within the Project Area.

The potential benefit of avoiding locations of higher marine megafauna sensitivity at certain times of the year, such as nesting periods for turtles and dolphin calving periods, is considered disproportionately low compared to the implications to Project scheduling and costs. There are also mutually exclusive sensitivity periods for dolphins and turtles. While there are known flatback turtle nesting sites (Cox Peninsula and Casuarina Beach), and a known period of increased nesting activity (May to October), the densities of nesting turtles in these areas are very low and not significant on a regional scale (Chatto and Baker, 2008). Furthermore, these sites are on a scale of 1000s of meters away from the pipeline route and trenching areas (as they are from existing vessel traffic using navigation channels) and the relative risk of behavioural effects to turtles at this scale from vessel noise is considered low (Popper et al., 2014).

For dolphins, there is evidence that there is a peak in calving within Darwin Harbour between October and April (Palmer, 2010). Important areas have not been defined however and given the high mobility of dolphin species within Darwin Harbour and the use of adjoining coastal areas (Griffiths et al., 2019) it is unlikely that behavioural disturbance around DPD Project activities, relative to the total area of Darwin Harbour and surrounding coastal waters, would have a significant impact on calving behaviour.

Other additional management actions were considered but rejected due to lack of feasibility, the associated cost or because the effort was disproportionate to any benefit (**Table 8-3**). Therefore, the risks to marine fauna from noise associated with the DPD Project activities are considered to be ALARP.

The potential consequence of noise emissions on receptors is assessed as II - Minor following the implementation of standard and additional (ALARP) management actions and will not have a significant impact on any habitat identified as critical to the survival of marine megafauna. With the management actions in place, no significant impacts are expected. Therefore, the impacts of noise emissions to the receiving environment are ALARP and considered environmentally acceptable.

9 Environmental management implementation strategy

Section 8 of the Offshore CEMP (BAS-210 0024) outlines the processes and procedures that will be implemented more broadly to all aspects of the DPD Project to ensure the environmental requirements within this draft MMNMP will be met, including:

- Specific systems, practices and procedures that ensure both environmental impacts and risks are reduced to ALARP and EPOs, performance criteria and management actions are being met;
- A clear chain of command, outlining roles and responsibilities of personnel involved in the implementation, management and review of the MMNMP;
- Measures to ensure that employees and/or contractors working in relation to this activity are aware of their responsibilities regarding the environment and have the appropriate skill and training;
- Auditing, review and revision processes;
- Incident recording and reporting in line with Santos and regulatory requirements;
- Maintenance of quantitative records of discharges and emissions; and
- Details of emergency response and oil spill arrangements.

This implementation strategy is consistent with the Barossa Health, Safety & Environment Management Plan for Execute (BAA-200 0003).

Stakeholder engagement is assessed separately for the requirements of the activity. Ongoing stakeholder management strategies are discussed in **Section 10.**

10 Stakeholder engagement and communications

The stakeholder engagement approach used for the Project is in accordance with Santos's corporate approach to stakeholder engagement and industry leading standards and practice. The approach recognises and is aligned with the NT EPA's Guidance for Proponents – Stakeholder Engagement (NT EPA 2021a), the NT EPA's guidance for Preparing a Supplementary Environmental Report (NT EPA 2021b) and the International Association for Public Participation's (IAP2) Quality Assurance Standard for Community and Stakeholder Engagement (IAP2 2015).

Due to the iterative nature of the stakeholder process all relevant details have been contained in one document, the SER (BAS-210 0020), to contain updates to one location. The SER provides an outline of the objectives, process and key stakeholders consulted for the DPD Project. Additionally, the Stakeholder Engagement Plan (SEP) is attached to the SER. It details all consultation undertaken to date and information on future engagement activities.

In preparing the SER, and project management plans, Santos has considered and assessed each submission individually, and taken into consideration the issues raised when engaging with stakeholders to assess potential impacts and proposed management measures.

The SER provides a summary of the issues raised relevant to the Project and Santos' assessment and response to these issues. A full register, with all submissions and responses, is provided as an attachment to the SER.

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Appendix 1: Santos Environment, Health and Safety Policies

Environment, Health & Safety

Santos

Policy

Our Commitment

Santos is committed to being the safest gas company wherever we have a presence and preventing harm to people and the environment

Our Actions

We will:

1. Integrate environment, health and safety management requirements into the way we work
2. Comply with all relevant environmental, health and safety laws and continuously improve our management systems
3. Include environmental, health and safety considerations in business planning, decision making and asset management processes
4. Identify, control and monitor risks that have the potential for harm to people and the environment, so far as is reasonably practicable
5. Report, investigate and learn from our incidents
6. Consult and communicate with, and promote the participation of all workers to maintain a strong environment, health and safety culture
7. Empower our people, regardless of position, to "Stop the Job" when they feel it necessary to prevent harm to themselves, others or the environment
8. Work proactively and collaboratively with our stakeholders and the communities in which we operate
9. Set, measure, review and monitor objectives and targets to demonstrate proactive processes are in place to reduce the risk of harm to people and the environment
10. Report publicly on our environmental, health and safety performance

Governance

The Environment Health Safety and Sustainability Committee is responsible for reviewing the effectiveness of this policy.

This policy will be reviewed at appropriate intervals and revised when necessary to keep it current.

Kevin Gallagher

Managing Director & CEO

Status: APPROVED

Document Owner:	Jodie Hatherly, General Counsel and VP Legal, Risk and Governance		
Approved by:	The Board	Version:	3

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